OPHTHALMIC DOCTORATE

Habits and attitudes towards retinoscopy and the relative accuracy of dedicated and combined retinoscopes

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HABITS AND ATTITUDES TOWARDS RETINOSCOPY AND THE RELATIVE ACCURACY OF DEDICATED AND COMBINED RETINOSCOPES

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Thesis summary

The studies presented in this thesis were carried out because of a lack of previous research with respect to (a) the habits and attitudes towards retinoscopy and (b) the relative accuracy of dedicated retinoscopes compared to combined types in which changing the bulb allows use in spot or streak mode.

An online British survey received responses from 298 optometrists. Decision tree analyses revealed that optometrists working in multiple practices tended to rely less on retinoscopy than those in the independent sector. Only half of the respondents used dynamic retinoscopy. The majority, however, agreed that retinoscopy was an important test. The University attended also influenced the type of retinoscope used and the use of autorefractors. Combined retinoscopes were used most by the more recently qualified optometrists and few agreed that combined retinoscopes were less accurate.

A trial indicated that combined and dedicated retinoscopes were equally accurate. Here, 4 optometrists (2 using spot and 2 using streak retinoscopes) tested one eye of 6 patients using combined and dedicated retinoscopes. This trial also demonstrated the utility of the relatively unknown '15 degrees of freedom' rule that exploits replication in factorial ANOVA designs to achieve sufficient statistical power when recruitment is limited.

An opportunistic international survey explored the use of retinoscopy by 468 practitioners (134 ophthalmologists, 334 optometrists) attending contact related courses. Decision tree analyses found (a) no differences in the habits of optometrists and ophthalmologists, (b) differences in the reliance on retinoscopy and use of dynamic techniques across the participating countries and (c) some evidence that younger practitioners were using static and dynamic retinoscopy least often.

In conclusion, this study has revealed infrequent use of static and dynamic retinoscopy by some optometrists, which may be the only means of determining refractive error and evaluating accommodation in patients with communication difficulties.

Key words

retinoscopy, survey, habits, attitudes, accuracy

I lovingly dedicate this thesis to my wife, Sally.

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- Keeler Ltd: donation of draw prize for survey,
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- College of Optometrists: electronic distribution of the UK survey.

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List of Abbreviations

ANOVA	Analysis of Variance
AOREC	Audiology / Optometry Research Ethics Committee (Aston University)
APL	Approved prior learning
ASD	Autism Spectrum Disorder
CHAID	Chi-squared Automatic Interaction Detection
College	The College of Optometrists
CV	Coefficient of Variation
Czech Slovak	Czech & Slovak Federal Republic
DC	Dioptre cylinder
DTA	Decision Tree Analysis
DF	Degrees of Freedom
DS	Dioptre sphere
GOC	General Optical Council
iPRO	Innovation in Practice-based Research for Optometrists
KSA	Kingdom of Saudi Arabia
MEM	Monocular Estimation Method (of dynamic retinoscopy)
MSE	Mean spherical equivalent
NRA	Negative Relative Accommodation
OD	Ophthalmic doctorate
PRA	Positive Relative Accommodation
RAF	Royal Air Force (Near Point Rule)
SPSS	IBM Statistics; formerly known as Statistical Package for the Social Sciences
U	Scalar vector (represents retinoscopy accuracy in Dioptres)
UAE	United Arab Emirates
WCO	World Council of Optometry
WD	Working Distance

1.0 Background and objectives

1.1 Description and history of retinoscopy

The technique of retinoscopy was initially described in 1859 by Sir William Bowman. (1) It was not until 1873 that retinoscopy was first introduced by Ferdinand Cuignet when a simple mirror with a peephole was used to diagnose and quantify ametropia.(2, 3) These early retinoscopes used a circular beam and can be described as spot type. Streak retinoscopy was patented in the USA in 1926 by Jack Copeland and produced an elongated image of a line filament bulb, which could be rotated through 360 degrees.(4, 5) Retinoscopy has thus been used by optometrists since the late nineteenth century to carry out objective refraction, to assess accommodation and to gain qualitative information regarding the clarity of the ocular media.

The objective nature of retinoscopy makes the technique particularly useful for ascertaining the spectacle prescription in patients incapable of verbal communication; very young children, or adults who either speak another language or have severe cognitive impairment. In these individuals, the spectacle prescription is often based primarily on the retinoscopic result and so the accuracy of this test is especially important. In all other individuals, the optimum spectacle prescription is determined after refining the retinoscopic result using subjective techniques, although an accurate objective refraction here can save considerable time. Autorefractors (or optometers) are another method of obtaining this information. (6)

Spot and streak retinoscopes each have their advantages and disadvantages in different circumstances but cylinder axis determination may be easier with a streak type, especially where there is a high cylinder.(5, 7) Spot retinoscopy has the advantage that both meridians can be observed at one time. There is a greater risk of accommodation changing while a streak is rotated to view the other meridian.(8) The first retinoscopes were dedicated spot or streak types. Keeler Combined retinoscopes have appeared since 1999 and can be used in either spot or streak mode simply by changing the bulb.(9) These combined retinoscopes are also described by various manufacturers as dual-mode, bimodal or combi instruments.

Modern retinoscopes often incorporate a halogen bulb, variable illumination, beam vergence adjustment and choice of sight-hole diameter. The size, design and position of the mirror, condensing lens, bulb and sight-hole influence the definition of the fundus patch and instrument accuracy.(10-14) Retinoscopy is easier with a larger the sight-hole since the reflex is brighter and a larger sweep can be made before the image is lost. However, the measurement of refractive error is more precise with a small sight hole (15) and Bennett & Rabbetts suggested a sight hole diameter of 1.5mm.(16)

The distance from the patient that the retinoscope is used is called the working distance (WD). An allowance for WD is made to the retinoscopy result by deducting the reciprocal of the WD or use of a WD lens. The retinoscopy reflex is brighter and easier to interpret if the WD is short e.g. 50cm. However, errors introduced by being positioned at a distance other than that being allowed for (the 'distance error') are greater for short WD's. At a WD of 1m the distance error is reduced but the reflex is less bright and more difficult to interpret. Since there are advantages and disadvantages to near and far WD's the compromise and recommended distance is 66cm. (17)

1.2 UK Regulations and guidance regarding retinoscopy

While College of Optometrists Guidance(18) states that in each routine examination a practitioner should obtain "objective refractive findings" and that refractive error "will often only be assessed by objective means in younger children", it does not specify that retinoscopy has to be used. Assessment of accommodation is included as a procedure that "may be included", although Guidelines do not mention preferred methods. The General Optical Council regulations(19) do not state that an eye examination should specifically include an assessment of accommodation but recommends inclusion of "such additional examinations as appear to the doctor or optometrist to be clinically necessary".

1.3 Assessment of refractive error

Refractive error can be assessed using retinoscopy, autorefraction and subjective techniques. There are some individuals that may not be suitable for autorefraction or subjective

techniques and on whom retinoscopy is essential. These may include young children (20), individuals with Specific Learning Difficulties (21), Cerebral Palsy and Down's syndrome (22, 23) and other groups.(24-27) Patients with Autism Spectrum Disorder (ASD) have a 41% chance of significant refractive error (28) yet, in some cases, may not be suitable for subjective or autorefractor testing.

1.3.1 Methods of retinoscopy for measurement of refractive error

Several methods of retinoscopy are available for the measurement of refractive error:

- Static retinoscopy: involves the patient fixating on a distant (usually 6m away), non-accommodative target (spot of light) in an attempt to relax the stimulus to accommodate.(13, 29-31)
- Binocular Method of Barratt: close fixation retinoscopy. The patient fixates the optometrists forehead, or dimmed retinoscope beam, and the spherical element is checked (in either eye) and adjusted (for both eyes) to allow for accommodation.(32) The major disadvantage of this method is potential inaccuracy caused by patient accommodation, which is particularly true for younger patients. Only one eye is used by the optometrist and so this technique is useful for practitioners with monocular reduced vision. (33, 34)
- Mohindra technique: a development of near-fixation retinoscopy that allows refraction of infants and young children without the use of cycloplegia. Low room and retinoscope illumination, and occlusion of the eye not being assessed, reduces stimulus to accommodate.(33, 35, 36)
- Estimation of spectacle prescription without using lenses (37): Low degrees of hyperopia can be estimated by focusing the streak within the pupil, using the vergence control, and comparing the width of the beam visible within and outside the pupil; the enhancement method. Myopia can be estimated by moving the retinoscope to the point of neutrality. The reciprocal of the distance from the patient at this point is the net myopia. 'Direct retinoscopy' involves seeking a focused image of the retinoscope bulb filament on the retina. The relative position of the vergence control and the distance from the patient are used to estimate spectacle

prescription.(37, 38) According to Wallace et al.(39), estimation retinoscopy has very good accuracy for low levels of myopia, hyperopia, and astigmatism. Techniques of estimation may be useful in excluding amblyogenic refractive errors, particularly in children who object to loose lenses held close to them.

- Carter method: A method of retinoscopy in which an optical arrangement magnifies the patient's pupil and makes it easier to see the retinoscopic reflex. This is particularly useful if miosis and/or cataract are present. A working distance of 40cm is employed and a +5D lens held midway between the retinoscope and the patient. Estimation of astigmatism is possible without the use of cylindrical lenses since the relationship between retinoscope position and dioptric power is linear.(40, 41)
- Cycloplegic: A cycloplegic refraction should be considered for non-communicative, uncooperative or inconsistent patients, when visual acuity cannot be corrected to an expected level, for young patients and when accommodative problems are suspected.(42) Cycloplegic refraction can be of great use in optometric practice, especially for cases involving latent hyperopia, esotropia and non-organic visual loss. (43)
- Radical Retinoscopy (44): use of decreased working distance to enable the reflex to be seen easier in cases of miotic pupils or opaque medii. If the media is clear, the optimum working distance (WD) for retinoscopy is 66cm. A shorter working distance provides a brighter reflex and it is easy to reach the patient yet if the retinoscopist is not exactly at the distance allowed for, by the WD lens or calculation, then the distance error is high. A WD greater than 66cm reduces the risk of distance error but the reflex is dim.(17)

1.4 Assessment of accommodation

Many authoritative texts recognise the importance of accommodation assessment.(45-49) Accommodation can be assessed and quantified in optometric practice using simple techniques and widely available equipment. All tests start with any distance refractive error being corrected.(49)

1.4.1 Indications for an assessment of accommodation

Assessment of accommodation during an optometric examination is especially important:

- when symptoms suggestive of accommodative dysfunction are present e.g. complaints of blur, headaches and/or asthenopia while attempting near work (47),
- if general health or ocular problems associated with accommodative dysfunction are present which include Myasthenia Gravis, anaemia, endocrine disturbances, diabetes, sinus conditions, Graves disease, glaucoma (46, 48, 50),
- if medication is taken for which accommodative dysfunction is a possible side effect, examples being botulinum toxin (51), chloroquine and hydroychloroquine (52), Isotretinoin (for acne)(53), antimuscarinics (54), anticholinergics (for example, the systemic antiarrhythic drug, disopyramide) (55), tricyclic antidepressants (56) and antipsychotics (57),
- for children experiencing reading difficulties (21, 58, 59), and/or dyslexia (21, 60).
- for special populations with a greater chance of accommodative dysfunction e.g. Down's syndrome or cerebral palsy.(23, 61-65) These groups can be helped with the prescribing of plus for near and/or bifocals in some instances (22, 64-67).
- to assist spectacle prescribing i.e. to establish the reading Addition (49) or improve performance, reading abilities and visual comfort. (68)

If the accommodative amplitude is >1.50DS lower than expected for age, or a lag found of >+1.00D in either eye, then accommodative insufficiency should be suspected (45). Rouse et al (69) state that if a lag of accommodation for a child by Monocular Estimation Method (MEM) dynamic retinoscopy is found to be greater than 0.75D then the following conditions need to be ruled-out:

- latent hyperopia,
- ocular or systemic pathology,
- accommodative/convergence imbalance, or
- the side effects of medications.

Daum (47) found that most cases of accommodative dysfunction were of the 'insufficiency' type (84%) whereas Lara et al. (70) found accommodative excess more common than insufficiency. These discrepancies were found as each study used a different population and diagnostic definition. Daum studied a preselected population of patients with severe accommodative dysfunction whereas Lara assessed patients with visual symptoms caused by binocular, refractive and accommodative disorders. The criteria used by Daum for diagnosis of accommodative insufficiency was based simply on the amplitude of accommodation using the push-up technique. Lara et al. measured amplitude of accommodation (using push-up and minus lens methods) and also considered relative accommodation, accommodative facility, dynamic retinoscopy (MEM technique) and binocular vision which may have resulted in cases being classified differently.

1.4.2 Subjective methods of accommodation assessment

Subjective methods of accommodation assessment are suitable for many patients and several techniques are available:

Royal Air Force (RAF) Near Point Rule (71); This is a bar on which is mounted a sliding drum containing test targets. The spectacle amplitude of accommodation can be read directly from the scale(72), since the reciprocal of the near point of focus is the measure of amplitude in Dioptres, and an indication of whether normal for age given. Two methods are available to measure Amplitude of Accommodation using this equipment:

1. Push-up test (47, 73) (50, 74) - this finds the point of blur as the print is moved closer, whereas the
2. Push-back test (45, 49, 67) (71) starts with the target close and finds the point when first clear.(49, 75)

According to Woodhouse (67), young children do not understand the concept of blur and so a push-down method is recommended, whereby a target is first placed close to the child and then slowly moved away and the child is asked to name the letters or targets as soon as they can see them. This technique will slightly under-estimate the amplitude but will provide a

useful subjective measure. Chen and O'Leary (72) also recommend a Push-back test for testing pre-school children and use LEA symbols as targets.

Minus Lens Technique (76, 77); A near vision card with letters is positioned at a viewing distance of 33 cm. Subjects are asked to indicate as soon as they notice the first, sustained blur as minus lenses are introduced. The Amplitude of Accommodation is the amount of additional minus lens power in place when the subject first reports sustained blur , plus an extra 3 D to allow for the target distance (78).

Accommodative Facility: This is a measure of the speed of accommodative change.(79) The accommodative stimulus is alternated between two levels and the examiner counts the number of cycles successfully completed in one minute. Two methods are available of varying accommodative stimulus:

- Lens power changes - plus and minus lenses mounted in a 'flipper', or
- target distance changes.

A problem with Accommodative Facility could be present if the result is less than 8 binocular cycles per minute (using +2.00/-2.00D flippers) when testing binocularly.(79) According to Evans et al. (59), accommodative facility testing is especially relevant if a child has problems changing focus from distance to near and vice versa.

Relative accommodation(45): This is useful to assess when symptoms suggest a problem with accommodation but normal amplitudes are found. Negative Relative Accommodation (NRA) is a measure of plus-to-blur power and Positive Relative Accommodation (PRA) is a measure of minus-to-blur power. Expected findings are +1.50 to +2.50D for NRA and -1.25 to -3.25D for PRA(80).

It can be seen from this brief description of each subjective method of accommodative assessment that these might not apply to patients with learning difficulties.

1.4.3 Dynamic retinoscopy

Dynamic retinoscopy is the only objective method of accommodative assessment available to most practitioners and is important when subjective responses are unavailable or unreliable.(45, 66, 81-84) Autorefractors have been modified to allow measurement of accommodation by Alderson et al.(85) and Davis et al. (86) but these types are not widely available. Leon et al. found that dynamic retinoscopy exhibited higher reproducibility when compared with subjective methods for the measurement of amplitude of accommodation.(76)

Methods of dynamic retinoscopy:

- Monocular Estimation Method (MEM) retinoscopy:

This is a dynamic retinoscopy technique to evaluate the accuracy of the accommodative response and is performed under normal room illumination with an MEM card attached to the retinoscope. The amount of plus or minus needed to neutralise the motion of the reflex is quantified using a trial lens placed for ½ second or less in front of the eye.(87) The fleeting use of lenses is used in order to try to ensure that the accommodation system does not change in response to the added lenses. (88) The reaction time of the accommodative response to a focusing stimulus has an average of 0.37 seconds +/- 0.08.(89) The expected finding for accommodative lag is zero to +0.75D (45, 69) or around +0.50D (66). Tassinari found a mean lag of 0.35D using MEM retinoscopy on pre-presbyopes.(90) MEM showed a greater lag compared with the Nott method in studies by del Pilar Cacho et al.(91) and Garcia & Cacho.(92)

- Modified Nott dynamic retinoscopy:

The retinoscope is held alongside the target and the child encouraged to view the target. If a child is accommodating accurately, the reflex will be neutral. The target is held in place and the practitioner moves away from or towards the child to find neutral – this is the point to which the child is actually accommodating. (67, 81) Accommodative Lag (a measure of the

accuracy of accommodation) can be quantified from the point of neutralisation(45). Antona et al. found this to be the optimum method for assessing accommodation, due to good repeatability when compared with MEM and other methods.(93)

- Assessment of Low and High Neutrals (82):

The Low Neutral is the first point of neutralisation found while the patient views a close target. Further positive power is then used until the reflex becomes "against". The positive power is then reduced until a neutral point is again found; this is the High Neutral. Whitefoot & Charman (94) looked at the low and high neutrals for a sample of normal subjects, aged between 10 and 80 years. A considerable variation in neutral values was found which limits the usefulness of the technique as an indication of abnormality in near responses. Much of this variation appears to be related to individual variation in the level of tonic accommodation and near heterophoria may also have some effect. The accommodative response measured is generally smaller than expected from the stimulus distance due to the depth of focus and accommodative lag.(95)

- Computer retinoscopy:

This is a type of dynamic retinoscopy described by Nielsen(84). The patient views a computer screen and retinoscopy is performed from behind the screen. The retinoscope is moved backwards and the lag of accommodation for the task determined. The degree of lag is an indicator to help ascertain the computer spectacle prescription.

1.5 Qualitative information gained from retinoscopy

As well as providing quantitative data regarding ametropia and accommodation, retinoscopy can also provide qualitative information during an eye examination. Drinan & Gilmour stated that the retinoscope can be used to detect opacities and abnormalities of the ocular media. This study also stated that rare cases of macular staphylomas can be detected using retinoscopy, by the presence of a significantly greater degree of myopia when moving the beam off-axis.(20) Keratoconus (96-98), retinoblastoma (99), retinal detachment (100),

ectopia lentis and lenticonus (101) may also detected by the presence of a distorted reflex or variable retinoscopy end point. Transillumination of the iris may be observed when performing retinoscopy, allowing detection of pigment dispersion syndrome (3) and peripheral iridectomy.(98) Qualitative data from retinoscopy is often enhanced by adjusting the vergence control to obtain the brightest reflex. This is the 'Incident neutral' point, which can also be obtained using neutralising lenses, and provides optimum retro-illumination to view cataract or corneal opacities. (102) The retinoscope can be used to obtain a view of the retina when necessary. The fundus image obtained with the retinoscope at a normal working distance is poorly illuminated and suffers from a small field of view. If, however, a lens corresponding to the refractive error of the patient is positioned in front of the patient and the retinoscope positioned close to this, the fundus view is clear, although poorly illuminated. (103) Indirect ophthalmoscopy can be carried out using a retinoscope and a high powered positive lens. (100) Retinoscopy can also be of use during examination of a contact lens wearer (Chapter 5, section 5.4.2).

1.6 The need for the present study

The author had noticed that some optometrists rely less on retinoscopy and use instead an autorefractor to gain objective refractive data. This equipment may bypass the need for retinoscopy in the majority of patients. When retinoscopy is used, many optometrists do not use the test comprehensively. Instead they may start with an existing ocular prescription in place (from the current spectacle prescription, patient record or following focimetry of existing spectacles) and then objectively assess for any potential change in ametropia.

This prompts the question as to how many optometrists are gradually losing the ability to perform retinoscopy. Such a loss of skill could lead to problems when faced with the occasional patient that cannot be tested using an autorefractor and whose responses to subjective techniques are unreliable. A national survey has been used to answer this question by ascertaining the retinoscopy habits and attitudes amongst qualified optometrists. The results of the questionnaire may be the stimulus for debate regarding the relevance or otherwise of this test in a routine optometric examination and be of interest to manufacturers, individual practitioners and professional bodies. A literature search has

shown that there has been no research published specifically regarding the habits and attitudes towards retinoscopy. (See Table 1.1 for a summary of electronic literature databases searched and the search terms).

Table 1.1. Details of online literature searches conducted in respect of surveys investigating habits and attitudes to retinoscopy, showing search engines, terms used and studies found.

Search engine	Date of online search	Search terms	Studies found
PubMed www.ncbi.nlm.nih.gov/pubmed	27 June 2013	retinoscopy AND optometrist AND survey AND (attitudes OR habits)	Nil
Google scholar http://scholar.google.co.uk	25 July 2013	retinoscopy AND optometrist AND survey AND (attitudes OR habits) NOT 'contact lenses'	215; nil relevant
Cochrane Library (includes Cochrane Database of Systematic Reviews) http://www.thecochranelibrary.com	26 November 2013	retinoscopy AND optometrist AND survey AND (attitudes OR habits)	1; nil relevant
College of Optometrists website http://www.college-optometrists.org/	26 November 2013	retinoscopy AND optometrist AND survey AND (attitudes OR habits)	Nil

Retinoscopy is taught in universities as a core skill and students are able to choose whether to use spot or streak design. Streak retinoscopy seems to be the preferred modality with practitioners at this time based on unpublished sales of bulbs (104) and type of retinoscope used was one of many retinoscopy habits investigated by the questionnaire. All retinoscopes are made of the same fundamental components: light source, condensing lens, mirror, and sleeve. The light source for a streak retinoscope is a halogen bulb with a linear filament, or elongated aperture to the lamp exterior, which projects a fine, linear streak of light. The light source, and therefore the streak, can be rotated 360 degrees by rotating the sleeve of the retinoscope. (105) The circular beam produced by a spot retinoscope is achieved by a compact (non linear) filament or diaphragm over the bulb.(13) The distance between the light source and the mirror is a factor in retinoscopy performance. Dedicated models were optimally designed and took into account the actual position of the light source within the lamp. Combined models are a potential compromise and may not allow for any difference between the light source position for spot and streak bulbs. To ensure the edge of the reflex is as sharp as possible the light source is required to be close to the mirror.(10)

Combined retinoscopes have been widely used over the last 14 years but there has been no published research found on the relative accuracy of these instruments compared with dedicated retinoscopes (See Table 1.2 for a summary of electronic literature databases searched and the search terms used). A major manufacturer of retinoscopes (Keeler UK Ltd) acknowledged that compromises have been made in the design of their 'Combi' retinoscopes, by alteration of the mirror and lens contained within the instrument, in order to achieve combined usage. (104) The author was of the opinion that Keeler's newer combined retinoscopes were easy to use (since the illumination was bright and the retinal reflex clear) but not as accurate as the older dedicated models, especially for the spot type. Several experienced practitioners had reported a preference for using their older dedicated retinoscopes, after purchasing newer combination models. The author had a suspicion that the point of neutralisation was more difficult to accurately ascertain with combined models; that is, the "zone of doubt" may be dioptrically wider. As such, the accuracy of instruments used needed to be established.

Table1.2. Summary of online literature searches conducted regarding combined retinoscopy accuracy showing search engines, terms used and studies found.

Date of online search	Search terms	Search engines used	Matches	Number of relevant studies found
8 August 2009	retinoscopy OR retinoscope AND accuracy OR comparison AND bi-modal OR bimodal OR dual mode OR combi	Google Scholar: http://scholar.google.co.uk	264	Nil
		Cochrane Library (which includes Cochrane Database of Systematic Reviews): http://www.thecochranelibrary.com	2	Nil
		PubMed: www.ncbi.nlm.nih.gov/pubmed	1	Nil
		College of Optometrists website: http://www.college-optometrists.org/	0	Nil

Thus, one purpose of this study was to determine whether there is any difference in accuracy between dedicated retinoscopes and combined models, for both spot and streak designs. A comparison in performance was also made with the practitioners' own/usual instrument to investigate whether increased accuracy existed with the most familiar model.

Research of this type may prove to be useful to optometrists in making appropriate choices about what type of retinoscope to use in practice. This information may be especially important for undergraduate optometrists purchasing retinoscopes for the first time, who do not yet have the skills or experience to be able to make comparisons regarding instrument accuracy. It is important for undergraduate, graduate and newly qualified optometrists to be aware of the characteristics and limitations of various retinoscopes to enable them to make an informed choice of instrument.

The latest combined instruments are easy to use since the illumination is bright and so the retinal reflex clear. Combined models are popular as they reduce manufacturing costs (by making spot and streak instruments exactly the same apart from the bulbs) and are popular with undergraduate optometrists as they give the opportunity to change from spot to streak use without buying a new instrument.(104) This study aimed to meet current needs by providing practice based research comparing the accuracy of different retinoscopes. Optometrists using retinoscopy as part of their eye examination are likely to be interested in the relative accuracy of different types of retinoscope. Analysis of results of this study may influence retinoscope design by manufacturers who are keen to provide the most accurate instruments.

1.7 Research outline and objectives

The study has used questionnaires to ascertain the retinoscopy habits and attitudes of optometrists in the UK and internationally. A pilot clinical trial was used to investigate the accuracy of dedicated and combined retinoscopes. The ’15 Degrees of Freedom (DF) rule’ was applied that can be used as a simple ‘rule of thumb’ to calculate the sample size required to achieve power in a study involving a small number of practitioners and patients. The number of degrees of freedom is the number of values in a statistical analysis that are free to vary.(106) The ’15 DF rule’ offered an opportunity to reach valid conclusions whilst recruiting only small numbers which is optimum for ethical and financial reasons. A secondary objective of the clinical trial was thus to utilise and demonstrate the potential of the ‘15 DF rule’.

1.8 Ethics

Ethical clearance was granted by Aston University's Research Ethics Committee which ensured that the study conformed to the tenets of the Declaration of Helsinki. Data storage conformed to the Data Protection Act 1998. Advice regarding ethics, consent and handling personal data was also obtained from the International Epidemiological Association.(107) Research Ethics application forms, study rationale and methodology, participant's information sheets, consent form, invites to participate and ethical approval notification have been included in Appendices 3-11.

1.9 Summary

The author, through working in different settings and discussions with peers, suspected that there had been a change of retinoscopy habits amongst optometrists and reduced accuracy of newer combined retinoscopes compared to older dedicated types.

This study represents original research as it provided the first a survey of retinoscopy habits and attitudes and the first clinical trial investigating the accuracy of dedicated versus combined retinoscopes.

The design of the UK questionnaire and overview of the findings is described in Chapter 2. Chapter 3 shows analysis of the survey results. Chapter 4 described the clinical trial and Chapter 5 details the international retinoscopy survey. Conclusions for the whole study are drawn in Chapter 6.

2.0 Survey of habits and attitudes to retinoscopy by optometrists in the UK; design & descriptive overview of the results

2.1 Introduction

Literature shows that retinoscopy is a potentially useful tool for assessment of refractive error and accommodation (see Chapter 1). The author, through working in different settings and discussions with peers, suspected that there had been a change of habits and attitudes to retinoscopy amongst some practitioners.

The purpose of this survey was, therefore, to:

1. To determine whether habits and attitudes to retinoscopy are influenced by date of qualification, the type and location of optometry practice, university attended, ethnic background and workload;
2. To investigate retinoscopy habits in terms of (1) how often retinoscopy is used, (2) whether retinoscopy is the primary method of objective refraction, (3) whether spectacles are prescribed based on static retinoscopy alone (4) whether dynamic retinoscopy is used (5) whether combination type is used (6) who is the manufacturer of retinoscope used and (7) what type of retinoscope is used (spot or streak, combined or dedicated);
3. To investigate attitudes to retinoscopy in terms of (1) whether it is considered important, (2) whether it is considered a useful aid in the detection of keratoconus, and cataract (3), satisfaction with retinoscope used (4) and (5) perceived accuracy of combined retinoscopes.

Here, habits were considered as routine clinical behavior, whereas attitudes were opinions.

2.2 Methods

2.2.1 Survey Design

The survey used in this study was designed and pilot tested in collaboration with the Suffolk Local Optical Committee. It was piloted with five Optometrists from this group to ensure that it was (i) easily understood, (ii) clinically relevant and (iii) brief enough. These aspects are known to promote maximum response rates.(108, 109) The piloting process facilitated the survey construction but fell short of validation which is a complex process. Validation aims to ensure the survey accurately measures what it aims to do and reduces bias by detecting ambiguities and misinterpretations which can be minimised. A validation procedure involves comparing the instrument against the available gold standard and other sources of data and also examines reliability.(106, 110) Several items were modified as a result of the pilot which made the questions more easily understood; details are summarised in Appendix 12. The pilot also provided evidence of interest in the outcome of the UK survey. To further encourage a good response rate, a draw prize provided by Keeler UK Ltd (of a retinoscope, direct ophthalmoscope and charger) was made available to all participants. The multiple choice survey included 23 items (Appendix 13) and was designed so that it took no more than 20 minutes to complete. Questions were asked to establish sample demographics; these are independent variables of date of qualification, ethnicity, practice type and location, university attended and workload. Other questions were asked to investigate habits and attitudes (dependent variables) and other potentially interesting points.

The demographic questions that related to practice type, geographical location and date of qualification were chosen to coincide with those asked on a previous College of Optometrists survey. (111) The question that asked about ethnicity was modeled on the College of Optometrists application form and requested in an initial attempt to ascertain whether the respondents were representative of the population as a whole. The university attended was asked to investigate for any influence of the training institution. It could be hypothesised that the university attended is the source of optometrists' initial habits and attitudes and so this needed to be considered as a possible influencing factor. All UK universities offering optometry degrees were included and 'other' offered as an option in case training was

received elsewhere, for example, from outside the UK. The percentage of eye examinations in which retinoscopy is used was asked to investigate whether frequency of retinoscopy use was influenced by date of qualification, practice type or any other independent variables. If habits were changing then more recently qualified optometrists might be expected to use retinoscopy less frequently than 'experienced' optometrists. One could hypothesise those optometrists in multiple type practices are under more time restraints which could be reflected by less retinoscopy use. The number of eye examinations carried out each week was asked to investigate for any link between workload and retinoscopy or autorefractor use.

A question was asked regarding whether optometrists prescribe spectacles in some cases using the retinoscopy result only. This question was asked to ascertain whether objective prescribing habits was influenced by any of the independent variables and to investigate a specific clinical scenario. One could hypothesise that the newer combined retinoscopes were used more by the 'recently qualified' optometrists. It could be expected that satisfaction with retinoscopy is greater for more experienced optometrists, as well as the finding retinoscopy useful in detection of cataract and keratoconus. One could hypothesise that dynamic retinoscopy was used more by 'recently qualified' optometrists, since they are more recently trained, or those working in hospital, since they are more likely to see patients with learning difficulties? Questions were asked to investigate whether optometrists were dissatisfied with a recently purchased retinoscope, since the author had been dissatisfied with Keeler combined retinoscopes. A further open ended question was asked that invited comments regarding retinoscopy. The responses were contextualised and separated into similar groups.

Other recent practitioner surveys have used between 8 and 38 items.(111-118) These previous studies have investigated optometrist habits and attitudes in respect of dry eye management(112), recall intervals for eye examinations(113), low vision training methods(115), rigid gas permeable contact lenses(117), domiciliary visual fields(114) and glaucoma tests(116). None of these surveys investigated retinoscopy habits and attitudes, apart from a College of Optometrists survey which had one question that included retinoscopy as an available test. (111)

2.2.2 Factors that influenced Survey Design; methods and response rates from practitioner surveys

It is important to get an adequate response rate from any survey otherwise it is unlikely to be representative of the group or profession as a whole. According to O'Leary & Evans(108), in order to achieve a good response rate a questionnaire must be designed to be easy to understand and quick to complete. Indeed, when O'Leary & Evans were investigating optometric prescribing habits they used only five questions (with each in two parts) where as Alwitry et al. (119)and Turner et al. (112) asked eight questions (each with several sub-sections). A survey of recall intervals specified following eye examinations carried out by Warburton et al. (113) asked 26 questions in a questionnaire to 189 individual optometrists and had a response rate of 65%. The highest response rate found in a literature search was 94% for an eight item survey of eye practitioners' attitudes towards diagnostic tests and therapies for dry eye disease by Turner et al.(112). A high response rate (86%) was also achieved by Tan et al.(120) who conducted a survey with three questions only, each with several parts, on the knowledge (in respect of visual experience during cataract surgery) of optometry students in Singapore.

The lowest percentage of respondents found in a review of optometric surveys was by Kammer et al. (115) who conducted a survey of optometric low vision rehabilitation training methods for the moderately visually impaired. Questionnaires, consisting of 18 items, were sent to 2028 optometrists and only 136 practitioners responded (7%). The response was low since only practitioners with a special interest in low vision were likely to complete the questionnaire. It can be seen that there are multiple factors that influence response rates. The number of questions is one factor but it seems that the number of practitioners in a particular specialty is another. A questionnaire should be designed with clear instructions, incentives offered, piloted prior to distribution and analysed properly. Edwards et al.(109) recommended electronic distribution of surveys and agreed that incentives should be offered and the document kept short to increase response. Recent practitioner surveys are more likely to be electronic (web based or email).

Research funded by The American Optometric Association and carried out by Silverman et al.(121) found a lower response rate from qualified optometrists as compared with optometry students, when asked about opinions regarding the future of optometric practice. A questionnaire was sent to 5,016 American optometrists with 786 replies (16%) and 811 surveys to students with 376 (46%) replies. The paper did not comment on why the response rate was different for student and qualified optometrists. The author believed the reason may have been associated with time availability for the qualified optometrists.
A large scale survey was conducted into Referrals and notifications by British optometrists (122). Questionnaires were sent to 5381 optometrists and 1031 returned the survey (19%). The authors commented that those who chose to take part constituted a self-selected group and, as such, inferences from the results could not be made concerning the whole profession. The demographics of the respondents were not ascertained in this research but other authors of surveys have considered this. For example, Turner(112) commented that the respondents were "evenly distributed in experience" and Needle et al. (123) ascertained personal and demographic information and commented that respondents were broadly representative of UK optometrists as a whole in terms of age, gender and geographical location.

A survey of the scope of therapeutic practice by UK optometrists and their attitudes to an extended prescribing role (123) consisted of 30 questions divided into five sections. Registered optometrists across the UK were recruited by sending an email message to 5284 members of The College of Optometrists inviting them to participate in the electronic survey and including a hypertext link to the survey homepage. Responses were received from 1288 practitioners (response rate 24%). In an attempt to improve the response rate two reminder messages were sent by email after 2 and 4 weeks.

Key design factors in the previous studies discussed have informed the development of this study. This retinoscopy study was not aimed at a specific specialty of optometrist and involved a technique that is taught to all optometrists. The questionnaire was sent only to qualified optometrists and was thus designed, with the help of testing on a group of practitioners, to be quick to complete. In an attempt to ensure a good response rate the survey was sent electronically, incentives were offered and reminders sent.

2.2.3 Previous optometric surveys considering retinoscopy

A large scale Clinical Practice Survey was carried out on behalf of The College of Optometrists (111). By post and email 9259 questionnaires were distributed and 2751 completed, which represents a response rate of 30%. This survey asked 20 questions regarding a wide range of optometric aspects and one question included retinoscopy. This asked which tests would be conducted on an asymptomatic pre-school child and with what frequency, from a list of ten clinical tests. This ascertained that retinoscopy would be performed "Always" on this type of patient by 92% of practitioners.

2.2.4 Survey distribution

One thousand UK members of the College of Optometrists were invited, via email, to participate in the survey that was delivered using SurveyMonkey questionnaire software (www.surveymonkey.com). One thousand questionnaires were distributed as this was a practical number agreed with the College who randomly selected the optometrists that were involved. The survey was distributed in March 2010 with a reply requested within four weeks. A reminder was sent by email after two weeks to the same 1000 practitioners. The invite to participate explained that (1) the aim of the survey was to determine the retinoscopy habits of qualified UK Optometrists, (2) to ascertain whether Optometrists felt that retinoscopy was an important test and (3) the survey results were to be published and may be the stimulus for debate regarding the relevance or otherwise of this test in a routine Optometric examination.

SurveyMonkey is a commercial, US based provider of online surveys that had been used in another recent optometrist survey by Needle et al.(123)

2.2.5 Demographics of respondents

The survey findings were prone to selection bias as responses were not received from all of the 1000 invites sent. It is possible that this cohort could have habits and attitudes that differ from the profession as a whole. A further source of potential bias was that reported practice may not reflect actual clinical practice. (124) An alternative approach to ascertain retinoscopy

habits could have been the use of Standardised Patients.(124, 125) This was prohibitively expensive and would have involved sending participating patients to participating optometrists' practices to ascertain retinoscopy clinical use.. A retrospective study of patient records was not pursued as a method of investigation since the author had noticed considerable variation among optometrists in the recording of retinoscopy results. This is in agreement with Millodot & O'Leary(126) who also chose not to obtain data from a large survey of clinical records, when comparing retinoscopy with subjective data, due to an observed inconsistency in the recording of this information by optometrists.

The College of Optometrists (College) and The General Optical Council (GOC) membership databases did not have suitable data for comparison at the time of analysis in respect of date of qualification, ethnicity, location and type of practice or university attended. These organizations are now starting to collect further demographic data which will be available in the future. (127-131) Therefore, it is not possible to say whether the profile of respondents was representative of the UK as a whole based on the characteristics presented. Online literature searches did not reveal any previous research indicating that ethnicity, location of work, workload or gender effected optometric clinical performance (Table 2.1)

Table 2.1. Details of online literature searches conducted in respect of possible of influence of locality of place of work, workload, gender and ethnicity of practitioner on clinical performance and search terms used.

Subject	Date of online search	Search terms	Matches	Relevant studies
Locality of work place	12 August 2013	optometrist, optometry, practice, location, geography, geographical	PubMed 47, Google Scholar 201, OiP 26, OPO 3	Kegel-Flom (1976)(132); Rural optometrists less stressed but performing similarly. Carnt et al.(2011)(133); location a predictor of the volume contact lens work and personality of the optometrist.
Workload (numbers of eye examinations carried out)	12 August 2013	optometrist, optometry, workload, eye examinations, performance	PubMed 23, Google Scholar 84, OiP 9, OPO 34	Long et al.(2011)(134); greater number eye examinations per day associated with increased risk of work related discomfort; Long (2012)(135), high and/or complex patient loads causes mental fatigue; Long et al (2013) (136), High workload demands causes stress.
Gender	6 January 2013	optometrist, optometry, gender, performance, accuracy	PubMed 23, Google Scholar 3, OiP 0, OPO 116	Prajapati et al.(2011)(137); Gender does not affect performance of optometry undergraduates
Ethnicity	12 August 2013	"optometrist" OR "optometry" AND "asian" NOT "asian patient" NOT "asian referral"	PubMed 107, Google Scholar 0, OiP 9, OPO 0	Kegel-Flom (1990)(138); 'verbal ability' relevant to undergraduate optometry performance
Search engines used: PubMed (www.ncbi.nlm.nih.gov/pubmed), Google Scholar (http://scholar.google.co.uk) , Optometry in Practice (OiP) & Ophthalmic and Physiological Optics (OPO) (via The College of Optometrists website http://www.college-optometrists.org/)				

Decision tree statistical analysis (DTA) was used (in chapter 3) and investigated whether each demographic factor, acting on its own, influences each outcome. The distribution of demographic factors relative to each other is immaterial and whether the population that responded to the survey is representative as a whole may not be an issue.

2.3 Results

Responses were received from 298 optometrists (response rate 30%) with representation from each geographical area of the country, type of practice and university attended. The responses represented 2.6% of the total population since the number of optometrists at that time was 11,559.(139) Retrospective use of an online calculator determined that a sample

size of 571 was required to achieve results that reflected the target population adequately, assuming a Confidence Level of 95% and Confidence Interval of 4. (140) The cohort for each of the potential influencing factors is shown in Table 2.2 and all raw data has been included in Appendix 14. Figures 2.1 to 2.22 show the results to each question.

Table 2.2. Distribution of potential influencing factors.

Nature of question	Alternatives responses	Answers	
		Percentage	Count
When qualified ('age')	Before 1965	0.0	0
	1965-1979	1.4	4
	1980-1994,	45.9	136
	1995-2010	52.7	156
	Skipped the question	0.7	2
Ethnic background	White	67.5	195
	Mixed	0.7	2
	Asian or Asian British	28.7	83
	Black or Black British	0.7	2
	Chinese	2.1	6
	Other ethnic group	0.3	1
	Skipped the question	3.0	9
Practice location	England – Eastern	4.4	13
	England – East Midlands	6.4	19
	England – London Boroughs	13.9	41
	England – North East	4.7	14
	England – North West	11.1	33
	England – South East	16.2	48
	England – South West	8.8	26
	England – West Midlands	9.8	29
	England – Yorkshire and Humber	6.4	19
	Northern Ireland	3.7	11
	Scotland	12.5	37
	Wales	2.0	6
	Skipped the question	0.7	2
Practice type	Community practice – independent (< 3 practices)	36.9	109
	Community practice – joint venture/multiple	37.3	110
	Community practice – locum	16.3	48
	Hospital	6.8	20
	Academic/research	2.0	6
	Training education	0.7	2
	Management	0.0	0
	Skipped the question	1.0	3
University attended	City	18.2	54
	Manchester	9.5	28
	Cardiff	9.8	29
	Glasgow	12.8	38
	Aston	26.7	79
	Anglia Ruskin	4.7	14
	Bradford	13.5	40
	Ulster	3.4	10
	Other	1.4	4
	Skipped the question	0.7	2
Workload (Number of eye exams. per week)	0 - 20	9.1	27
	21 - 40	23.6	70
	41 - 60	28.4	84
	61 – 80	26.7	79
	81 or more	12.2	36
	Skipped the question	0.7	2

Figure 2.1. Percentage of respondents for various dates of qualification.

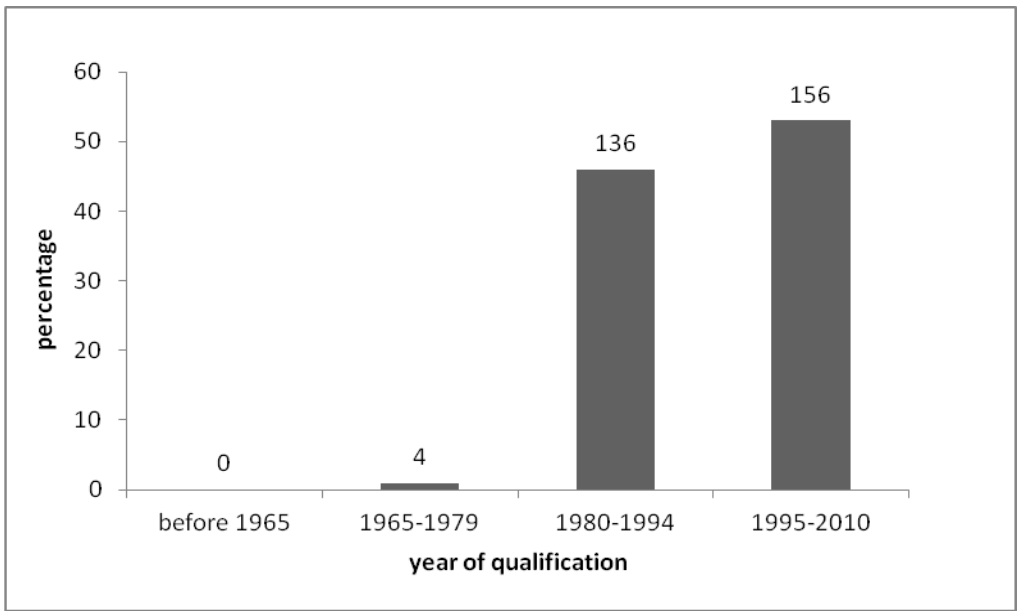


Figure 2.2. Percentage of respondents from each ethnic group.

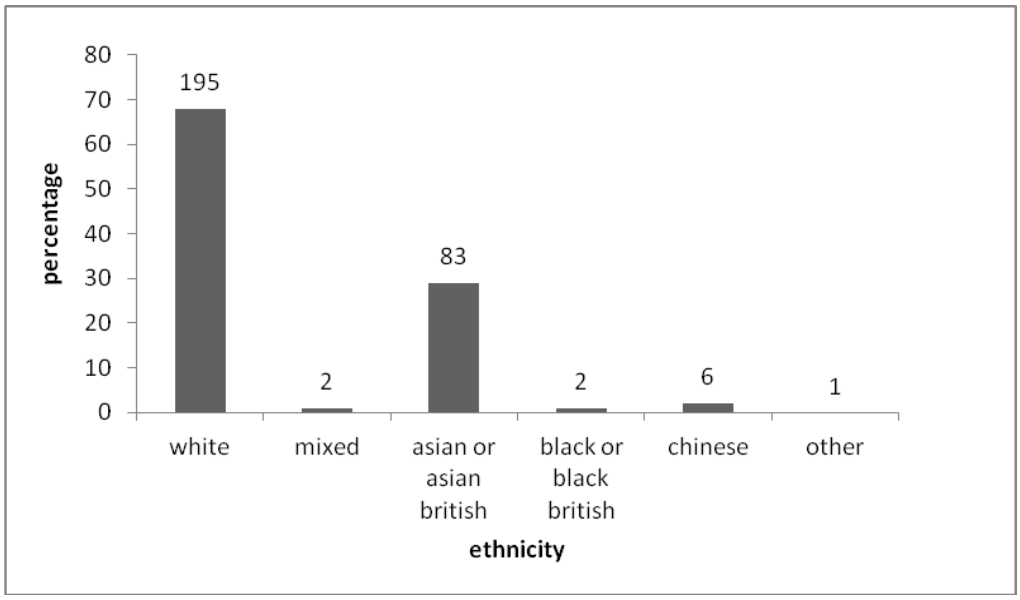


Figure 2.3. Percentage of respondents from each geographical area of the UK.

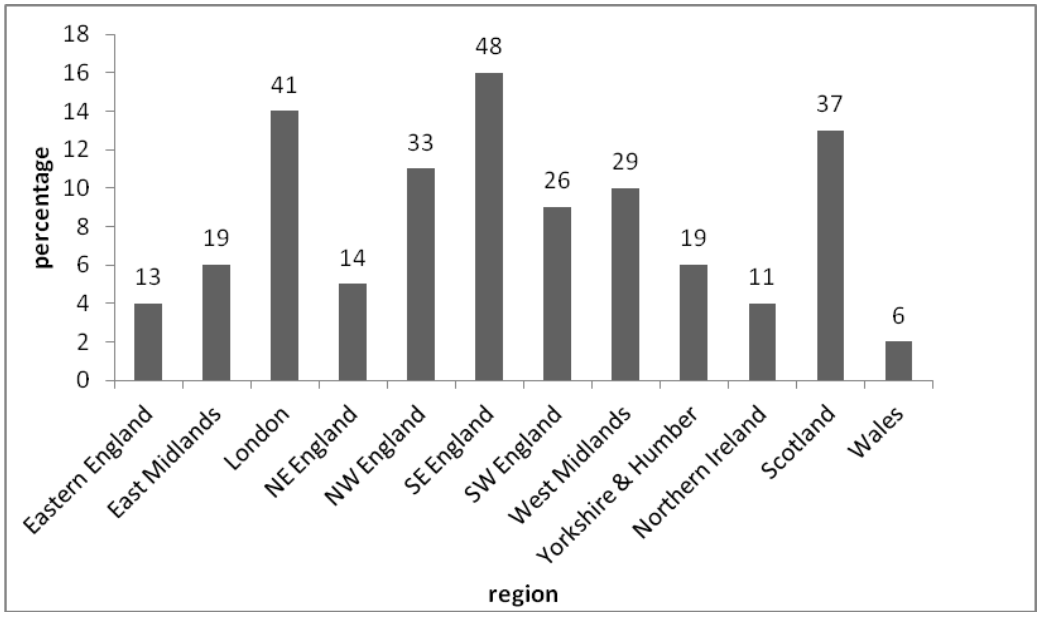


Figure 2.4. Percentage of respondents from different types of optometry practice.

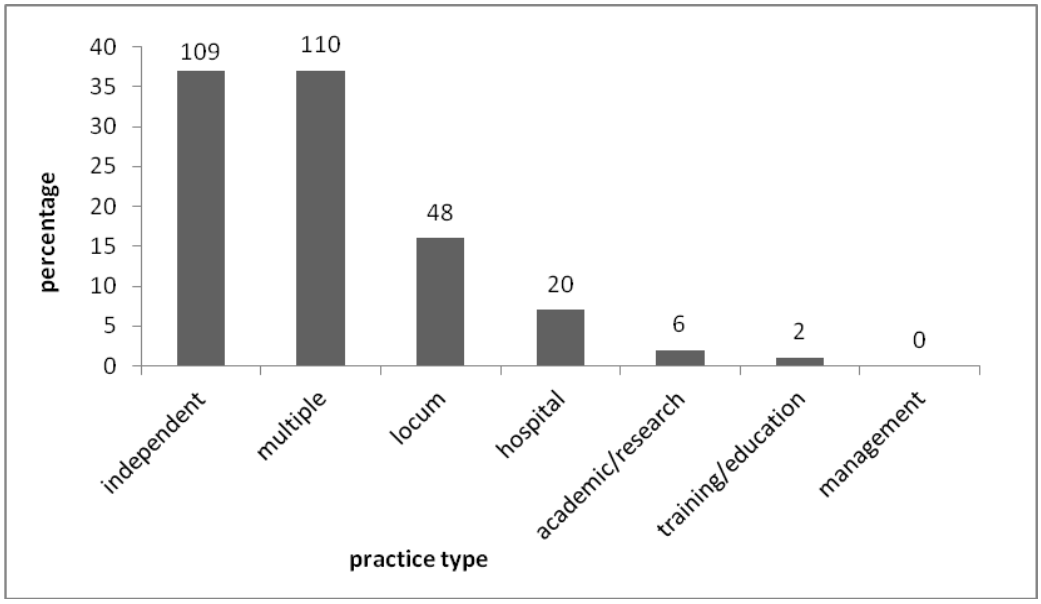


Figure 2.5. Percentage of respondents who graduated from each university.

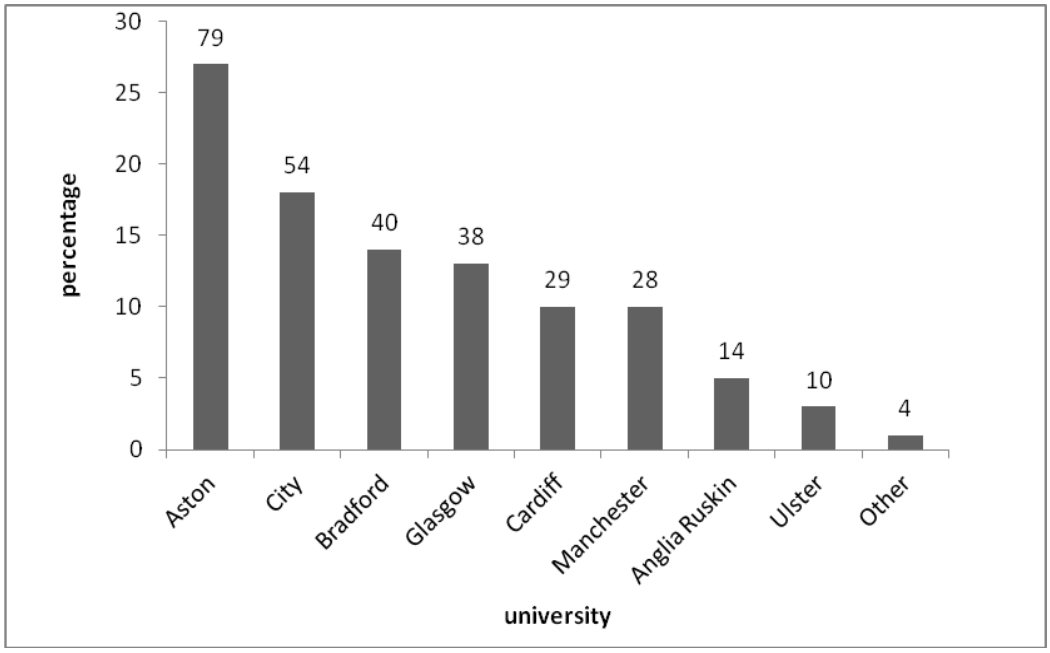


Figure 2.6. The percentage of respondents with different typical workloads.

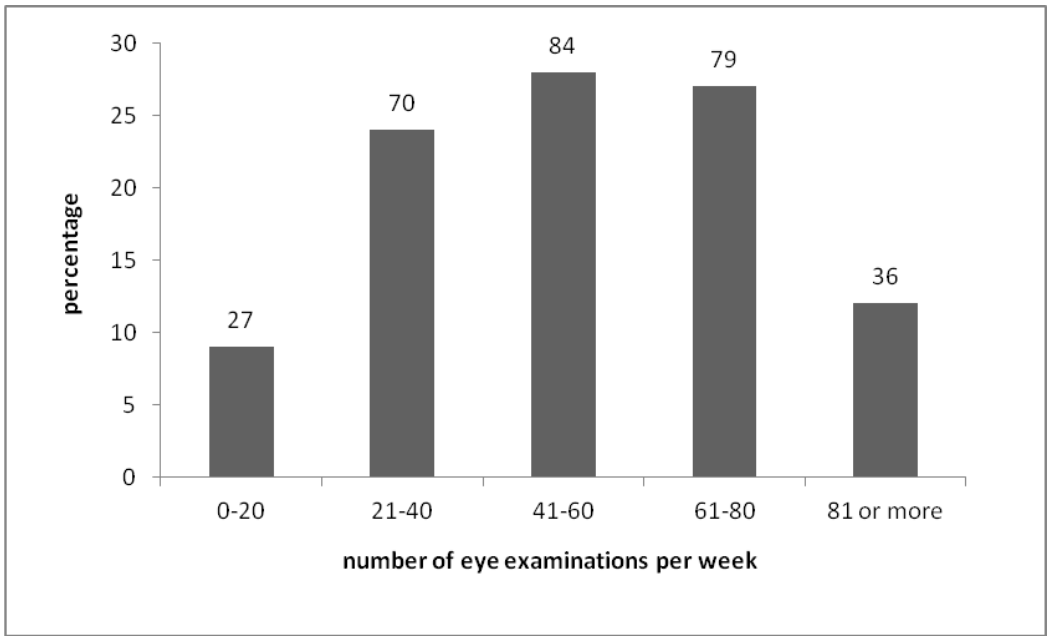
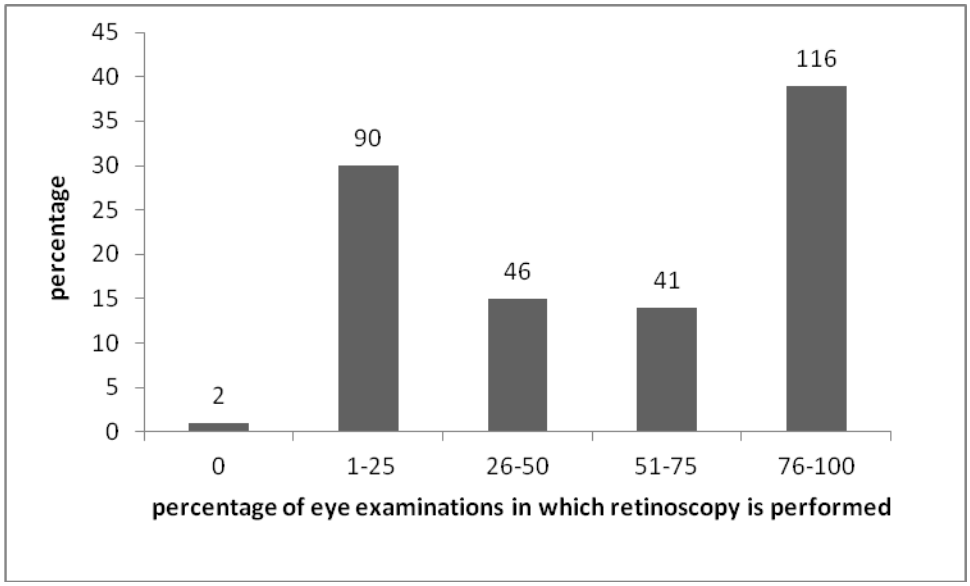
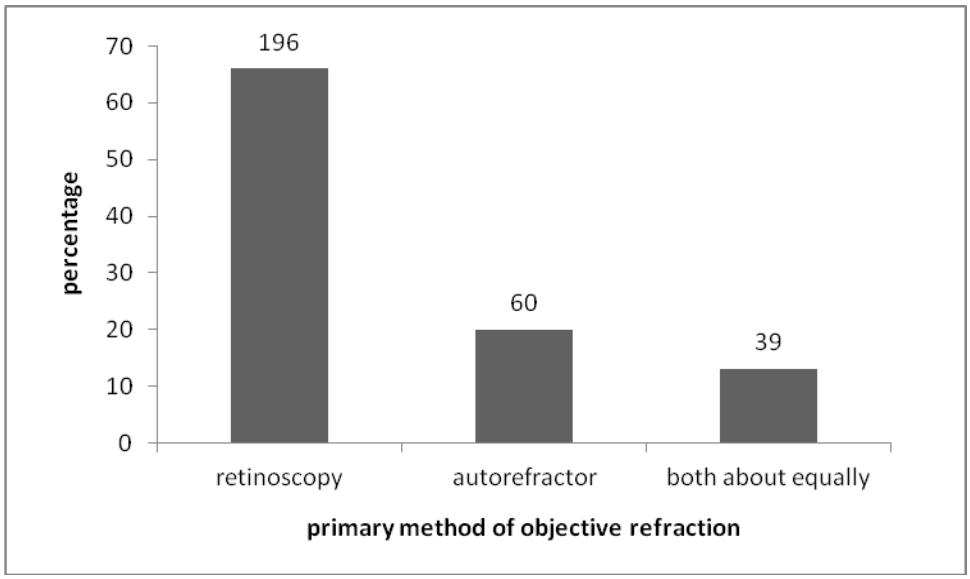


Figure 2.7. Percentage of eye examinations in which retinoscopy was performed.



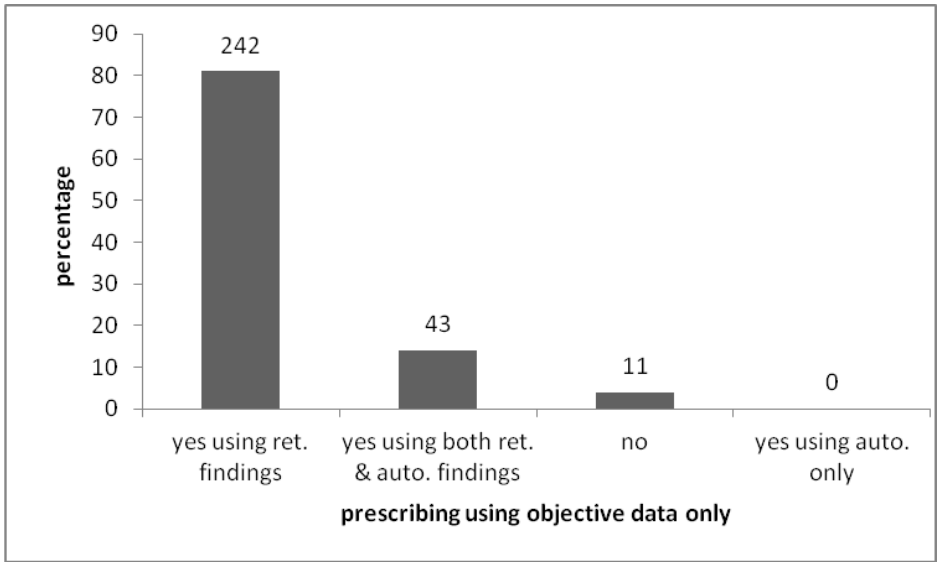
A third (31%) of optometrists use retinoscopy in 25% or less of their eye examinations. Retinoscopy was used in more than 50% of eye examinations by 53% of optometrists.

Figure 2.8. Percentage of respondents indicating that retinoscopy, use of an autorefractor or both was the primary method of objective refraction.



The majority of optometrists (66%) used retinoscopy as their main method of objective refraction.

Figure 2.9. Percentage of respondents indicating that spectacles were prescribed using retinoscopy findings alone, using both retinoscopy or autorefractor findings, using autorefractor findings alone or who never prescribed spectacles on objective refraction alone (ret = retinoscopy, auto = autorefractor)



The majority of optometrists (81%) prescribe spectacles in some cases using the retinoscopy result only. No practitioners prescribe using the autorefraction result only.

Figure 2.10. Percentage of optometrists using spot or steak retinoscopes. (ret = retinoscope)

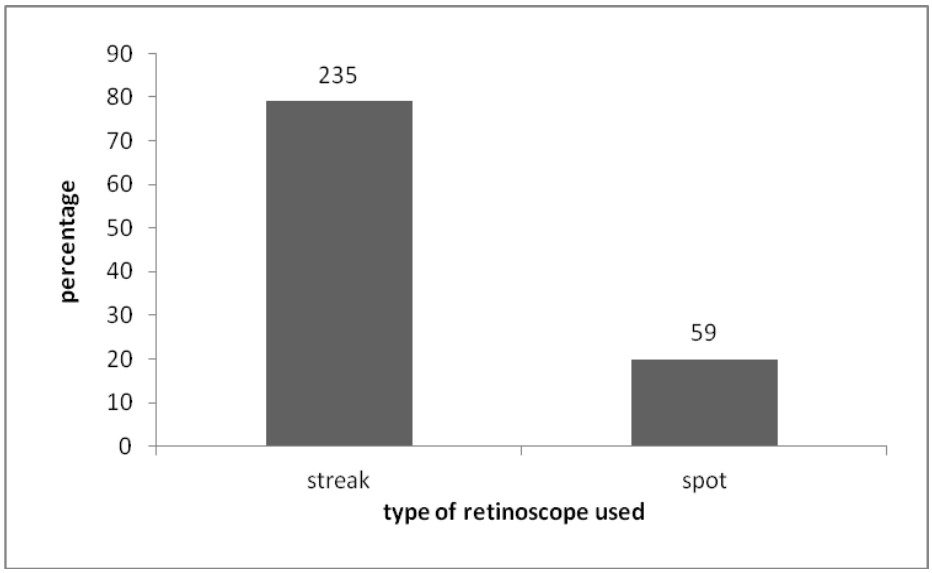


Figure 2.11. Percentage of optometrists using combined or dedicated retinoscopes.

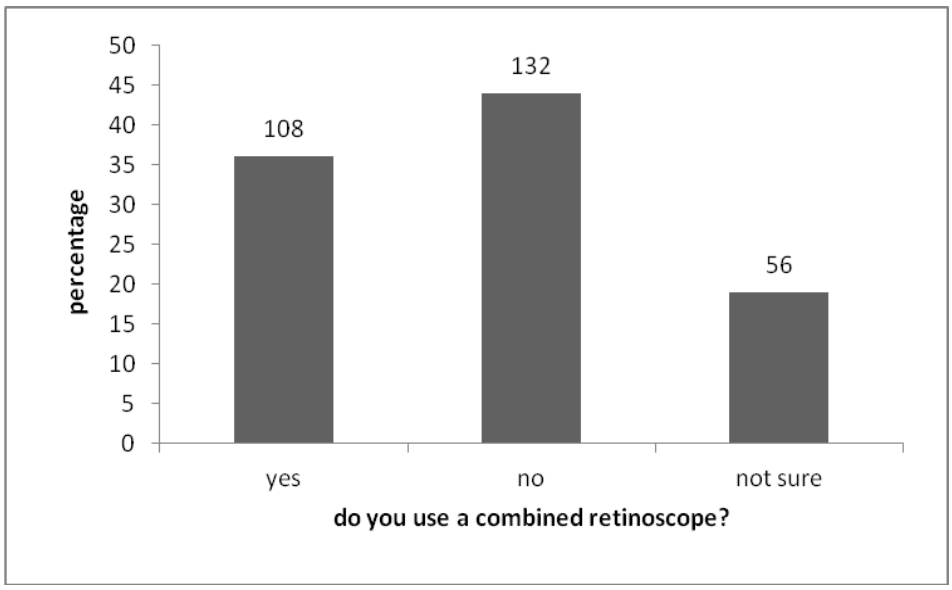


Figure 2.12. Percentage of optometrists using retinoscopes made by different manufacturers.

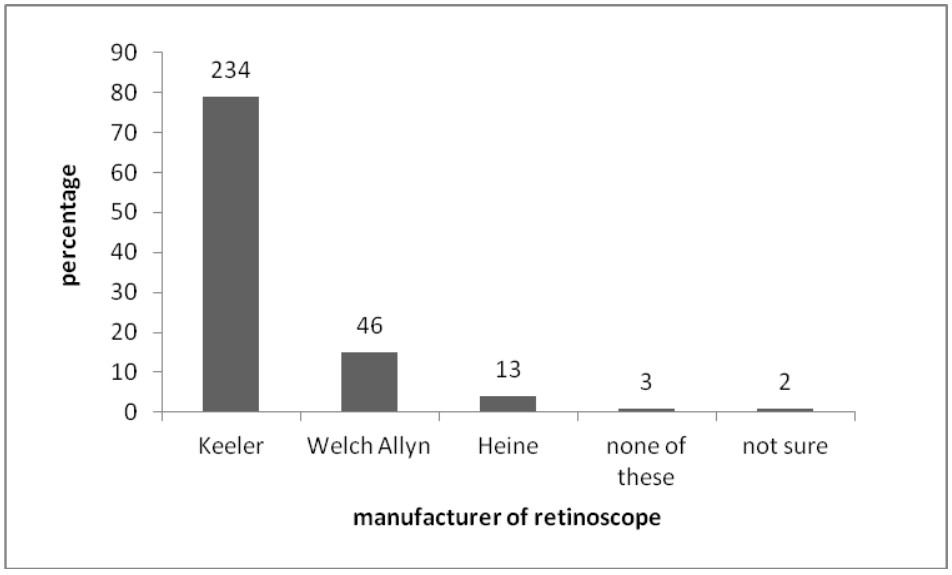


Figure 2.13. Percentage of optometrists using retinoscopes of differing ages.

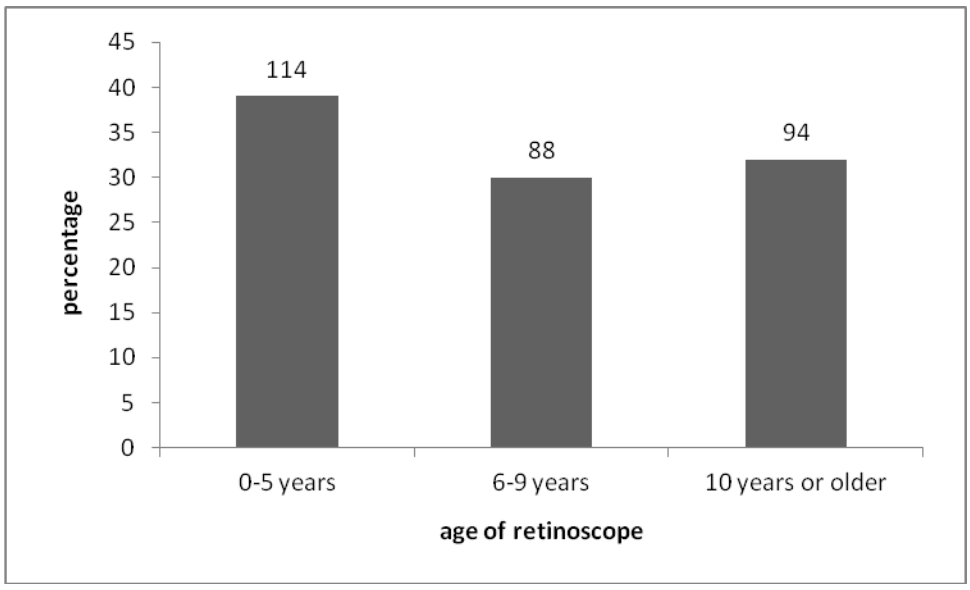


Figure 2.14. Percentage of optometrists sharing various levels of satisfaction with their own retinoscope.

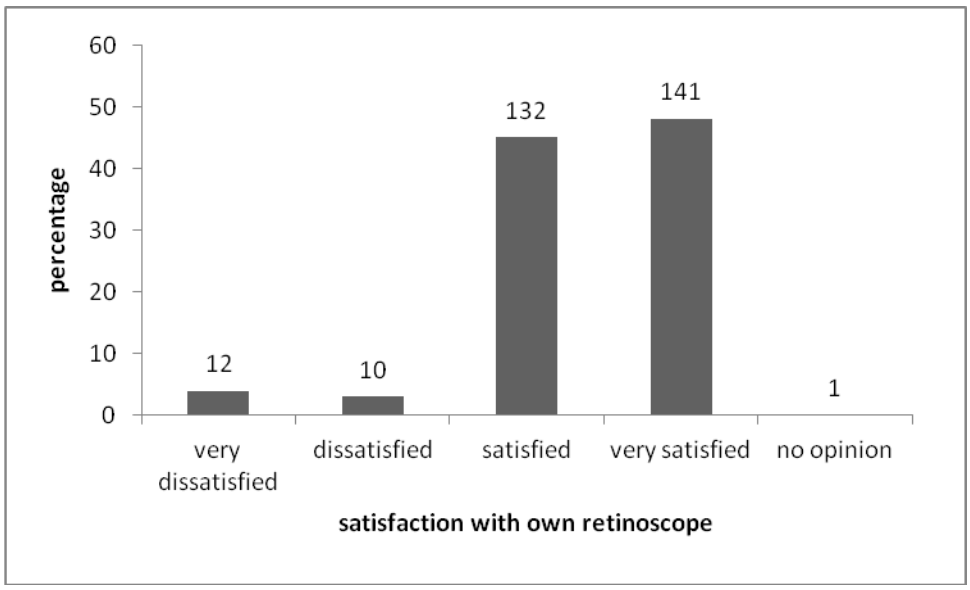


Figure 2.15. Percentage of optometrists with various levels of agreement as to whether combined retinoscopes are as accurate as dedicated models.

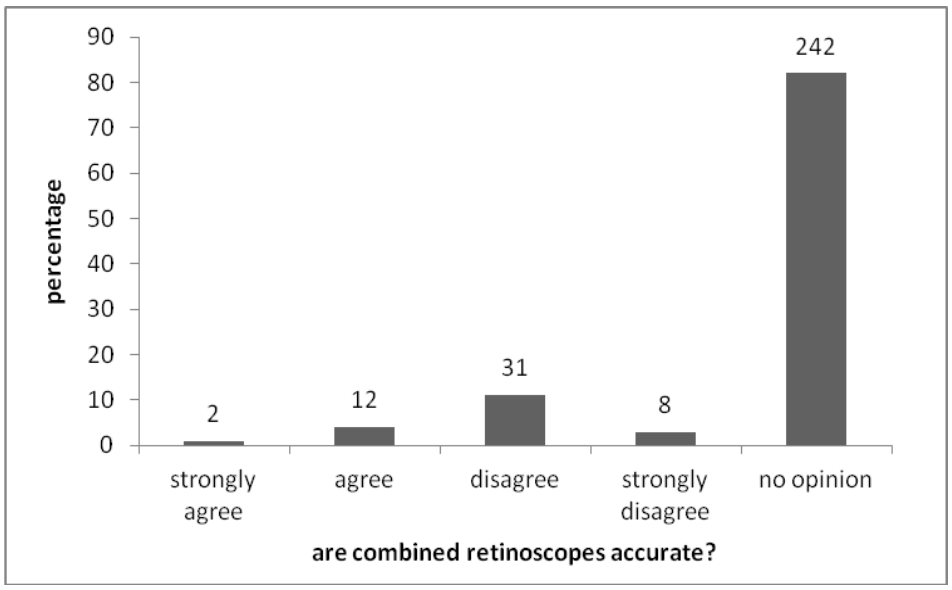


Figure 2.16. Percentage of optometrists with various levels of agreement to the statement that retinoscopy is NOT an important aspect of an optometric examination.

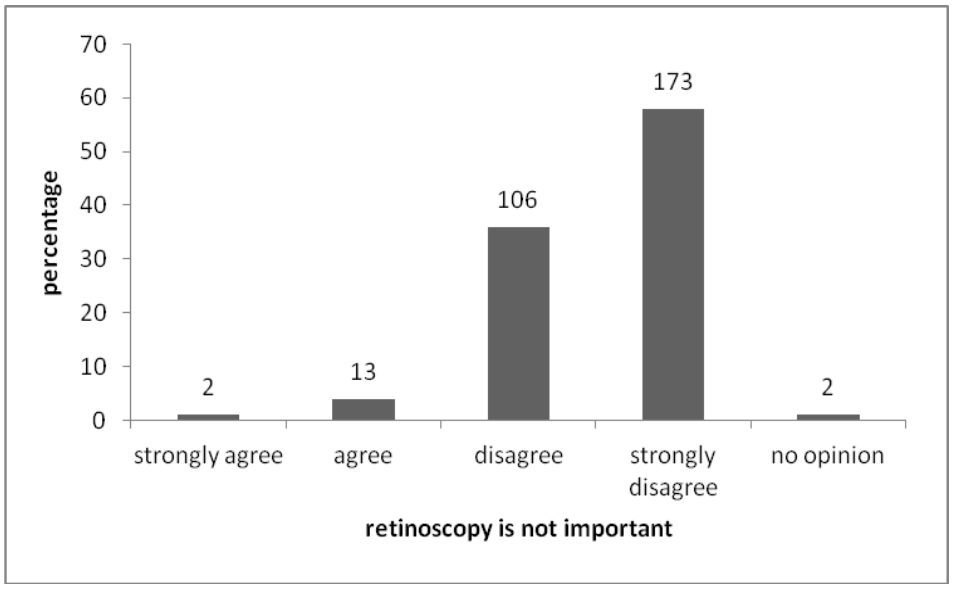


Figure 2.17. Percentage of optometrists with various levels of agreement to the statement that retinoscopy is useful in the detection of keratoconus.

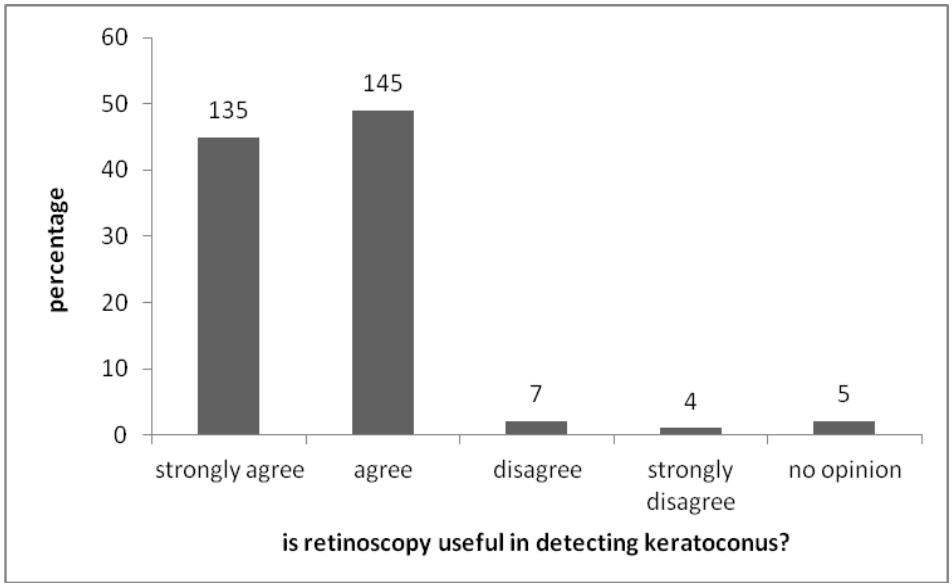


Figure 2.18. Percentage of optometrists with various levels of agreement to the statement that it is preferable to use a starting point lens when initiating retinoscopy.

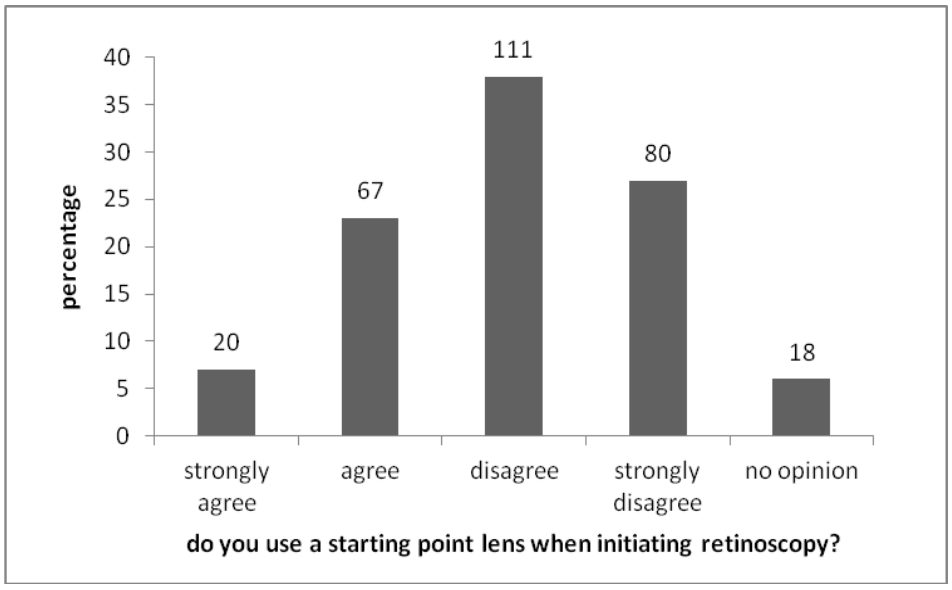


Figure 2.19. Percentage of optometrists with various levels of agreement to the statement that retinoscopy is NOT useful in the detection of crystalline lens changes or opacities.

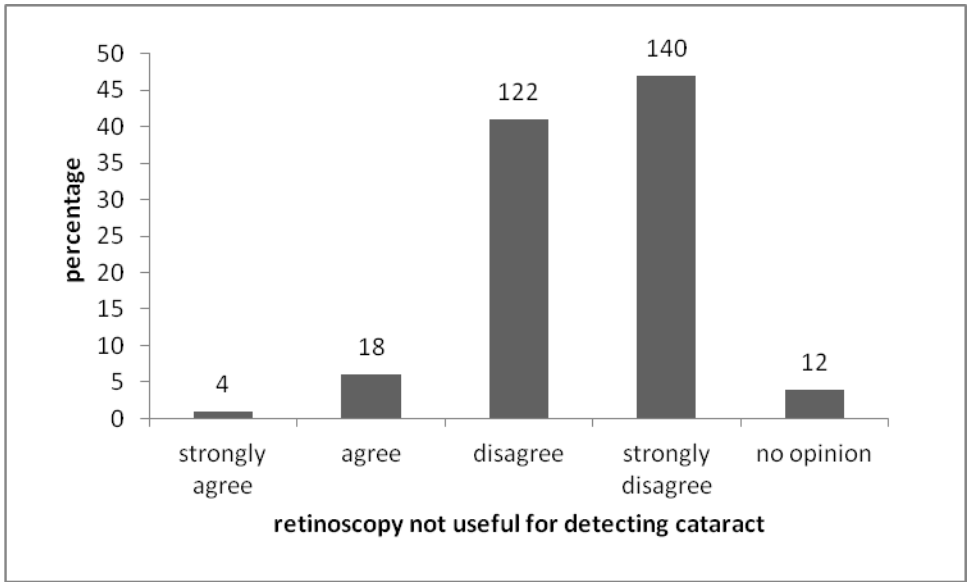
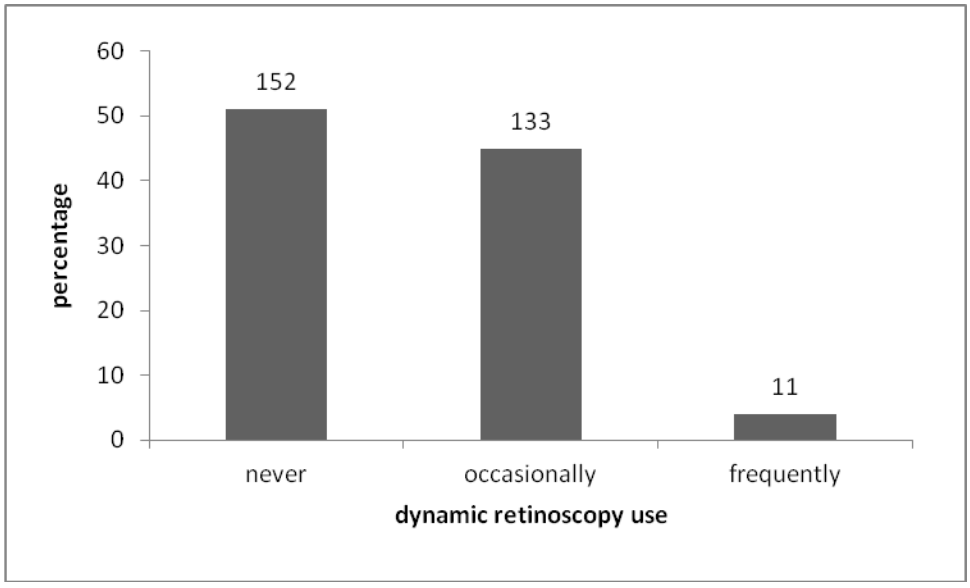


Figure 2.20. Percentage of the frequency with which dynamic retinoscopy is used.



Less than half of the respondents (49%) reported using dynamic retinoscopy.

Figure 2.21. Percentage of optometrists who prefer an older model of retinoscope.

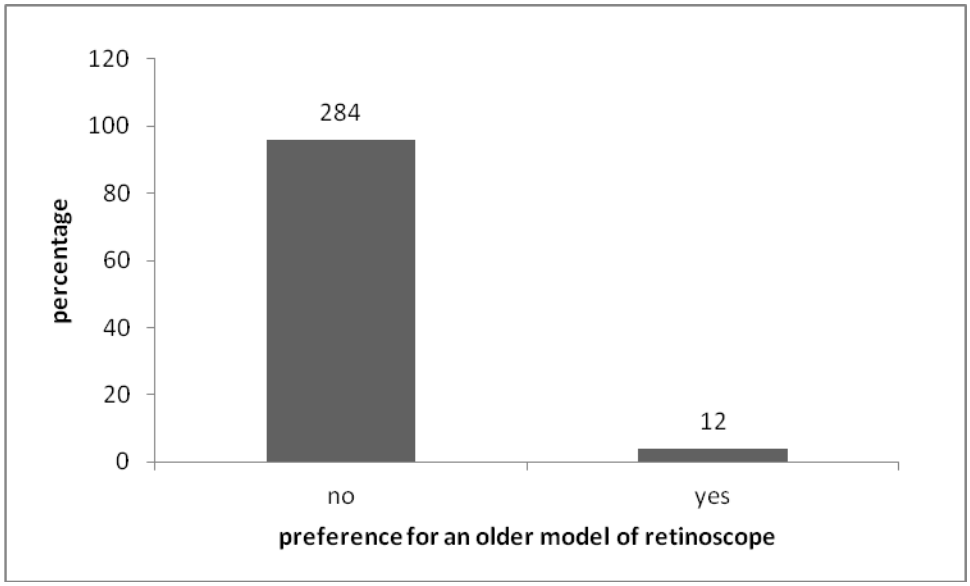
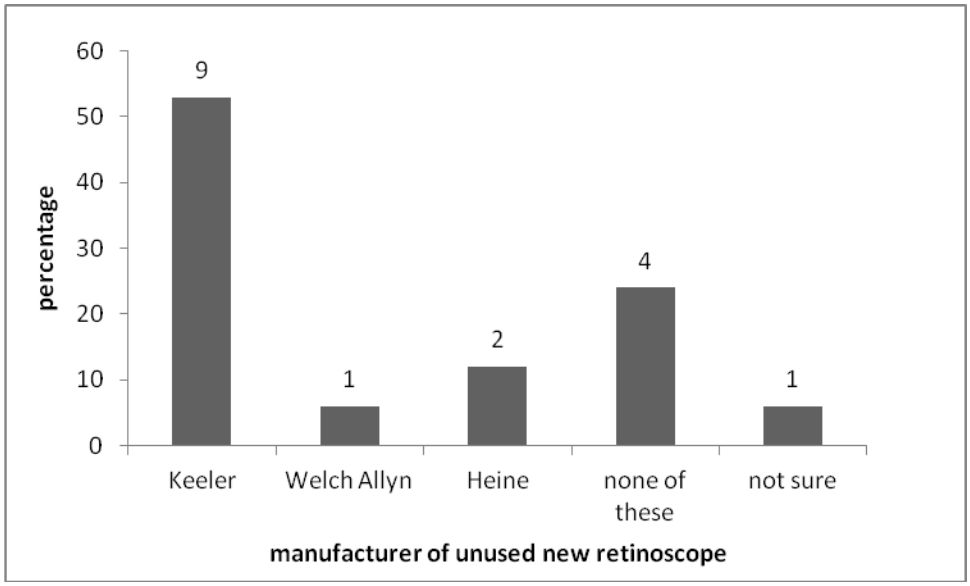


Figure 2.22. Percentage of optometrists who own an unused retinoscope, split by the manufacturer of that retinoscope.



The results showed that the vast majority of respondents reported that they had (1) prescribed spectacles from retinoscopy alone, (2) considered retinoscopy to be important, (3) found retinoscopy useful for detecting keratoconus or cataract, and (4) are satisfied with their own retinoscope.

Appendix 15 and Table 2.3 shows full details and author's interpretation respectively of the comments received from the final survey item. These will likely be of particular interest to manufacturers of retinoscopes. Comments were received from 110 of the 298 survey respondents (37%). As performed by Turner et al. (112), qualitative data collected from the open question section of the survey were decontextualized in a content analysis and presented in thematic categories. This involved breaking down written comments into specific points and grouping them with similar statements from other individual responses. Computer software is available to contextualise comments (written text) into similar groups. (141) In this case the responses were interpreted into broad categories by the author. The comments were believed by the author to be too varied and optometric specific for computer differentiation.

Table 2.3. Author's interpretation of the comments received from the final survey item.

Comments	Count	Percentage
Positive regarding retinoscopy	86	78
Negative regarding retinoscopy	2	2
Relating to multiple type practice	1	1
Relating to retinoscope manufacturers	8	7
General point	13	12
Total	110	100

2.4 Conclusion

Survey distribution and data collection using SurveyMonkey questionnaire software (www.surveymonkey.com) was found to be efficient and cost effective.

An overview of the survey results has been presented in this chapter and showed an overview of retinoscopy use in the UK. The next chapter presents an in depth a statistical analysis of the factors influencing habits and attitudes to retinoscopy.

2.5 Key points

- A survey was sent to 1000 optometrists to explore trends in habits and attitudes to retinoscopy.
- Responses were received from 298 optometrists (response rate 30%).
- A third (31%) of optometrists use retinoscopy in 25% or less of their eye examinations.
- The vast majority of respondents reported that they had (1) prescribed spectacles from retinoscopy alone, (2) considered retinoscopy to be important, (3) found retinoscopy useful for detecting keratoconus or cataract, and (4) are satisfied with their own retinoscope. Less than half of the respondents reported using dynamic retinoscopy.
- The contents of this chapter form part of a published article: Dunstone DJ, Armstrong RM & Dunne M. Survey of habits and attitudes to retinoscopy by optometrists in the UK. Optometry in Practice, 2013. 14(2): p. 45-53.

3 UK Survey: Analysis of habits and attitudes to retinoscopy

3.1 Introduction

The objectives of this chapter were to present an in depth statistical analysis of the factors influencing the habits and attitudes to retinoscopy presented as an overview in chapter 2.

3.2 Methods

The survey questions were split between independent variables (potential influencing factors), and dependent variables (habits and attitudes). Appendix 13 shows the full survey with each question and alternative answers. The survey items representing potential influencing factors, habit and attitudes are shown in Tables 3.1, 3.2 & 3.3.

Table 3.1. Survey items that represented influencing factors.

Nature of question		Full question with alternative responses
Potential Influencing factors	Date of qualification	When did you qualify as an Optometrist? Before 1965, 1965-1979, 1980-1994, 1995-2010.
	Practice type	Which type of practice do you consider to be your principal work? Independent (less than 3 practices), joint venture/multiple, locum, hospital, academic/research, training/education, management.
	University attended	At which university did you study Optometry? City, Manchester, Cardiff, Glasgow, Aston, Anglia Ruskin, Bradford, Ulster, Other.
	Ethnic background	Ethnic Group (This information is for statistical purposes only. Complete this question only if you wish to do so). White, Mixed, Asian or Asian British, British, Chinese, Other ethnic group.
	Practice location	Where is the practice in which you spend most of your time? England-Eastern, England-East Midlands, England-London Boroughs, England-North East, England- North West, England-South East, England-South West, England-West Midlands, England-Yorkshire and Humber, Northern Ireland, Scotland, Wales.
	Workload	How many eye examinations do you carry out in any typical week? 0-20, 21-40, 41-80, 81 or more.

Table 3.2. Survey items that represented habits.

Nature of question	Full question with alternative responses
Retinoscopy or autorefraction	What is your primary method of objective refraction? Retinoscopy, Autorefractor, both about equally.
Frequency of retinoscopy use	In what percentage of your eye examinations do you perform retinoscopy? 0%, 1 - 25%, 26 - 50%, 51 - 75%, 76 - 100%.
Type of retinoscope used	What type of retinoscope do you use? Spot, Streak, Retinoscope not used.
Spectacle prescribing using objective data	Do you ever prescribe spectacles based on your objective refraction result alone e.g. for infants or learning difficulty patients? YES using retinoscopy findings, YES using both retinoscopy and autorefractor findings, YES using autorefractor findings, No.
Combination type used	Does your retinoscope have the facility to change from spot to streak design, or visa versa, by simply changing the bulb? (Sometimes described as Combination, Combi, dual mode or bimodal retinoscopes) Yes, No, Not sure.
Maker of own retinoscope	Which company manufactured your retinoscope? Keeler, Welch Allyn, Heine, None of these, Not sure.
Dynamic retinoscopy use	Dynamic retinoscopy (i.e. use of a retinoscope to give information regarding accommodation) is used: Occasionally, Frequently, Never.
Use of starting point lenses	Ignore the use of a working distance allowance lens in this question. When initiating retinoscopy, I prefer to use starting point lenses in the trial frame (i.e. the previous prescription or autorefractor result). Do you: strongly agree, agree, disagree, strongly disagree, no opinion?

Table 3.3. Survey items that represented attitudes.

Nature of question	Full question with alternative responses
Importance of retinoscopy	Retinoscopy is NOT an important aspect of an Optometric examination. Do you strongly agree, agree, disagree, strongly disagree, no opinion?
Usefulness with cataract	Retinoscopy is NOT useful for detecting crystalline lens changes or opacities. Do you strongly agree, agree, disagree, strongly disagree, no opinion?
Usefulness with keratoconus	Retinoscopy is useful for detecting keratoconus. Do you strongly agree, agree, disagree, strongly disagree, no opinion?
Satisfaction with own retinoscope	How satisfied are you with the performance of your own retinoscope? Very dissatisfied, Dissatisfied, Satisfied, Very satisfied, No opinion.
Perceived accuracy of combination retinoscopes	Combination retinoscopes (that have the facility to change from spot to streak design, or visa versa, by simply changing the bulb) are not as accurate as the older/designated models. Do you: strongly agree, agree, disagree, strongly disagree, no opinion?

3.3 Statistical Analysis

3.3.1 Statistical analyses used in previous optometric practitioner surveys

To analyse and communicate the results of optometric surveys, several authors have displayed percentages for each answer and displayed the data in tables and charts without any supporting statistical analyses(115, 119, 122, 142). Warburton et al (113) highlighted the most frequently selected answer to each question, calculated a mode and also displayed the percentage of respondents that gave each answer.

Turner et al. (112) in a Survey of eye practitioners' attitudes towards diagnostic tests and therapies for dry eye disease displayed the diagnostic tests used by eye practitioners

graphically (histogram) and gives probability (P-values) for group comparisons. Qualitative data collected from the open question sections of the survey were analysed and presented in thematic categories. This involved breaking down written comments into specific points and grouping them with similar statements from other individual responses. These qualitative results were then compared and differences assessed using the t-tests.

Median, upper and inter-quartile values for questionnaire results were calculated and displayed graphically by O'Leary & Evans (108).

Chi-square statistical tests were used by several authors to analyse their results and compare frequencies. These tests are a simple and widely used method to establish whether the null hypothesis can be rejected.(120, 121, 123, 143). If the chi-square value obtained is greater than the tabled figure (corresponding to a probability level of 0.05) then the observed frequencies are statistically significant.(144)

The Wilcoxon Rank test was used in analysis of a survey of UK practitioner attitudes to the fitting of rigid gas permeable lenses (117). A questionnaire was sent to 1000 randomly selected UK practitioners and a response obtained from 45.1% of clinicians. Some of the questions asked for a numerical value of disagreement or agreement to a statement. The Wilcoxon rank test is used to analyze ranked data and is the non-parametric equivalent of a paired t test (144, 145).

3.3.2 Analyses carried out

Decision tree analysis (DTA) was considered in favour of previously used statistical methods as it considered all factors at the same time. Decision trees have been widely used since 1959 to detect non-linear effects on the response variable and interactions between predictors. DTA is also known as hierarchical splitting or group dividing. (146) Multivariate analysis was performed using SPSS Version 20.0 (IBM SPSS Statistics)(147) and involved Decision Tree Analysis using the CHAID (Chi-squared Automatic Interaction Detection) tree growing method.(148, 149) At each step, CHAID chooses the independent variable that has the strongest interaction with the dependent variable.(150) This type of analysis was considered

most appropriate due to its hierarchical element and since more than one inter-related dependent variable was being investigated.(145) CHAID uses p-values of the Chi-square as the splitting criteria. The p-values are given a Bonferroni adjustment to account for multiple testing. (146) Similar alternative methods of analysis were considered (multiple regression and multiple discriminant analysis) but these have no explicit hierarchy. Separate analyses were performed for each habit or attitude question shown in Tables 3.2 & 3.3 versus all potentially influencing factors shown in Table 3.1.

Multivariate analysis (151) involves analysis of numerous outcome variables at a time and has been previously used in optometric surveys and investigations.(134, 152-159) Decision Tree Analysis (DTA) has been used in previous eye care research, including a dry eye survey by Yu et al.(160) which looked at the costs incurred to treat dry eye. The decision tree differentiated those patients who obtained medical care and those who self treated, and was further split into the different treatments used and the costs of each. This method of analysis was preferred by the authors since it offered ease of updating data and reanalyzing over time. A study by Twa et al.(161) used DTA to differentiate between normal and keratoconic corneal shapes. The authors commented that the benefit of DTA was its ability to accommodate many different types of data, such as complex clinical measurements and demographic details of patients. The method of DTA used by Twa et al. was the C4.5 Java based program as proposed by Quinlan. (162)

Thus, all 298 responses from the UK retinoscopy questionnaire were added to a SPSS database worksheet i.e. the demographic information and questions to be analysed for all respondents. For each analysis, one habit or attitude question was chosen as the dependent variable while the date of qualification, when qualified , race, practice location, practice type, and workload were assigned as independent variables. CHAID default settings for parent and child nodes were found to influence tree growth. The default settings specified a sample size of 100 for parent nodes and 50 for child nodes. Initial analysis showed that these settings artificially limited tree growth. After some experimentation, the settings used for analysis required a sample size of 50 for parent nodes and 20 for child nodes. There are no strict rules to define the size of the DTA nodes but using a sample size for the parent node greater than 30 was chosen after Bailey who considered this number large enough to be defined as a

population and so large enough to analyse.(163) The default setting for tree growth levels for CHAID was 3. This controls the maximum number of levels of growth beneath the root mode. For the present analysis the number of tree levels was increased to 5 to further ensure that maximum tree growth had been achieved.(164) Studies using DTA by Yu et al. (160)and Twa et al.(161) used alternative DTA methods from CHAID and it was unclear what node and tree level settings were used.

3.4 Results

The results (from chapter 2, section 2.3) have been analysed.

3.4.1 Main method of objective refraction

Results are shown in Figures 3.1 & 3.2. This decision tree showed that practice type influenced the method of objective refraction used. It showed that the majority of optometrists (85%) working in independent practice consider retinoscopy to be their main method, followed by hospital (83%), locum and training optometrists (62%) and, finally, by those working in multiple practice, academia and research (46%). Autorefractors were the primary method of objective refraction for 40% of respondents from multiple practice, academia and research, 10% of locums and training optometrists, 7% of respondents in independent practice and 4% of those working in hospital. The analysis correctly classified 70.1% of the data and was highly statistically significant (Chi = 101, df = 9, P< 0.001). A further influence was found for multiple and academic optometrists; here 'recently qualified' optometrists (qualified 1995-2010) use autorefraction more (46%) than the 'experienced' practitioners (qualified 1965-1994) (30%). (Chi = 17, df 2, p<0.005). A link with university was also established for the 'younger' multiple and academic optometrists; here retinoscopy was used less as a main method by graduates from City, Bradford, Anglia Ruskin and Ulster than for Cardiff, Aston, Manchester and Glasgow universities (Chi = 15, df = 2, p<0.05).

Figure 3.1. Decision Tree showing how main method of objective refraction used was influenced by practice type. Main method (Habit) was entered as the dependent variable and date of qualification, ethnic group, location of practice, practice type, university attended and workload as the independent variables. The majority of optometrists (85%) working in independent practice consider retinoscopy to be their main method, compared with 46% for those working in multiple practice, academia and research; Chi = 101, df = 9, P< 0.001. Further influences were found for multiple and academic optometrists.

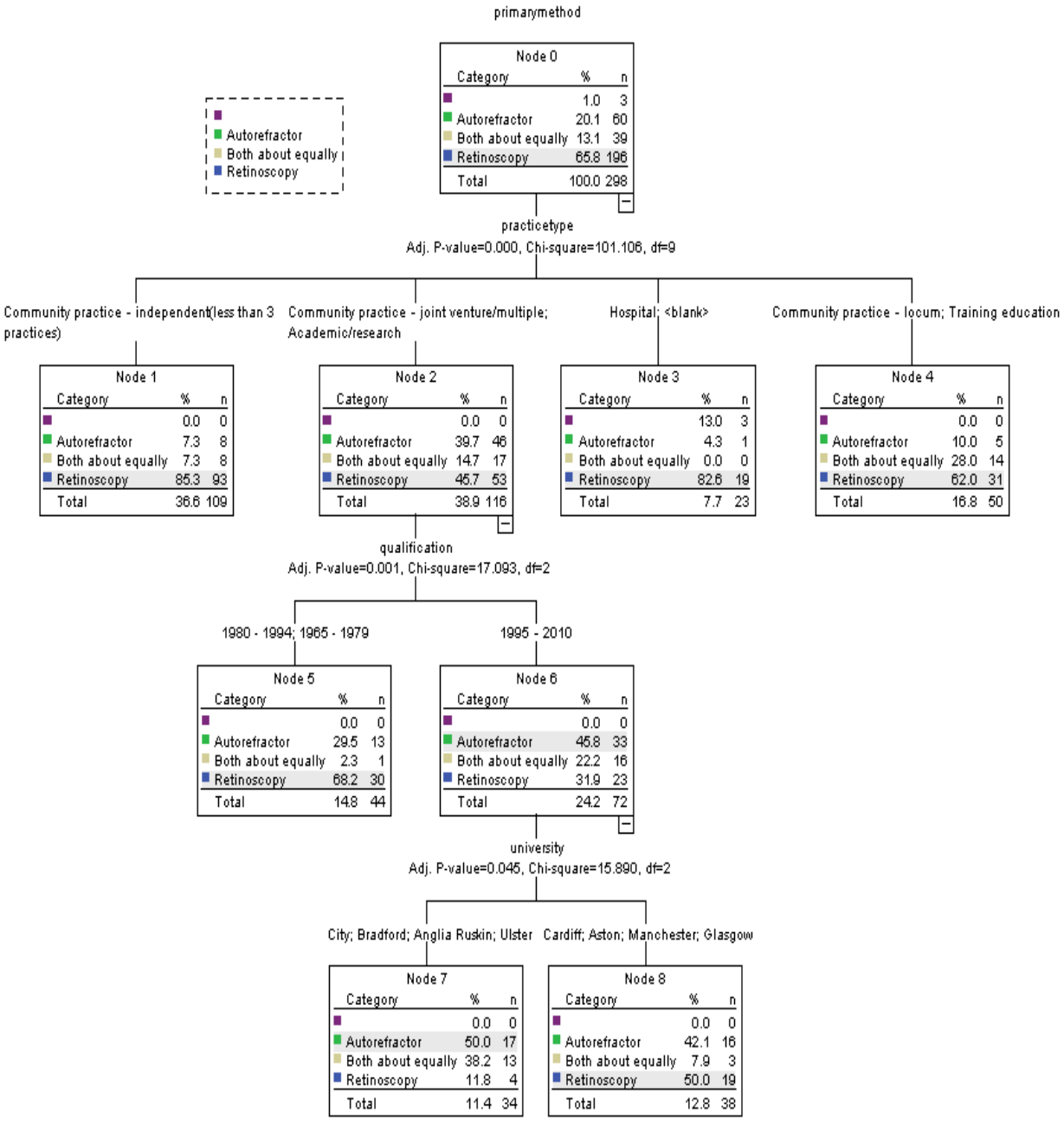
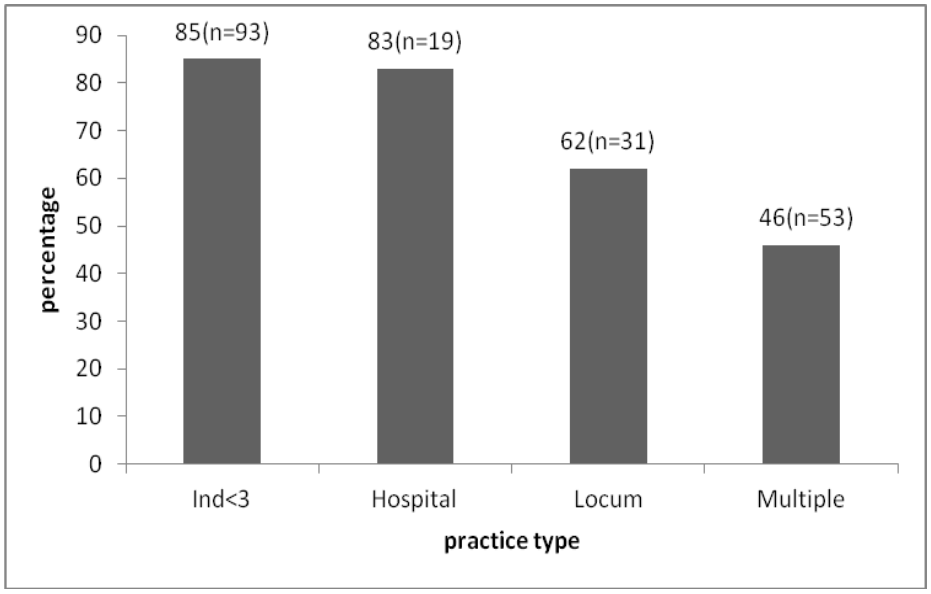


Figure 3.2. Percentage of optometrists using retinoscopy as their primary method of objective refraction for differing Practice types. The 'Multiple' group includes optometrists working for multiple practices, academics & researchers. The 'Locum' group includes locum and training/education optometrists. The 'Ind<3' and 'Hospital' groups consisted only of optometrists working in independent practices and hospitals, respectively.



3.4.2 Frequency of retinoscopy use

Decision tree analysis showed that none of the independent variables influence the percentage of examinations in which retinoscopy was used. Thus no effect has been established, including practice type and 'age', for the dependent variable 'frequency of retinoscopy use'. The model uses dF=3, correctly classifies 39% of the data and is not statistically significant. This analysis was repeated in order to increase validity (the percentage of data correctly classified) by grouping frequency of use as 0-50% and 51 – 100%. This provided greater numbers of responses in each group but again showed no effect and this model correctly classified 53% of data.

3.4.3 Retinoscope type

Results are shown in Figures 3.3 & 3.4. Decision tree analysis showed that streak retinoscopy was preferred by most (79%) practitioners. The type of retinoscope used was influenced by the university attended; with spot retinoscopy used most by graduates of City and Aston

(38%), then Cardiff, Manchester and Other (11%) and least by graduates of Bradford, Anglia Ruskin, Glasgow and Ulster (2%). The model correctly classified 79% of the data and was highly statistically significant (Chi = 62, df = 6, P< 0.001).

A further influence occurred specifically for City and Aston graduates. For these optometrists, date of qualification influenced the type of retinoscope used. The ’experienced’ optometrists (qualified 1980-1994) used spot type retinoscopes more than 'recently qualified' optometrists (qualified 1995-2010). Just over a half (51%) of the ‘experienced’ practitioners use spot retinoscopes as compared with 25% of the ‘recently qualified’ optometrists. This result was statistically significant (Chi = 9, df = 1, P< 0.01) and is shown in Figure 3.3.

Figure 3.3. Decision Tree showing how type of retinoscope used (spot or streak) was influenced by university attended and date of qualification. Retinoscope type used (habit) was entered as the dependent variable and date of qualification, ethnic group, location of practice, practice type, university attended and workload as the independent variables. The type of retinoscope used was influenced by the university attended; with spot retinoscopy used most by graduates of City and Aston (38%) and least by graduates of Bradford, Anglia Ruskin, Glasgow and Ulster (2%); Chi = 62, df = 6, P< 0.001. For City and Aston graduates the 'experienced' optometrists (qualified 1980-1994) use spot type retinoscopes more than those 'recently qualified' (qualified 1995-2010); Chi = 9, df = 1, P< 0.01.

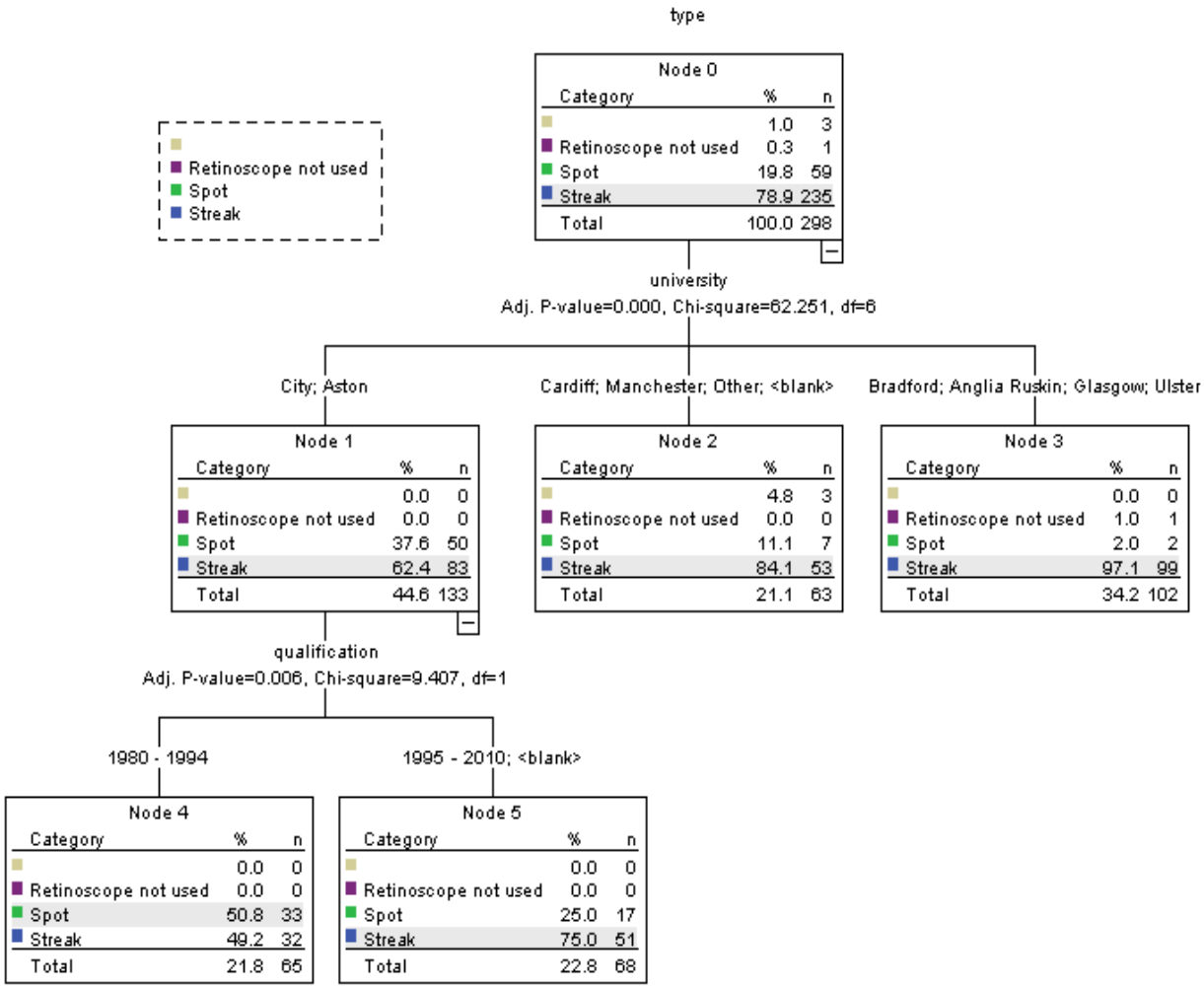
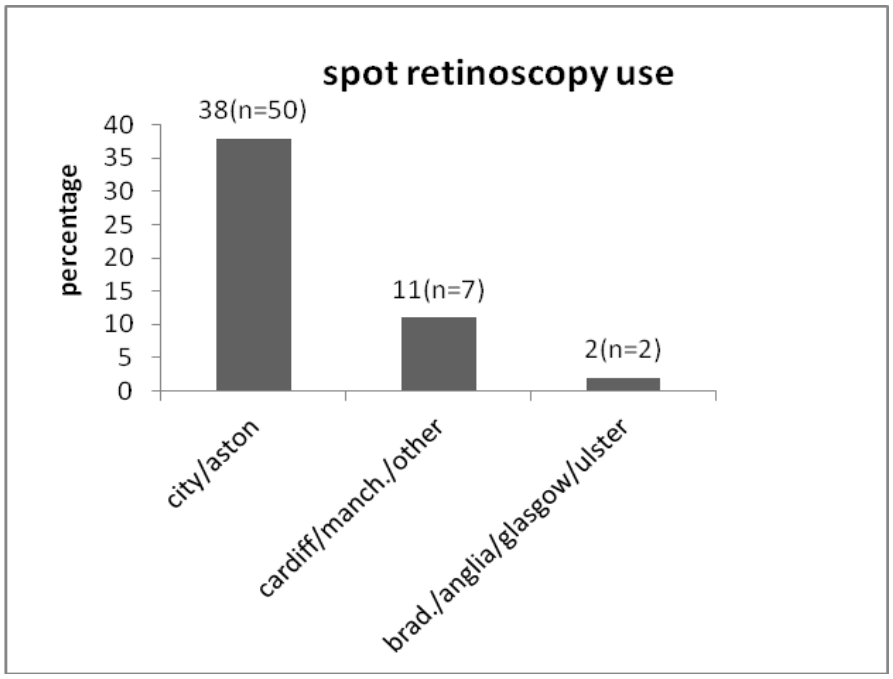


Figure 3.4. Percentage of optometrists using spot retinoscopy who graduated from different universities. (manch. = Manchester, anglia = Anglia Ruskin, brad = Bradford)



3.4.4 Prescribing of spectacles using objective data only

Most practitioners (96%) reported that they prescribed spectacles using objective data when necessary. For those who did prescribe spectacles in this manner, 14% used the result of both retinoscopy and autorefraction, whereas the majority (81%) only used retinoscopy. No respondents prescribed spectacles using autorefraction only. Practice type influenced whether spectacles are prescribed using the retinoscope result only in cases where only objective data was used. The analysis indicated that optometrists working in independent practice, hospital and training/education prescribe most often by using the retinoscopy result only (93%) followed by multiple practice and academia (72%). 24% from multiple practice and academia prescribed in some cases using both retinoscopy and autorefractor findings , as compared with just 2% from Independent practice. The model correctly classified 81% of the data and was statistically significant (Chi = 31, df = 3, P< 0.001). The decision tree is shown in Figure 3.5.

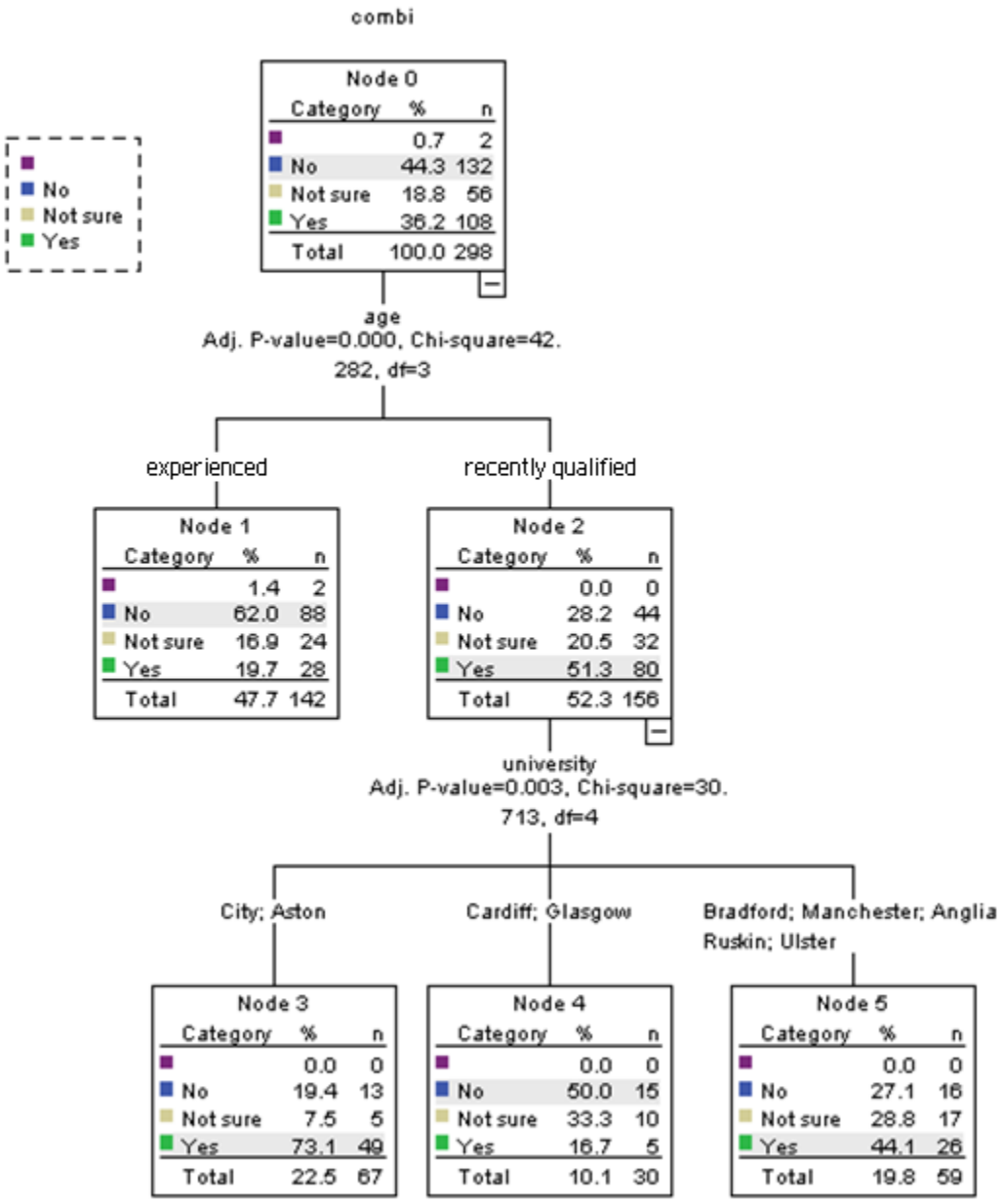
Figure 3.5. Decision Tree showing how whether spectacles are prescribed using objective data only was influenced by practice type. Whether spectacles are prescribed using objective data (Habit) was entered as the dependent variable and date of qualification, ethnic group, location of practice, practice type, university attended and workload as the independent variables. Most practitioners (96%) reported that they prescribed spectacles using objective data when necessary and practice type was an influence. Optometrists working in independent practice, hospital and training/education prescribe most often by using the retinoscopy result only (93%) followed by multiple practice and academia (72%); Chi = 31, df = 3, P< 0.001.

3.4.5 Combined retinoscopes

Results are shown in Figure 3.6. Combined retinoscopes were used by 36% of the respondents. This was influenced by the date of qualification. Here, combined retinoscopes were used mostly by optometrists who qualified between 1995-2010 (51%) and least by those who qualified in 1965-1994 (20%); Chi= 42, df=3, p< 0.001. A further influence emerged for practitioners who qualified between 1995-2010. Here, combination type retinoscopes

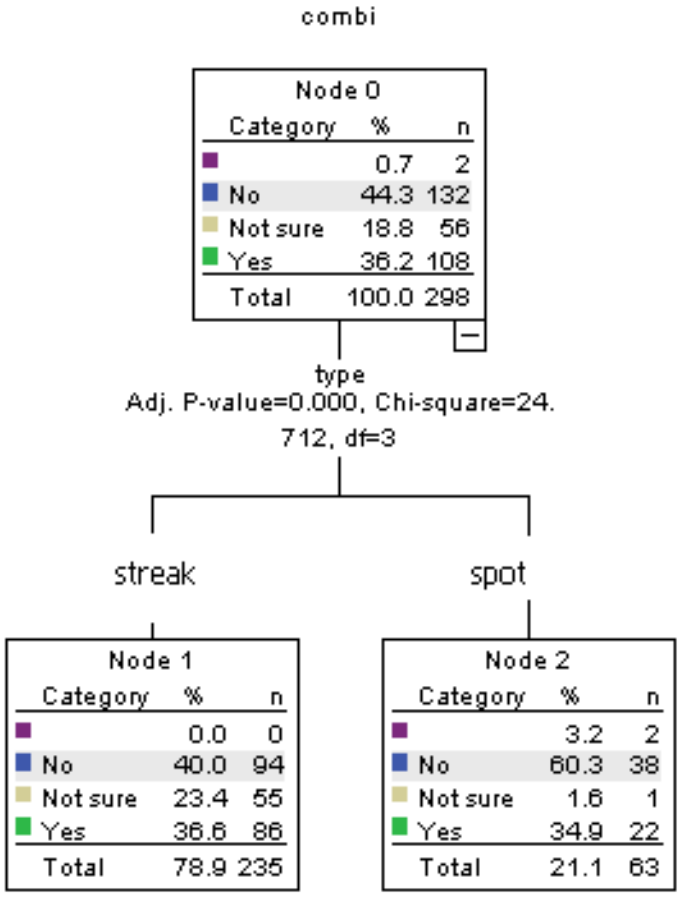
were used most by optometrists graduating from City & Aston (73%) and least by graduates from Cardiff and Glasgow (17%). This was statistically significant (Chi= 30, df=4, p= <0.005). Some practitioners (19%) answered that they were ‘not sure’ whether their own retinoscope was a combined type. This was influenced by the university attended but only for those optometrists qualifying between 1995-2010; 8% of these recently qualified optometrists from City & Aston were ‘not sure’ as compared with 29-33% from all the remaining universities.

Figure 3.6. Decision Tree showing how type of retinoscope used (combined or dedicated) was influenced by date of qualification and university attended. Whether combined retinoscopy was used (Habit) was entered as the dependent variable and date of qualification, ethnic group, location of practice, practice type, university attended and workload as the independent variables. Combined retinoscopes were used mostly by optometrists who qualified between 1995-2010 (51%) and least by those who qualified 1965-1994 (20%); Chi= 42, df=3, p< 0.001. A further influence emerged for 'recently qualified' practitioners. Here, combined type retinoscopes were used most by optometrists graduating from City & Aston (73%); Chi= 30.713, df=4, p= <0.005.



Combined retinoscopy use was further influenced by spot or streak use; see Figure 3.7. Decision Tree analysis showed that the type of retinoscope used (combined or dedicated) was influenced by whether spot or streak retinoscopy was preferred. For this analysis, whether combined retinoscopy was used (Habit) was entered as the dependent variable and type of retinoscope as the independent variable. For streak users, 37% use combined, 40% use dedicated and 23% are unsure whether their retinoscope is combined or dedicated. For spot users 35% use combined, 60% use dedicated and 2% are unsure; Chi = 24, df=3, p< 0.001.

Figure 3.7. Decision Tree showing how the type of retinoscope used (combined or dedicated) was influenced by whether spot or streak retinoscopy was preferred. Whether combined retinoscopy was used (Habit) was entered as the dependent variable and type of retinoscope as the independent variable. For streak users, 23% are unsure whether their retinoscope is combined or dedicated whereas 2% of spot users are unsure; Chi = 24, df=3, p< 0.001.



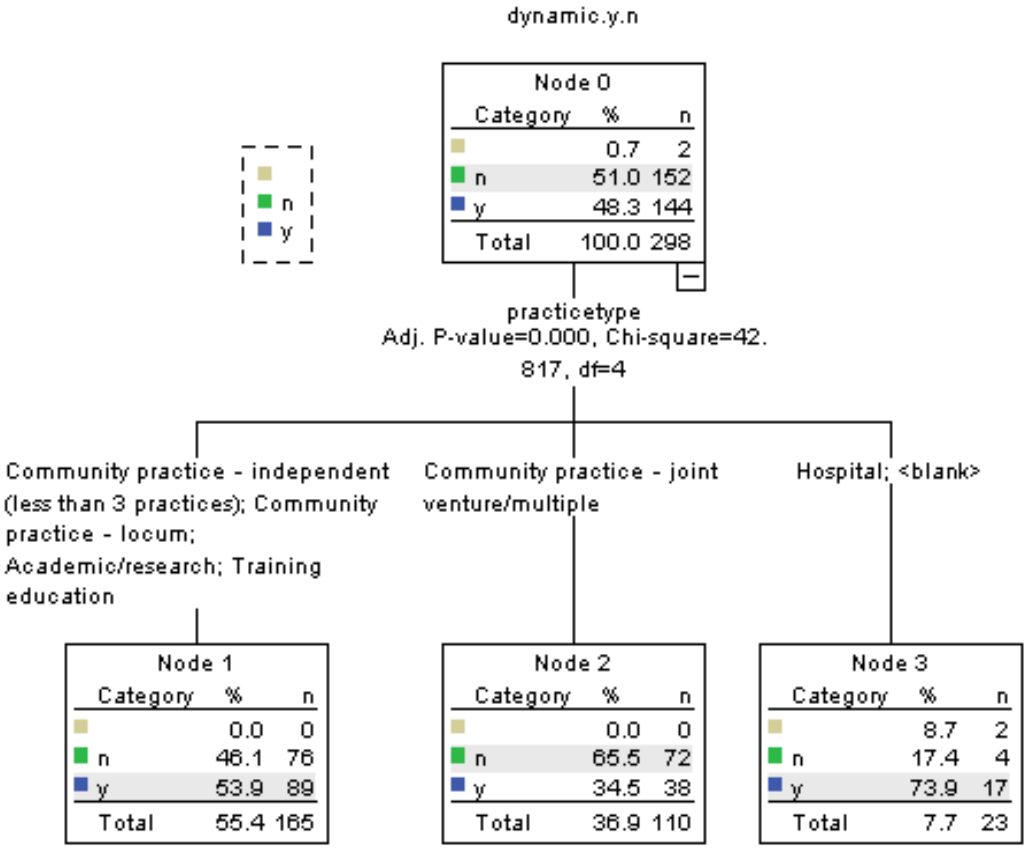
3.4.6 Manufacturer

Keeler retinoscopes were the most commonly used (79%) followed by Welch Allyn (16%) and Heini (4%). Decision tree analysis showed that there were no factors that influenced the manufacturer of retinoscope used.

3.4.7 Dynamic retinoscopy

Results are shown in Figure 3.8. About half (48%) of optometrists performed dynamic retinoscopy. Decision tree analysis showed that practice type influenced whether dynamic retinoscopy is used. Analysis was carried out after classifying frequent and occasional dynamic use as yes ('y') and dynamic retinoscopy never used ('n'). It showed that hospital optometrists used dynamic retinoscopy most (74%), followed by independent, locum and training optometrists (54%) and least by multiple practitioners (35%). The model correctly classified 60% of the data and was highly statistically significant (Chi = 42, df = 4, $P < 0.001$).

Figure 3.8. Decision Tree showing how dynamic retinoscopy use was influenced by the type of practice worked in. Whether dynamic retinoscopy was used (Habit) was entered as the dependent variable and date of qualification, ethnic group, location of practice, practice type, university attended and workload as the independent variables. Hospital optometrists use dynamic retinoscopy most (74%) and multiple practitioners least (35%); Chi = 42, df = 4, P< 0.001. Analysis was carried out after classifying frequent and occasional dynamic use as yes ('y') and dynamic retinoscopy never used ('n').

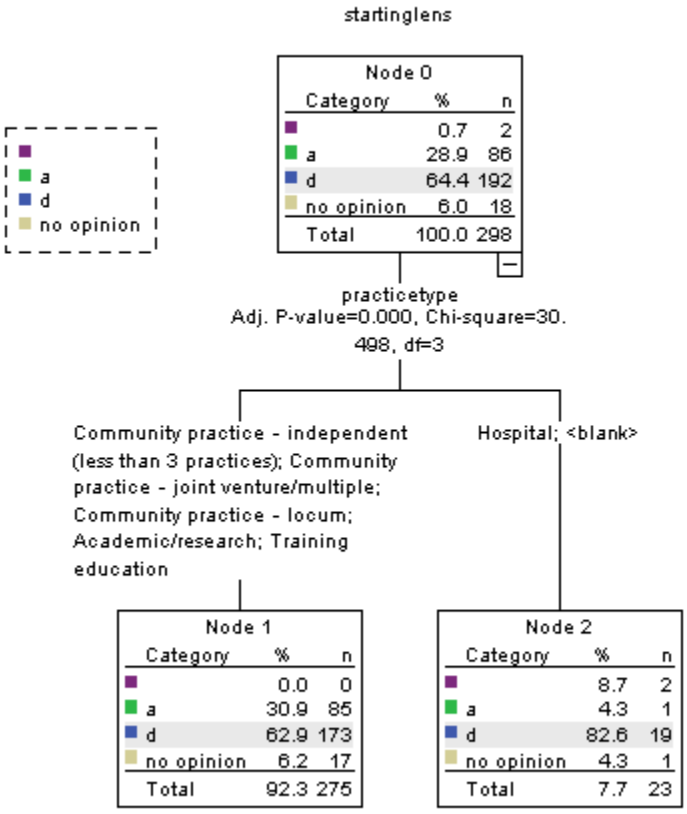


3.4.8 Use of starting point lenses when initiating retinoscopy

Results are shown in Figure 3.9. A starting point lens was used when initiating retinoscopy by 29% of optometrists whereas the majority (64%) preferred to start retinoscopy from scratch. After grouping answers into 'agree' to use of a starting point lens (a) or 'disagree' (d), decision tree analysis showed that practice type was influential. Here, hospital optometrists were less likely to use starting point lenses, based on the previous prescription or

autorefractor result, when initiating retinoscopy (4%). Practitioners from independent, multiple and other types of practices used starting point lenses with little variation in frequency between them (31%). The model correctly classified 64% of the data and is statistically significant (Chi = 30, df = 3, P< 0.001).

Figure 3.9. Decision Tree showing how use of a starting point lens prior to retinoscopy was influenced by the type of practice worked in. Whether a starting point lens was used (Habit) was entered as the dependent variable and date of qualification, ethnic group, location of practice, practice type, university attended and workload as the independent variables. Hospital optometrists are less likely to use starting point lenses (4%). Practitioners from independent, multiple and other types of practices use starting point lenses to similar amounts (31%); Chi = 30, df = 3, P< 0.001). 'a' = agree to use of a starting point lens, 'd' ='disagree'.



3.4.9 Importance of retinoscopy and usefulness in detection of cataract and keratoconus.

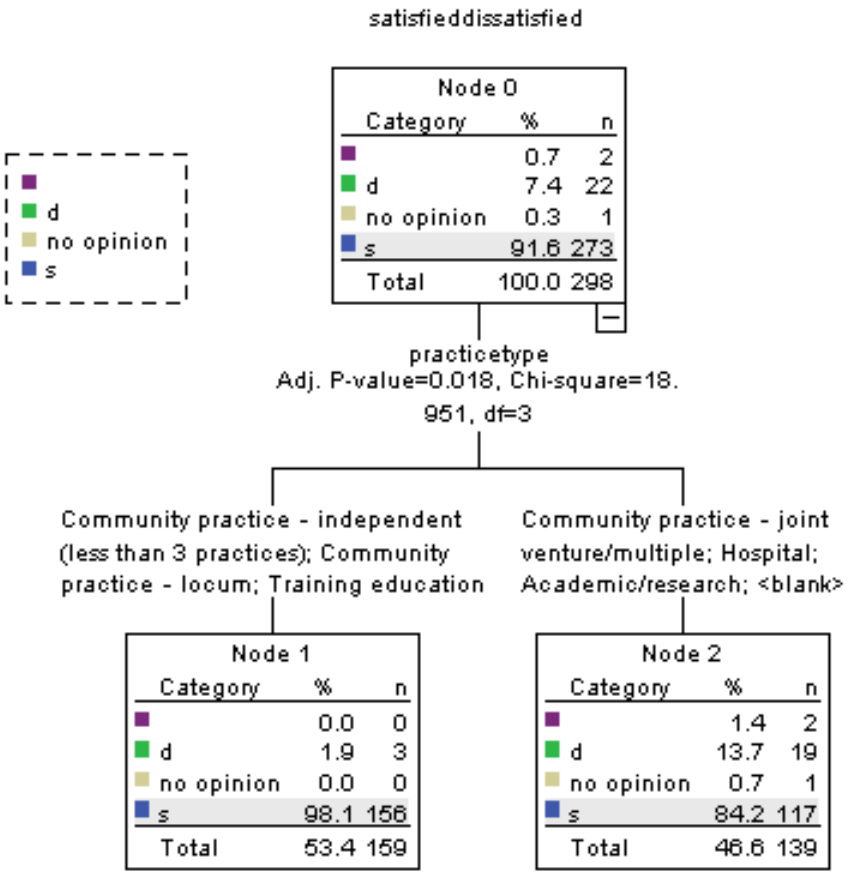
Retinoscopy was considered to be an important aspect of an optometric examination by 94% of optometrists. Retinoscopy was considered useful for detection of cataract and keratoconus by 88% and 94% respondents respectively. Decision tree analysis showed no interrelationships were found between potential influencing factors versus these retinoscopy habits and attitudes.

3.4.10 Satisfaction with the performance of own retinoscope

The majority of optometrists (92%) were satisfied with their own retinoscope. For decision tree analysis, responses were classified into two groups (satisfied and dissatisfied) to increase the number of responses in each group. Satisfaction with own retinoscope was influenced by type of practice (Figure 3.10). Multiple, hospital and academic optometrists were more likely to be dissatisfied (14%) compared with independent, locum and training practitioners (2%). The model correctly classified 92% of data and is statistically significant (Chi = 18, df =3, $P< 0.05$).

Only 4% of optometrists prefer to use an older model of retinoscope rather than a newer instrument. The results refute the authors hypothesis of dissatisfaction with Keeler retinoscopes as UK optometrists are overwhelmingly satisfied with their most recently purchased retinoscope.

Figure 3.10. Decision Tree showing how satisfaction with the performance of own retinoscope was influenced by type of practice. Satisfaction with performance entered as the dependent variable and date of qualification, ethnic group, location of practice, practice type, university attended and workload as the independent variables. Multiple, hospital and academic optometrists are more likely dissatisfied (14%), compared with independent, locum and training practitioners (2%); Chi = 18, df =3, P< 0.05. Satisfied and very satisfied classified as ‘s’ and dissatisfied and very dissatisfied as ‘d’.



3.4.11 Perceived accuracy of combined retinoscopes

Only 5% of optometrists agreed, or strongly agreed, that combination retinoscopes were less accurate than designated types. Decision tree analysis showed that no influencing factors influenced the perceived accuracy of combined retinoscopes.

3.4. 12 Summary of influencing factors

Table 3.4 shows a summary of the influencing factors found, showing that practice type was an influencing factor for use of autorefraction, spectacle prescribing based on objective refraction, dynamic retinoscopy, use of starting point lenses and satisfaction with own retinoscope. Both date of qualification and university attended influenced autorefractor use and the type of retinoscope used.

Table 3.4. Summary of the influencing factors found (if any) for the retinoscopy habits and attitude questions asked.

Nature of question	Influencing factor	Influence (if any)
Retinoscopy or autorefraction	Practice type	> use of autorefractors by multiple optometrists
	Date of qualification (‘age’)	> use of autorefractors by ‘recently qualified’ multiple optometrists
	University	> autorefraction by ‘recently qualified’ multiple graduates from City, Bradford, Anglia & Ulster
Frequency of retinoscopy use	None	
Type of retinoscope used	University	> spot use by City & Aston graduates
	Date of qualification (‘age’)	> streak retinoscopy by ‘recently qualified’ graduates of City & Aston
Spectacle prescribing using objective data	Practice type	>use of autorefractors to assist prescribing by multiple, locum & academics
Combination type used	Date of qualification (‘age’)	> use of combined retinoscopes by ‘recently qualified’ optometrists
	University	> combination use from City & Aston, > unsure whether combination used from Cardiff & Glasgow
Maker of own retinoscope	None	
Dynamic retinoscopy use	Practice type	< dynamic retinoscopy by multiples
Use of starting point lenses	Practice type	< use of starting point lenses by hospital optometrists
Importance of retinoscopy	None	
Usefulness with cataract	None	
Usefulness with keratoconus	None	
Satisfaction with own retinoscope	Practice type	> dissatisfaction by multiple, hospital & academics
Perceived accuracy of combination retinoscopes	None	

3.5 Discussion

3.5.1 Demographics of responders

This study achieved a response rate of 30%, which falls within the range of 7% to 94% for previous practitioner surveys (See Appendix 16). With less than one in three invited optometrists choosing to respond, representing 2.6% of the total population in the UK at that time of 11,559, (139) the findings were prone to selection bias. A further source of bias was that reported practice may not reflect actual clinical practice.(124) An alternative approach to ascertain retinoscopy habits could have been use of Standardised Patients(124, 125) , although it would be prohibitively expensive to see sufficient numbers to investigate a change in habits. Use of Standardised Patients is considered to be the gold standard methodology for measuring clinical practice by Shah, Edgar & Evans. (165) A retrospective study of patient records was not pursued as a method of investigation since the author had noticed considerable variation among optometrists in recording of retinoscopy results.

The five optometrists who helped with the design of the survey were all qualified pre-1995 and from predominantly independent practice (4 out of 5 practitioners). All of those from independent practice reported using retinoscopy as the preferred method of objective refraction whereas the practitioner from multiple practice mainly used an autorefractor.

The survey received replies from all geographical areas of the UK. It was not possible to compare profile of respondents to College or GOC records as they were not readily available at the time of the study. It may have been possible to access the address and postcodes from these organisations but this data would not be ideal for comparison since the author could not be sure whether the address was for home or work and it would be difficult to categorize into the regions used in the survey.(129, 166) Many of the addresses held by the GOC were home addresses and would not be released to a third party. (130) However, there was no evidence in literature to suggest that practice location should be considered as an influencing factor. This is partly corroborated by Saward who considered and discussed the location of optometric practices but did not draw any conclusion that this could influence performance.(167)

A similar number of responses (37%) were received from those working in Independent and multiple community practices, with 16% Locums and 7% from Hospital. A similar proportion of responses from different practice types were found in an optometric survey by Alderson & Davey, with 39% of responses from practitioners working in multiple type practice and 48% from independents. (168) It could be hypothesised that 'chair time' pressures might lead 'multiples' to favour autorefraction over retinoscopy and so practice type was considered as a possible influencing factor.

Responses were received from all of the UK Universities offering a course in optometry. The largest number of responses was from Aston graduates (27%). The smallest number of responses was from Anglia Ruskin, Ulster and Other which constituted 5%, 3% and 1% respectively.

3.5.2 Retinoscopy use in the UK

Only practice type, date of qualification and university attended influenced attitudes and habits relating to the use of retinoscopy.

Retinoscopy was considered an important test by the majority of respondents (94%). This corroborates with data from a Clinical Practice Survey of 2008 (111) which ascertained that retinoscopy would be performed on young children “Always” by 92% of practitioners. The present study has shown that the majority of optometrists found retinoscopy useful for detection of cataract and keratoconus. This is in agreement with Drinan & Gilmour who stated the retinoscope can be used to detect opacities and abnormalities of the ocular media.(20)

Spot retinoscopes were used more by graduates from City and Aston University but habits appeared to be changing. The more recently qualified practitioners from these universities appeared to be using steak retinoscopes more often.

This study provides evidence that optometrists from multiple type practice were often (40%) considering autorefractor to be their primary method of objective refraction yet were still

using retinoscopy in the same percentage of eye examinations as optometrists from other practice types. This suggests that these optometrists were using their retinoscope to check the result of the autorefractor and/or gain qualitative information. The majority of multiple optometrists shared the same positive attitudes to retinoscopy yet also considered autorefraction to be important.

The majority of respondents (81%) used retinoscopy alone to occasionally prescribe spectacles. No respondents prescribed spectacles using the autorefractor result only. This is reassuring since autorefractors were not considered to be reliable enough, in a study by Strang et al.(169), to allow spectacles to be prescribed directly from the results of automated refraction. Optometrists working in multiple type practice (together with locums and academics) are more likely to use both retinoscopy and autorefractor findings to prescribe spectacles in cases where only objective data is available. This is unsurprising since those working in multiple used autorefractor more often as the main form of objective refraction. It could be hypothesised that using the autorefraction result to assist prescribing is linked with a reduced confidence in retinoscopy, which is possibly corroborated by the finding that multiple practitioners (as well as those working in hospital and academia) are more likely to be dissatisfied with the performance of their own retinoscope. It appears that some optometrists use the autorefractor instead of retinoscopy in the majority of their eye examinations. This may save time, especially since these autorefractors can be used by non-optometrists. We could then hypothesise that 'chair time' pressures might lead practitioners from some types of practice to favour autorefraction over retinoscopy. It could be hypothesised that retinoscopy is more difficult through a phoropter (refractor head) and these may be used more by optometrists working in multiple type practices. Other techniques are also available to ascertain a starting point for refraction, such as the use of the previous prescription recorded in records or focimetry of the current spectacle correction. On reflection, the survey would have benefitted from asking about these alternatives.

That a third (31%) of optometrists use retinoscopy in 25% or less of their eye examinations may be a potential problem if this could, in turn, cause a reduction in the accuracy of eye examinations for which autorefraction or subjective refraction is not reliable. No previously published research has been found that shows whether giving less importance to retinoscopy

brings about a loss of accuracy. Other studies have looked into the effects of training and experience on clinical accuracy. Efron, Morgan & Jagpal (170) established that experience has a positive affect when grading contact lens complications. Accuracy of tonometry has been shown to be improved with training.(171) Outside of optometry, clinical performance is known be related to experience for radiologists.(172) Ericsson states that "combined deliberate practice is necessary for maintenance of many types of professional performance." (173) The fact that the retinoscopy result alone is frequently used to prescribe spectacles, when necessary, emphasises the need to maintain retinoscopy skills.

This research finds that practice type influences the importance given to retinoscopy but not the frequency of use. This does not corroborate with a study by Shah et al. (2008) who found less retinoscopy use by optometrists from multiple practices, with 42% of independent optometrists performing retinoscopy on a standardized patient presenting with headache, compared with 29% within multiple type practice.(174) This difference may be because reported practice (measured by survey) does not always reflect actual clinical practice (ascertained from standardized patients).(124)

Most Optometrists (64%) prefer to start retinoscopy from scratch and do not use a starting point lens. Hospital optometrists are least likely to use starting point lenses; 83% (19 out of 23) of hospital optometrists did not use starting point lenses (i.e. the previous prescription or autorefractor result) when initiating retinoscopy. There are other valid methods of starting refraction, such as using a lens based on the previous prescription, ascertaining the power of the existing spectacles by focimetry or using an autorefraction result. A hypothesis to explain the low use of starting point lenses by hospital optometrists could be a higher possibility of the patient being seen for the first time and the low use of autorefractors in hospitals (4%).

This present survey showed that autorefractors were widely used by the sample of UK optometrists surveyed. Literature showed that autorefractors are accurate (175-185) but not suitable for all patients. Some authors conclude that autorefractors are not as accurate as retinoscopy.(3, 186) Strang et al. found that autorefraction was not as accurate as subjective refraction (187) whereas Choong et al. found that autorefraction was as accurate as subjective refraction if cycloplegia was used.(183) Funarunart et al. (188) and Rotsos et al.

(189) established that non-cycloplegic autorefraction had a tendency towards minus over-correction. Zadnik et al. (179) found autorefraction to be more reliable than retinoscopy (especially with cycloplegia) and stated that retinoscopy is a poor choice for the determination of refractive error. This was, however, in the context of scientific research regarding the repeatability of measurement of the ocular components.
Hand-held autorefractors can be used with pre-school children but are not as accurate as retinoscopy.(190) Dahlmann-Noor et al. (191) concluded that autorefractors may underestimate children's refractive error. Werner & Press (192) discussed sources of variability in autorefraction which include unstable tear film, keratoconus, refractive surgery, media opacities, small or irregular pupils and accommodative spasm. They stated that it was possible to use an autorefractor as the primary method of objective refraction and reserve the retinoscope for confirmatory or supplemental findings.

The low reported use of dynamic retinoscopy in the UK (48% of practitioners) raises questions about the perceived importance of such techniques and how they are being taught. It may be that university lecturers will want to consider whether dynamic retinoscopy is being given enough prominence in the optometry course. Date of qualification was found not to be an influence to dynamic retinoscopy use, which appeared to rule out a change in teaching of this technique over recent decades. An explanation for why dynamic techniques are used most by hospital optometrists could be if more patients from special populations with a greater chance of accommodative dysfunction (e.g. Down's syndrome or cerebral palsy) or children were attending hospital clinics. It could be hypothesised that the low reported use of dynamic retinoscopy by multiple optometrists could be explained if less patients from special populations were visiting these types of practice or it could be linked with greater dissatisfaction with retinoscopy by multiple practitioners.

Accommodation is an important aspect of ocular function that can be assessed by dynamic retinoscopy for the potential benefit of patients during an eye examination and an optometrist should not assume all young people have normal accommodation.(67) There are many patients for whom accommodation needs to be assessed yet subjective techniques may not be possible and so dynamic retinoscopy techniques are most useful. This is especially the case for adults or children with special needs (23, 61, 62, 81) and patients with general

health problems, or taking medication, associated with possible accommodative dysfunction.(46-48) A study by León et al. (76) concluded that dynamic retinoscopy was a valuable technique for routine eye care. They found that, compared to subjective methods, dynamic retinoscopy gave a more truthful and reliable measure of the amplitude of accommodation.

The findings of the present study have shown that although retinoscopy is considered to be an important part of the eye examination by the majority, a third (31%) of optometrists use retinoscopy in 25% or less eye examinations. Autorefractors were used more by optometrists working in multiple practices. The increased reliance on autorefractors may be associated with the greater use of non-optometric staff in pre-screening and that the more 'difficult' patients (young children or adults with poor communication) may be more likely to attend independent practices or a hospital eye clinic. These findings may be the stimulus for debate regarding the relevance or otherwise of retinoscopy in a routine optometric examination.

This study has demonstrated that combined retinoscopes manufactured by Keeler are popular, especially for newly qualified optometrists. This is not surprising as optometrists usually purchase a retinoscope during training and new retinoscopes since 1999 are predominantly of the combination type.

Spot retinoscopes were used more by graduates from City and Aston University but the more recently graduated optometrists from these universities were now leaning towards streak retinoscopy.

Few practitioners shared the author's opinion that combined retinoscopes were less accurate. Optometrists were satisfied with their retinoscopes and believed that combined models were accurate. Questions regarding satisfaction and accuracy could be considered problematical as some practitioners may have only ever used the one type of retinoscope.

3.5.3 Awareness of combined retinoscopes

Lack of retinoscope design knowledge amongst optometrists was demonstrated as approximately one fifth of respondents (19%) answered that they were unsure whether their own instrument was a combined type (chapter 3, section 3.4.5). Spot users and graduates from City and Aston were least confused regarding this issue. A third (33%) of more recent optometry graduates from Cardiff and Glasgow universities were unsure whether their own retinoscope was of a combined or designated design.

Also, discussion with Suffolk Local Optometric Committee members (prior to the clinical trial and survey distribution) ascertained that some practitioners could not recall when their instrument was purchased and some were unaware that they were using combined models. Two optometrists believed their own Keeler instrument was not a combined type and yet one optometrist have bought their retinoscope within the last 5 years while the other had made their purchase within the last 10 years. Keeler has been supplying the 'Professional Combi' design since 1999 and thus has not manufactured dedicated instruments over the last 10 years (from the date the survey was distributed).

This evidence suggests increased education may be required into awareness of retinoscope types. This knowledge is especially important when buying a replacement bulb as using the wrong bulb may affect accuracy. Manufacturers and training institutions may like to consider education into this subject.

3.6 Conclusion

The author suspected a change in retinoscopy habits with more recent graduates of optometry using retinoscopy less. This has been refuted. The date of qualification did not affect the frequency of retinoscopy use or any of the other influencing factors, except greater use of combined type of retinoscopes by the more recently qualified. On the other hand, practice type had a bigger impact on retinoscopy use, with optometrists from multiple type practices using autorefraction more and dynamic retinoscopy less.

The study has found high levels of satisfaction with retinoscopes, including Keeler and combination types. That 14% of optometrists from multiple and hospital practice and academia are dissatisfied with their own retinoscope could be a reason for further education to these groups or consideration for improvements in retinoscopy design.

The majority of optometrists (82%) had no opinion as to whether combined retinoscopes were as accurate as dedicated types. Even so, the following chapter investigates the accuracy of Keeler combined and dedicated retinoscopes, since no such a study has been published to date. Approximately one third (32%) of optometrists used a retinoscope that was 10 years old or older. These optometrists, and others like them, will eventually need to purchase a new retinoscope and will likely be interested in the result of the following clinical trial described in chapter 4.

3.7 Key points

- 298 responses of a UK retinoscopy survey were analysed using decision tree analysis.
- Practice type influenced the main method of objective refraction used. Here, the majority of optometrists working in independent practice (85%) and hospital (83%) considered retinoscopy to be their main method, followed by locum and training optometrists (62%) and, finally, by those working in multiple practice, academia and research (46%).
- The frequency of retinoscopy use was not influenced by practice type or other potential independent variables.
- Most practitioners (96%) reported that they prescribed spectacles using objective refraction alone, when necessary. Practice type was an influencing factor. Optometrists working in independent practice, hospital and training prescribe most often by using the retinoscopy result only (93%), followed by multiple practice and academia (72%).
- Streak retinoscopy was preferred by most (79%) practitioners. The type of retinoscope used was influenced by the university attended; with spot retinoscopy used most by graduates of City and Aston (38%), then Cardiff, Manchester and Other (11%) and least by graduates of Bradford, Anglia Ruskin, Glasgow and Ulster (2%)

- Combined retinoscopes were used by 36% of the respondents. This was influenced by the date of qualification; combined retinoscopes were used mostly by optometrists who qualified between 1995-2010 (51%) and least by those who qualified 1980-1994 (18%).
- Less than half (48%) of the respondents reported using dynamic retinoscopy. Practice type influenced this with hospital optometrists using dynamic retinoscopy the most (74%) and multiple practitioners the least (35%).

4.0 Pilot trial; a comparison of the accuracy of combined versus dedicated Keeler retinoscopes

4.1 Introduction

There are two major types of retinoscope; spot and streak. The first retinoscopes were dedicated spot or streak types. Combined retinoscopes have appeared since 1999 and can be used in spot or streak mode simply by changing the bulb.(9) A major manufacturer of retinoscopes (Keeler UK Ltd) acknowledges that compromises have been made in the design of their retinoscopes in order to achieve combined usage.(104) (See chapter 1, section 1.6)

The author was of the opinion that Keeler's newer combined retinoscopes were not as accurate as the older dedicated models. No previously published research had been found on the relative accuracy of both types of retinoscope (See Table 1.2 for a summary of electronic literature databases searched and the search terms used).

4.2 Objectives

The objectives of this study were to investigate the relative accuracy of Keeler combined and dedicated retinoscopes. An additional aim was to evaluate a relatively unknown method of determining sample size and statistical power, the '15 DF rule'. This is a simple 'rule of thumb' that can be used in factorial experimental designs.

4.3 Methods

A trial was carried out to investigate the relative accuracy of dedicated versus combination retinoscopes.

4.3.1 Statistical methods

Difficulties encountered with respect to recruiting participants (optometrists and subjects) for this study were overcome by minimising the sample required to achieve the required

statistical power. The ’15 DF rule’ (106) was applied. This rule utilises the fact that internal replication in an ANOVA design can elevate the degrees of freedom and so achieve power in a study involving a small number of practitioners and patients. The variance ratio (F), which must be exceeded in order to achieve statistical significance, initially falls rapidly and non-linearly as the degrees of freedom increase but then decreases less rapidly after 15 degrees of freedom, meaning that little extra power is gained by increasing the sample size of an experiment. Simple power statistics do not take into account the additional power gained in ANOVA designs that involve replication. (106, 193)

A table was constructed (Table 4.1), using Microsoft Excel (version 12, Office 2007, www.microsoft.com) to determine the number of optometrists and subjects (patients) required to achieve a residual error of at least 15 degrees of freedom (DF) in a two-factor (retinoscopes, optometrists) factorial ANOVA with randomised blocks (patients).(144, 193) The calculation was made separately for spot and streak retinoscopes. Explanation of terms used follows:

1. Factors: Two factors were considered. The ‘retinoscopes’ factor had 2 DF (3 levels [own, dedicated and combined] – 1). The factor for ‘optometrists’ had 1 DF (2 levels [experienced, inexperienced] – 1).
2. Interactions: interaction between the 2 factors (retinoscopes and optometrist) contributed a further 2 DF.
3. Randomised blocks: 5 DF were attributable to the 6 subjects (DF = 6 – 1 = 5).
4. Errors: The total DF was equal to 35 ([3 retinoscope levels x 2 optometrist levels x 6 subjects] - 1). The ‘factor and interaction DF’ is the sum of the DF (2 [retinoscope DF] + 1 [optometrist DF] + 5 [subject DF] + 2 [Retinoscope & optometrists interaction DF]). The ‘Residual error’ was the ‘total DF’ minus ‘factor and interaction DF’. Hence, the DF of the residual error was determined by the combination of variables, the number of levels of each variable and the number of subjects. It can, therefore, be seen that the DF of the residual error is not determined by the number of subjects alone.

Table 4.1 shows that 2 optometrists and 6 subjects were all that was needed to achieve sufficient statistical power (a residual error DF of at least 15). Therefore, 2 optometrists were recruited who preferentially used spot retinoscopes. Another 2 were recruited who

preferentially used streak retinoscopes. One optometrist in each pair had a high level of experience compared to the other.

Table 4.1. Table (Microsoft Excel spreadsheet) used to determine the number of optometrists (2) and patients (6) required to achieve a residual error of greater than 15 degrees of freedom (DF) in a two-factor (retinoscopes, optometrists) factorial ANOVA with randomised blocks (subjects).

Model: Each retinoscope used on ONE eye of SAME subject		
Factors:	Number:	Degrees of Freedom
Retinoscopes	3	2
Optometrists (differing experience)	2	1
Subjects (patients)	6	5
Interractions:		
Retinoscopes & optometrists		2
Errors:		
Total DF	36	35
Factor & interraction DF		10
Residual error (needs to be >15 DF)		25

Variance in the data was not taken into account in calculation of sample size using the 15DF rule.

4.3.2 Recruitment of optometrists

Participating optometrists were recruited from an invite posted on the Local Optical Committee newsletter that was distributed to all practices in Suffolk. Participating optometrists were chosen according to the following criteria:

1. They were Practising optometrists;
2. They had a preference for either spot or streak retinoscopy;
3. They were right hand and right eye dominant (as retinoscopy is only being carried out on the right eye of each patient). Corboy (194) stated that most practitioners are more comfortable holding the retinoscope in their dominant hand while sighting

through the peephole with their dominant eye. Safir et al.(195) found retinoscopy measurements more precise for right eyes compared with left. Hyams, Safir & Philpot (196) found no significant right versus left eye differences in the accuracy of retinoscopy but this criteria (of just investigating right eyes) has been used to reduce possible variables in other clinical trials.(179, 186, 188) Conducting the measurements on one eye only was in agreement with the majority (64%) of studies reviewed by Armstrong in 2013.(197);

4. They had indicated how experienced they were at using retinoscopy from the questionnaire shown in Appendix 13;

Details of participating optometrists, including retinoscopy experience, are shown in Table 4.2.

Table 4.2. Details of the four optometrists who participated in the clinical trial.

Optometrist Number	Type of retinoscope preferred	Retinoscopy experience			
		Date of qualification	Percentage of patients on whom retinoscopy typically performed	Main method of objective refraction	Classification for analysis
1	Spot	1986	1-25	Both about equally	Inexperienced Spot user
2		1969	100	Retinoscopy	Experienced Spot user
3	Streak	2008	1-25	Autorefractor	Inexperienced streak user
4		1994	100	Retinoscopy	Experienced Streak user

4.3.3 Subject recruitment

The 6 subjects recruited for this study were selected to meet the following criteria:

1. They were aged between 46 and 55 years (as this age group shows least discrepancy between retinoscopy and the final spectacle prescription, according to Millodot and O'Leary(126));
2. They had no noticeable cataract or other opacification of the ocular media (that could complicate retinoscopy and the subjective determination of spectacle prescription);

3. They did not wear contact lenses (that could lead to variable spectacle prescription);
4. They were not using eye drops (that could lead to variable spectacle prescription);
5. They had a good retinoscopic reflex and subjective responses.

4.3.4 Data collection: Objective refraction

In order to minimize inconvenience the clinical trial was completed in just half a day (between 2pm and 7.30pm) with optometrists and subjects that lived or worked close to the site of the clinical trial.

All 4 optometrists were asked to perform static retinoscopy (an orthodox method taught to all optometrists)(29) using their preferred type of retinoscope (spot or streak) on the right eye of six subjects using 3 different retinoscopes:

1. Their own retinoscope;
2. A Keeler dedicated retinoscope;
3. A Keeler combination retinoscope.

The rationale behind each optometrist also using their own instrument was that this gave an opportunity to investigate whether an optometrist is most likely to perform better with an instrument that they are familiar, although this was not the central purpose of the study. However, each optometrist preferred different retinoscopes and this will have confounded comparisons between instruments. Therefore, all optometrists were required to repeat retinoscopy with a Keeler dedicated and combined instrument. Instruments were kindly loaned by Keeler UK Ltd for this study. Although the dedicated instruments were of an older design they were, none the less, in excellent condition as checked by the manufacturers. All participating optometrists used Keeler retinoscopes habitually. However, both spot users habitually used dedicated instruments while both streak users habitually used combined instruments. The details of all instruments used for the trial pilot study are described in Table 4.3.

Table 4.3. Details of retinoscopes used in the trial.

Origin	Category	Description	Date of manufacture
Loaned by Keeler UK Ltd	Designated streak	Hamblin Purvis Streak, labelled No. 8	1995
	Combined streak	Keeler Professional Combi with streak bulb, labelled No. 1.	2008
	Dedicated spot	Keeler V type with flared base, labelled No. 4	pre-1999, probably around 1990
	Combined spot	Keeler Professional Combi with spot bulb, labelled No. 2	2008
Participants own retinoscopes	Dedicated spot, used by Optometrist 1	Keeler Vista Spot	pre-1999
	Dedicated spot, used by Optometrist 2	Keeler V type spot	pre-1990
	Combined streak, used by Optometrists 3 &4	Keeler Professional Combi	post-2005

All participating optometrists were told that speed was not of importance but time would be limited to 4 minutes per eye with a further 3 minutes allowed between patients to record the result, swap patients and fit the trial frame. Three minutes of practice time was made available initially (on a model eye) for each of the new instruments provided. Retinoscopy was performed under low ambient illumination. A duochrome target was used for patient fixation and the eye not being tested was fogged. To reduce potential errors caused by obliquity of observation practitioners were requested to ensure they keep within 5 degrees from the visual axis of the eye being measured (11, 13) but not to block the binocular view of the fixation target where possible. Jackson et al.(198) stated that, erroneously induced cylinder power increased by an average of 3% for each degree the retinoscopist is off axis. Hodd (11) offered reassurance that, off axis errors are small as long as the retinoscopist keeps within 8 degrees from the visual axis. Participating optometrists were asked to record each retinoscopy result after allowance for working distance but a recommended working distance was not suggested.

4.3.5 Data collection: Spectacle prescription

All six subjects had their spectacle prescription determined for their right eye prior to the trial by the lead investigator. This involved objective and subjective refraction followed by the +1.00 blur test. As used by Grosvenor et al (181) and Mallen et al.(177), the endpoint for subjective findings was maximum plus or minimum minus power for best acuity, since this is an orthodox method with a clearly defined end point and is not influenced by modification for the prescribing of spectacles. The spectacle prescription of each subject was not made known to the participating optometrists during the clinical trial.

4.3.6 Data analysis: Scalar vectors

Accuracy was determined by comparing each retinoscopic result to the corresponding spectacle prescription.

Fourier components for spectacle prescription (M_{spx}, $J0_{spx}$, $J45_{spx}$) and retinoscopy (M_{ret}, $J0_{ret}$, $J45_{ret}$) were calculated as follows:

M = mean spherical equivalent = sphere + (cylinder power/2),
J0= orthogonal cylinder = -(0.5x cylinder power) cosine (2 x axis), and
J45= oblique cylinder = -(0.5 x cylinder power) sine (2 x axis).

Differences between the Fourier (ΔM, ΔJ0, ΔJ45) components were calculated as follows:

$$\Delta M = M_{spx} - M_{ret}$$

$$\Delta J0 = J0_{spx} - J0_{ret}$$

$$\Delta J45 = J45_{spx} - J45_{ret}$$

Scalar vectors (U) were calculated as follows:

$$U = \sqrt{(\Delta M^2 + \Delta J0^2 + \Delta J45^2)}$$

Thus, a single scalar quantity (U) was calculated, using Fourier components, to represent the difference between two sphero-cylindrical prescriptions. This treatment of the results is currently advocated to overcome the difficulties of comparing prescriptions expressed in sphero-cylindrical form or Mean Spherical Equivalent (MSE). This method was proposed by Rabbetts in 1996 (199, 200) and Thibos et al. in 1997 (201), following on from work by Bennett (202) and Harris (203). Expressing and analysing prescriptions using three Fourier coefficients takes into account the magnitude and axis of astigmatism and offered a method of deriving a scalar quantity. This method of presenting and analysing spectacle prescriptions has since been used in numerous studies.(176, 177, 186, 201, 204, 205)

4.4 Results

The subjects recruited had the following attributes:

Age range: 45.6 to 55.1 years (mean age 51.5 years);

Spherical power: -0.75 to +1.00D;

Astigmatism: -0.25 to -1.00DC.

The mean difference between subjective and retinoscopic refraction (in Dioptres) for each of the Fourier components of the prescription and for each type of retinoscope are shown in Tables 4.4- 4.9. Appendices 23 & 24 show the results displayed as a chart for spot and streak retinoscopy separately and include 95% confidence limits. The mean spherical equivalent difference between subjective and objective refraction for spot and streak retinoscopy was -0.20D and +0.03D respectively. The mean difference in spherical equivalent between subjective and objective refraction for all retinoscopes was -0.09D. That the mean of all spherical equivalent differences (ΔM) is -0.09 shows the retinoscopy results were 0.09D more positive than the subjective data. Inspection of the differences for mean spherical equivalent showed 64% of spot retinoscopy readings were more positive compared with the subjective result whereas streak retinoscopy exhibited equal numbers of positive and negative errors.

Table 4.4. Difference between subjective and retinoscopic refraction (in Dioptres) for the Fourier components of the prescription for dedicated spot retinoscope users. Also shows patient identifier number, mean and standard deviation. ΔM = difference in mean spherical equivalent, ΔJ0 = difference in orthogonal cylinder, ΔJ45 = difference in oblique cylinder.

Optometrist experience	Patient number	Difference between subjective & objective refraction			
		ΔM	ΔJ0	ΔJ45	U
	1	-0.50	0.26	0.09	0.57
	2	0.75	0.39	-0.06	0.85
	3	0.13	-0.12	-0.04	0.18
	4	0.38	-0.14	-0.06	0.41
	5	0.00	-0.01	0.13	0.13
inexperienced	6	0.38	0.11	-0.13	0.41
	1	-0.25	0.76	0.09	0.80
	2	0.00	-0.04	-0.01	0.04
	3	-0.75	0.00	0.00	0.75
	4	0.00	-0.02	-0.06	0.06
	5	-0.13	-0.13	0.09	0.20
experienced	6	-0.38	-0.39	-0.13	0.56
Mean		-0.03	0.06	-0.01	0.41
Standard Deviation		0.41	0.30	0.09	0.29

Table 4.5. Difference between subjective and retinoscopic refraction (in Dioptres) for the Fourier components of the prescription for combined spot retinoscope users. Also shows the patient identifier number, mean and standard deviation. ΔM = difference in mean spherical equivalent, ΔJ0 = difference in orthogonal cylinder, ΔJ45 = difference in oblique cylinder.

Optometrist experience	Patient number	Difference between subjective & objective refraction			
		ΔM	ΔJ0	ΔJ45	U
	1	-0.75	0.01	0.09	0.76
	2	0.50	0.39	-0.06	0.64
	3	-0.13	-0.12	-0.04	0.18
	4	0.38	-0.14	-0.06	0.41
	5	-0.25	-0.01	0.13	0.28
inexperienced	6	-0.13	0.11	-0.13	0.21
	1	-1.50	0.76	0.09	1.68
	2	-0.38	-0.10	0.09	0.40
	3	-1.38	-0.12	-0.04	1.38
	4	-0.25	-0.02	-0.06	0.26
	5	-0.63	-0.13	0.09	0.64
experienced	6	-1.13	-0.39	-0.13	1.20
Mean		-0.47	0.02	0.00	0.67
Standard Deviation		0.63	0.30	0.09	0.50

Table 4.6. Difference between subjective and retinoscopic refraction (in Dioptres) for the Fourier components of the prescription for spot retinoscope users using their own retinoscope. Also shows patient identifier number, mean and standard deviation. ΔM = difference in mean spherical equivalent, ΔJ0 = difference in orthogonal cylinder, ΔJ45 = difference in oblique cylinder.

Optometrist experience	Patient number	Difference between subjective & objective refraction			
		ΔM	ΔJ0	ΔJ45	U
	1	-0.50	0.26	0.09	0.57
	2	0.50	0.39	-0.06	0.64
	3	-0.13	-0.12	-0.04	0.18
	4	0.38	-0.14	-0.06	0.41
	5	-0.25	-0.01	0.13	0.28
inexperienced	6	-0.13	0.11	-0.13	0.21
	1	-0.25	0.76	0.09	0.80
	2	0.00	-0.04	-0.01	0.04
	3	-0.75	0.01	-0.04	0.75
	4	0.13	0.11	-0.06	0.18
	5	-0.13	-0.13	0.09	0.20
experienced	6	-0.13	-0.39	-0.13	0.43
Mean		-0.10	0.07	-0.01	0.39
Standard Deviation		0.34	0.30	0.09	0.25

Table 4.7. Difference between subjective and retinoscopic refraction (in Dioptres) for the Fourier components of the prescription for dedicated streak retinoscope users. Also shows patient identifier number, mean and standard deviation. ΔM = difference in mean spherical equivalent, ΔJ0 = difference in orthogonal cylinder, ΔJ45 = difference in oblique cylinder.

Optometrist experience	Patient number	Difference between subjective & objective refraction			
		ΔM	ΔJ0	ΔJ45	U
	1	0.13	0.37	-0.07	0.40
	2	0.88	0.02	-0.12	0.88
	3	-0.25	0.01	-0.04	0.25
	4	0.50	-0.02	-0.06	0.50
	5	-0.13	0.11	0.17	0.24
inexperienced	6	0.00	-0.27	-0.13	0.30
	1	-0.13	0.62	-0.11	0.64
	2	0.00	0.15	-0.12	0.19
	3	-0.38	0.13	-0.04	0.40
	4	0.00	-0.01	-0.04	0.04
	5	-0.25	0.14	-0.28	0.40
experienced	6	-0.13	-0.14	-0.13	0.23
Mean		0.02	0.09	-0.08	0.37
Standard Deviation		0.35	0.23	0.10	0.22

Table 4.8. Difference between subjective and retinoscopic refraction (in Dioptres) for the Fourier components of the prescription for combination streak retinoscope users. Also shows patient identifier number, mean and standard deviation. ΔM = difference in mean spherical equivalent, ΔJ0 = difference in orthogonal cylinder, ΔJ45 = difference in oblique cylinder.

Optometrist experience	Patient number	Difference between subjective & objective refraction			
		ΔM	ΔJ0	ΔJ45	U
	1	0.00	0.45	0.43	0.62
	2	1.13	0.02	-0.12	1.13
	3	-0.13	0.13	-0.04	0.19
	4	0.75	-0.27	-0.06	0.80
	5	-0.38	-0.13	0.09	0.41
inexperienced	6	-0.13	-0.14	-0.13	0.23
	1	-0.13	0.56	-0.30	0.65
	2	0.13	0.02	-0.12	0.18
	3	-0.38	0.13	-0.04	0.40
	4	0.13	-0.13	0.00	0.18
	5	0.00	-0.01	-0.04	0.04
experienced	6	-0.13	-0.14	-0.13	0.23
Mean		0.07	0.04	-0.04	0.42
Standard Deviation		0.44	0.25	0.17	0.32

Table 4.9. Difference between subjective and retinoscopic refraction (in Dioptres) for the Fourier components of the prescription for streak retinoscope users using their own retinoscope. Also shows patient identifier number, mean and standard deviation. ΔM = difference in mean spherical equivalent, ΔJ0 = difference in orthogonal cylinder, ΔJ45 = difference in oblique cylinder.

Optometrist experience	Patient number	Difference between subjective & objective refraction			
		ΔM	ΔJ0	ΔJ45	U
	1	0.00	0.45	0.43	0.62
	2	1.00	-0.10	-0.12	1.01
	3	-0.13	0.13	-0.04	0.19
	4	0.63	-0.14	-0.06	0.64
	5	-0.50	0.00	0.09	0.51
inexperienced	6	-0.13	-0.14	-0.13	0.23
	1	-0.38	0.80	-0.38	0.96
	2	0.00	0.15	-0.12	0.19
	3	-0.38	0.13	-0.09	0.41
	4	0.00	-0.26	0.00	0.26
	5	0.00	-0.01	-0.04	0.04
experienced	6	-0.25	-0.02	-0.17	0.30
Mean		-0.01	0.08	-0.05	0.45
Standard Deviation		0.43	0.29	0.19	0.31

Table 4.10 shows the mean accuracy of each type of retinoscope compared to spectacle prescription (expressed as a scalar vector U) and the dispersion of the results (Coefficient of Variation , CV; Standard deviation expressed as a percentage of the mean). Here, the higher the CV, the greater the dispersion in the data. Interestingly, the experienced optometrists appeared to exhibit the greatest variation in accuracy.

Table 4.10. Results of the clinical trial. The scalar vectors, U, represent the accuracy (overall difference between retinoscopy and spectacle prescription, in Dioptres) and Coefficient of Variation (CV) is the standard deviation expressed as a percentage of the mean.

Retinoscope Type	Optom Number	Experience	Retinoscope used	Mean U	CV (%)
Spot	1	Inexperienced	Own	0.38	50.3
			Dedicated	0.43	52.2
			Combined	0.41	57.7
	2	Experienced	Own	0.40	79.2
			Dedicated	0.40	85.2
			Combined	0.93	62.1
Streak	3	Inexperienced	Own	0.53	57.0
			Dedicated	0.43	57.0
			Combined	0.56	64.6
	4	Experienced	Own	0.36	88.1
			Dedicated	0.32	65.4
			Combined	0.28	76.5

Tables 4.11 & 4.12 show the ANOVA results for spot and streak retinoscopy errors. No statistically significant effects were found for spot retinoscopy. Only one statistically significant finding arose at the 95% level and this was for streak retinoscopes; the optometrists differed in their accuracy ($F_{1,25} = 5.42$, $P < 0.05$) but this difference was not influenced by retinoscope design. None of the streak or spot retinoscopes influenced the variations in the scalar vector U.

Table 4.11. Result of a 2 factor factorial (optometrists x retinoscopes) ANOVA in randomised blocks for spot retinoscopy errors. No statistically significant effects were found at the 95% level.

	DF	F	P-value
optometrist	1	3.06	0.09
retinoscopes	2	3.30	0.08
optometrist x retinoscope	2	3.07	0.09
block (subjects)	5		
error	25		

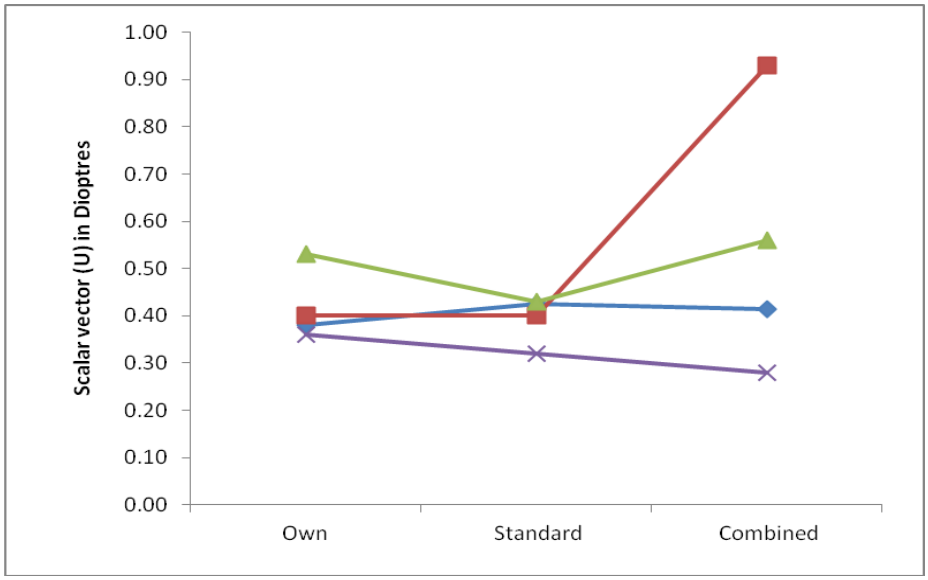
Table 4.12. Result of a 2 factor factorial (optometrists x retinoscopes) ANOVA in randomised blocks for streak retinoscopy errors. Only one statistically significant finding arose at the 95% level; the optometrists differed in their accuracy ($F_{1,25} = 5.42$, $P < 0.05$) but this difference was not influenced by retinoscope design.

	DF	F	P-value
optometrist	1	5.42	0.03
retinoscopes	2	0.28	0.60
optometrist x retinoscope	2	0.38	0.54
block (subjects)	5		
error	25		

The results showed that one experienced practitioner performed worse using a combination retinoscope with a spot bulb. However, analysis showed that combination retinoscopes are no less accurate than non-combination types. None of the spot retinoscopes influenced the variations in the scalar vector U.

Results for the accuracy of each type of retinoscope are displayed in Figure 4.1. Appendices 17 & 18 show the results displayed for spot and streak retinoscopy separately and include 95% confidence limits.

Figure 4.1. Spot and streak retinoscopy inaccuracy values (U) for different types of retinoscopes. Inexperienced spot user = blue, experienced spot user = red, inexperienced streak user = green, experienced streak user = purple.



4.5 Discussion

The UK survey (chapters 2 & 3; figure 2.11 and section 3.4.5) had demonstrated that combined retinoscopes are popular especially for newly qualified optometrists. Keeler retinoscopes were the most popular which justified the clinical trial being restricted to this manufacturer. The trial was further justified as it showed that use of combined retinoscopes was increasing and yet no research into the accuracy of these newer models had been previously published. In the authors' opinion, the latest combined instruments were not as accurate as dedicated designs. Combined models were also popular as they reduced manufacturing costs (since spot and streak instruments were exactly the same apart from the bulbs) and gave the opportunity to change from spot to streak use without needing to buy a new instrument.

The trial provided no evidence that newer combined spot or streak retinoscopes, with known design compromises, were less accurate than the older dedicated types. This information might be reassuring for undergraduate optometrists who are purchasing retinoscopes for the first time, but do not yet have the skills or experience to be able to make comparisons

regarding instrument accuracy. It is important for undergraduate, graduate and newly qualified optometrists to be aware of the characteristics and limitations of various retinoscopes in order to make an informed choice of instrument. Spot retinoscopy may be preferable for detecting changes in the ocular media (49) and streak may be easier for the novice to detect astigmatism.

Post-hoc power calculations are not possible to confirm that all statistical analyses achieved at least 80% power for large size effects. (144, 206) This is because a GPower test (using GPower Version 3.1.2) (207-209) was unable to have calculated minimum sample sizes required for such a complicated factorial ANOVA.

The trial showed that retinoscopy most often fell within 0.50D of the spectacle prescription (61%, 44 out of 72). Putting this in context, spectacles are prescribed in 0.25D steps and retinoscopy findings are recorded for sphere and cylinder to the nearest 0.25D.(29). Retinoscopy accuracy is also expected to be within +/- 1.00D sphere and cylinder for pre-registration optometric assessment. (210)

The results show that none of the retinoscopes influenced the variations in the scalar vector, U. This means that optometrists were no more or less accurate using their own retinoscope compared with those supplied by Keeler UK Ltd.

Various aspects of the present study and previous studies that have compared accuracy of retinoscopy with subjective refraction are shown in Table 4.13. The present study showed that retinoscopy results were more positive compared to the spectacle prescription for the mean spherical equivalents. This is in agreement with most of these studies, as well as earlier work by Charman (211)and Glickstein & Millodot.(212) This is also corroborated by Allen, Fletcher & Still who state that most retinoscopists should expect, “a little more plus by retinoscopy in most cases.” (213) According to Millodot & O’Leary (126) this tendency is greater when testing young eyes and is attributable to the site of the retinoscope reflex, the refractive index of the vitreous and chromatic and spherical aberrations. However, Grosvenor et al.(181) and Jorge et al. (186) found retinoscopy gave a more negative result.

Table 4.13 also shows that this study used the smallest number of patients. Interestingly, Guillon (182) also used a small sample due to the difficulties in obtaining patients who were willing to participate.

Table 4.13. Various aspects of the present study (highlighted in bold) compared with previous studies that have compared accuracy of retinoscopy against subjective refraction. All studies are arranged in chronological order. SE = Spherical equivalent (Sphere - ½ Cylinder).

Authors, country	Number of patients	R, L or both	Eyes tested	Age range of patients	Number of Optoms.	Method of analysis	Mean Sphere difference; Retinoscopy vs Subjective (D)	Key message regarding accuracy of retinoscopy
Mohindra (1977), USA(214)	27	both	54	20-35	1	Mean SE	+1.24	Promotes "Near retinoscopy" technique
Millodot & O'Leary (1978), UK(126)	1078	both	1078	5-80	3	Mean SE	+0.33 (age 5-15 years) Nil (at age 60 years approx)	Retinoscopy finds too much plus in young eyes
Belkin & Horev (1982), Israel(185)	70	-	97	52-75	Unknown	Results compared in a single meridian, t-test	Unknown amount but more plus found by retinoscopy	Ultrasonographic refraction more accurate than retinoscopy in aphakic patients
Grosvenor et al (1985), USA(181)	100	-	-	6-15	Unknown-Students	Mean SE Note: practitioners aware of old prescription	-0.01	Retinoscopy & Subjective compare favorably
Guillon (1986), UK(182)	17	both	21	38-80	3	Mid-equivalent Sphere data paired	Spot +0.75 Streak +0.45	Automatic refraction comparable with retinoscopy for aphakic patients
Zadnik et al (1992), USA (179)	40	R	20	20-43	2	Mean SE, paired t-test	+0.31	Cycloplegic retinoscopy unreliable
Jorge et al (2005), Portugal (186)	192	R	192	18-34	1	Means calculated from scalar vectors	-0.02	Retinoscopy more accurate than automatic refraction
Funarunart (2009), Thailand (188)	120	R	60	6-13	3	Mean SE, paired t-test	+0.07	Non-cycloplegic retinoscopy accurate
Present study, UK	**6**	**R**	**6**	**46-55**	**4**	**Scalar vectors, mean SE & 2 Factor Factorial ANOVA**	**+0.09D (Spot +0.20, Streak -0.03)**	**Combined retinoscopes are accurate & validation of the'15 DF rule'**

4.5.1 The ’15 DF rule’

Enough power is established if the residual error is at least 15DF. The present study demonstrated how, in this case, a factorial design with replication can achieve sufficient statistical power with recruitment of just two optometrists and six patients. Internal replication was achieved by using the combination of retinoscopes, optometrists and subjects.

Financial restrictions and difficulties in recruiting optometrists (especially inexperienced spot users) limited the size of the clinical trial. Costly recruitment of large numbers of optometrists or patients would be considered unethical and poor value for money if sufficient statistical power was achieved with smaller samples sizes.(215)

4.5.2 Limitations

The ’15 DF rule’ showed that the experimental design used in this study had sufficient power. Although this means that this study had demonstrable internal validity, a larger study (involving greater numbers of optometrists and patients with greater range of refractive errors) would be desirable to provide convincing external validity. A limitation of the ‘15 DF rule’ for calculation of sample size is that variance in the data was not taken into account. A post-hoc method of statistical analysis to consider variance and power is currently unavailable for such a complicated factorial ANOVA.

Mallen et al. (177) compared the accuracy of autorefraction and subjective refraction. They converted refractive results into vectors and comparison between measures was performed using paired two-tailed t-tests. This method produced robust and valid results using considerably more tests as established using traditional statistical analyses; 200 eyes were refracted using an autorefractor and conventional subjective techniques on 100 subjects.

Retinoscopy working distance and sight-hole diameter are potential variables in retinoscopy accuracy (Chapter 1, section 1.1) which were not controlled in this trial.

4.6 Conclusion

There was no evidence to suggest that changes made by Keeler in the design of their combined retinoscopes made them less accurate. The result of this trial, together with the result of the questionnaire that found high levels of satisfaction with Keeler streak combination retinoscopes, allowed this study to refute the author's original opinions regarding combined retinoscopes.

A secondary purpose of this study was to evaluate a relatively unknown method of determining statistical power, the '15 DF rule'. This has been shown to be easy to apply and more clinical researchers might like to know about this rule which has been published (106, 193) but perhaps overlooked by the optometric profession.

The next chapter considers the use of static and dynamic retinoscopy in other countries .

4.7 Key points

- A pilot trial has investigated the accuracy of combined vs designated retinoscopes.
- The '15 DF' rule was used to calculate the sample size required.
- 4 optometrists performed retinoscopy on the right eyes of 6 subjects using 3 different retinoscopes.
- The '15 DF rule' showed that the experimental design used in this study had sufficient power.
- There was no evidence to suggest that changes made by Keeler in the design of their combined retinoscopes make them less accurate than dedicated models.

5.0 An international perspective on the use of retinoscopy by optometrists attending contact lens related courses

5.1 Introduction

The World Council of Optometry (WCO) defined optometrists as "the primary healthcare practitioners of the eye and visual system who provide comprehensive eye and vision care, which includes refraction and dispensing, detection/diagnosis and management of disease in the eye".(216) It is difficult to compare the expected duties and customs of optometrists from other countries due to the wide variation in training and regulations, and the different professions involved in eye care. For example, in the Netherlands the dispensing opticians are involved with refraction. Regulations sometimes fail to specifically mention retinoscopy and it is difficult to ascertain what is actually going on in respect of objective refraction. (217) It can be assumed from the WCO definition that optometrists will be expected to be able to carry out objective refraction but this can be either autorefraction or retinoscopy. The European Council of Optics and Optometry (ECOO) outlined the scope of practice and described objective refraction as a 'permitted' process for all European countries surveyed apart from Slovenia, Romania, Belgium and Luxemburg. Objective refraction was 'not permitted but done in practice' in Slovenia. Information was unavailable for Romania, Belgium and Luxemburg. (218) The syllabus of the European Diploma in Optometry stated that, "knowledge, understanding and testing skills should be demonstrated in …..objective static and dynamic refractive status, including automatic refractive devices."(219) A report comparing primary eye care in France, Germany and the UK mentioned objective refraction but not specifically retinoscopy. (220) German optometry regulations suggested the use of retinoscopy while testing for ametropia and anisometropia.(221) In Russia, retinoscopy was given an importance value of 0.2 out of 1.0 by ophthalmologists for use during the examination of several categories of patients.(222) Optometry was not officially established in Russia until 1995. (223)

An opportunity became available to gain an insight into international static and dynamic retinoscopy habits using a small item questionnaire presented to delegates of international contact lens courses.The purposes of this study were:

1. To determine whether retinoscopy habits were influenced by date of qualification and the country worked in;
2. To investigate retinoscopy habits in terms of 1) whether static retinoscopy is the primary method of objective refraction and, 2) whether dynamic retinoscopy is used.

The author was not aware of any previous studies regarding the retinoscopy habits of optometrists internationally. See Table 1.1 for details of electronic literature searches.

5.2 Methods

5.2.1 Survey Design

The survey items used in this study were taken from part of the UK survey (described in chapters 1 and 2) which was first piloted with five UK Optometrists to ensure that it was (i) easily understood, (ii) clinically relevant and (iii) brief enough. These aspects are known to promote maximum response rates.(108, 109) The UK piloting process facilitated the survey construction but falls short of validation which is a complex process.(106, 110) The international survey described in this chapter had not been piloted for the intended audience, which would have required input from international optometrists, because the window of opportunity was too brief to allow this.

The international survey included 5 items (see Table 5.1) using similar wording and answer options as used in the UK National Retinoscopy Survey.(224) The questionnaire was printed on paper, answered using tick boxes and designed so that it took no more than 5 minutes to complete. The questionnaire was distributed in English for the majority of the nationalities surveyed and translated for the Russian, Czech & Slovak Federal Republic and 'Dach' (Germany, Austria and Switzerland) audiences. See appendix 19 for the exact form used in English and appendices 20-22 for the translated versions.

The survey included a question that asked about the profession to which each respondent belonged. This was because the questionnaire was distributed to a range of eye care practitioners with an interest in contact lenses, rather than specifically to optometrists. The

results from optometrists and ophthalmologists were investigated in this study. Potential influencing factors of the country worked in and the date of qualification were ascertained. The country worked in was gathered by the course organizers and the date of qualification was asked in the survey. Other questions were used to determine retinoscopy habits. The survey also asked for the respondent's consent to have their responses analysed for the purposes of research and publication.

Table 5.1. Survey items that represent influencing factors, habits and profession of cohort. The full questions of the international survey, with alternative responses, are shown.

Nature of question		Full question with alternative responses
Potential Influencing factors	'Age'	When did you qualify as an eye care practitioner? 1965-1979, 1980-1994, 1995-2010, 2011, no qualifications. (For analysis date of qualification has been combined as 1965-1994 ('older) and 1995-2011 ('younger'))
	Country or area	Dach (Germany, Austria and Switzerland), Czech and Slovak Federal Republics, Russia, South East Europe(Bulgaria/Croatia/Romania /Slovenia), Benelux (Belgium/Netherlands/Luxembourg), Kingdom of Saudi Arabia, Kuwait, Kingdom of Bahrain, Qatar, United Arab Emirates, Nordic (Sweden/Norway/Finland/Denmark), UK
Habits	Retinoscopy or autorefraction	What is your primary method of objective refraction? Retinoscopy, Autorefractor, both about equally, no objective refraction.
	Dynamic retinoscopy use	Dynamic retinoscopy (i.e. use of a retinoscope to give information regarding accommodation) is used: Occasionally, Frequently, Never.
Profession	To establish optometrist cohort	What is the profession to which you belong? Ophthalmologist, Dispensing Optician, optometrist, no qualification

A secondary objective of this study was to investigate any differences in retinoscopy habits between the optometrists and ophthalmologists surveyed since it was likely that both professions carry out eye examinations and contact lens consultations. For these analyses, data from both professions was included and profession was entered as a possible influencing factor.

5.2.2 Survey distribution

Practitioners from across mainland Europe, Russia and the Middle East, attending The Vision Care Institute's of Johnson and Johnson Ltd in UK, Prague and Dubai, were surveyed during September and October 2011.

The invite to participate (See appendix 10) explained that (1) the aim of the survey was to determine the retinoscopy habits of eye care practitioners, (2) to ascertain whether practitioners felt that retinoscopy was an important test and (3) the survey results were to be published and may be the stimulus for debate regarding the relevance or otherwise of static and dynamic retinoscopy in routine optometric examination. No incentive to participate was offered.

5.2.3 Statistical Analysis

Multivariate analysis was performed using SPSS Version 20.0 (IBM SPSS Statistics)(147) and involved Decision Tree Analysis using the CHAID (Chi-squared Automatic Interaction Detection) tree growing method.(148) (See chapter 3, section 3.3.2) CHAID default settings for parent and child nodes on SPSS were set as: sample size of 50 for parent nodes and sample size 20 for child nodes. These were chosen to match those of the UK study. The default setting for growth limits was set to 4. Decision tree analysis has been used in eye related studies by Yu et al.(160) and Twa el al.(161).

5.3 Results

5.3.1 Optometrist responses

Responses were received from 583 eye care practitioners (optometrists, ophthalmologists, dispensing opticians and other professions). Analyses were restricted to the responses from qualified optometrists who reported using objective refraction and responses from Kuwait (n=1), Kingdom of Bahrain (n=2) and Qatar (n=1) were deselected as numbers were small. The responses from dispensing opticians (n=81) were deselected since only 3 (4%) reported using retinoscopy. The cohort of the sample analysed (n= 334) is shown in Table 5.2. Date of qualification was divided into two groups for convenience and because numbers who qualified in 1965-1979 and 2011 were small.

Table 5.2. Distribution of potential influencing factors for respondents (optometrists that reported carrying out objective refraction) whose data was analyzed in this study (n=334).

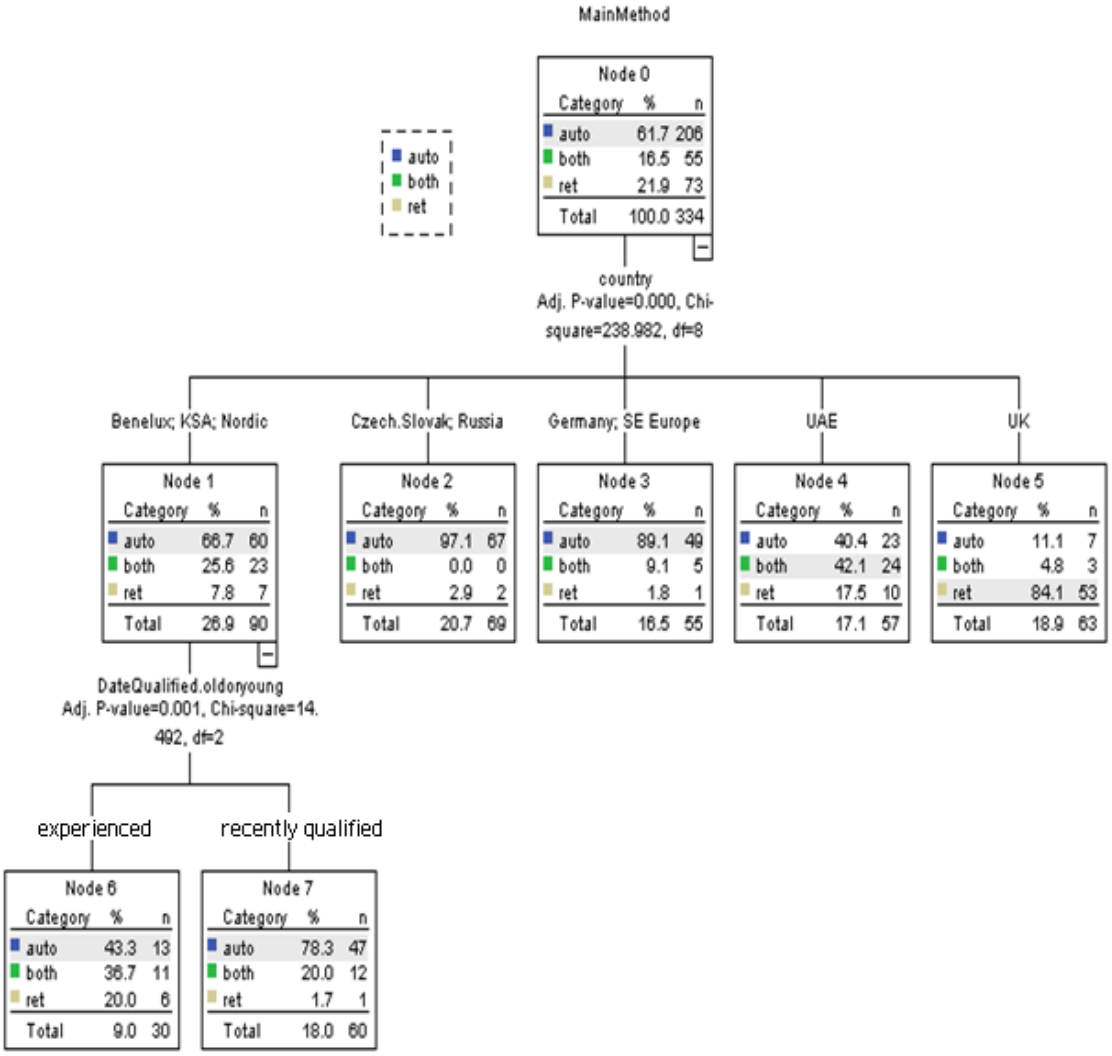
Country	Total	Date of qualification	
		Qualified 1995-2011 'recently qualified'	Qualified 1965-1994 'experienced'
Germany, Austria & Switzerland	36	18	18
Czech and Slovak Federal Republic	58	46	12
Russia	11	11	0
South East Europe(Bulgaria/ Croatia/Romania/Slovenia)	19	19	0
Benelux (Belgium/Netherlands/Luxembourg)	11	6	5
Kingdom of Saudi Arabia	12	11	1
United Arab Emirates	57	46	11
Nordic(Sweden/Norway/Finland/Denmark)	67	43	24
UK	63	34	29

The cohort for each of the potential influencing factors is shown in Appendix 23 (for all 583 respondents) and Appendix 24 (for the 338 optometric respondents who reported using

objective refraction). Responses from three countries with small numbers (n= 4) were deselected leaving a cohort of 334 optometrists.

CHAID decision tree analysis (Figure 5.1) showed that the country worked in influenced the main method of objective refraction. UK optometrists used retinoscopy most (84%) as their main method of objective refraction compared with all other countries (18% - 2%); Chi = 238, df = 8, P<0.001. Autorefraction was used as the main method of objective refraction by more than half (62%) of the respondents. Date of qualification was an influencing factor for one group of countries; 'experienced' optometrists (qualified prior to 1995) from Benelux, KSA and Nordic use retinoscopy more as their main method (20%) compared with the 'recently qualified' group (2%) who qualified 1995-2011; Chi = 14, df = 2, P < 0.005. CHAID analysis grouped together countries with similar responses.

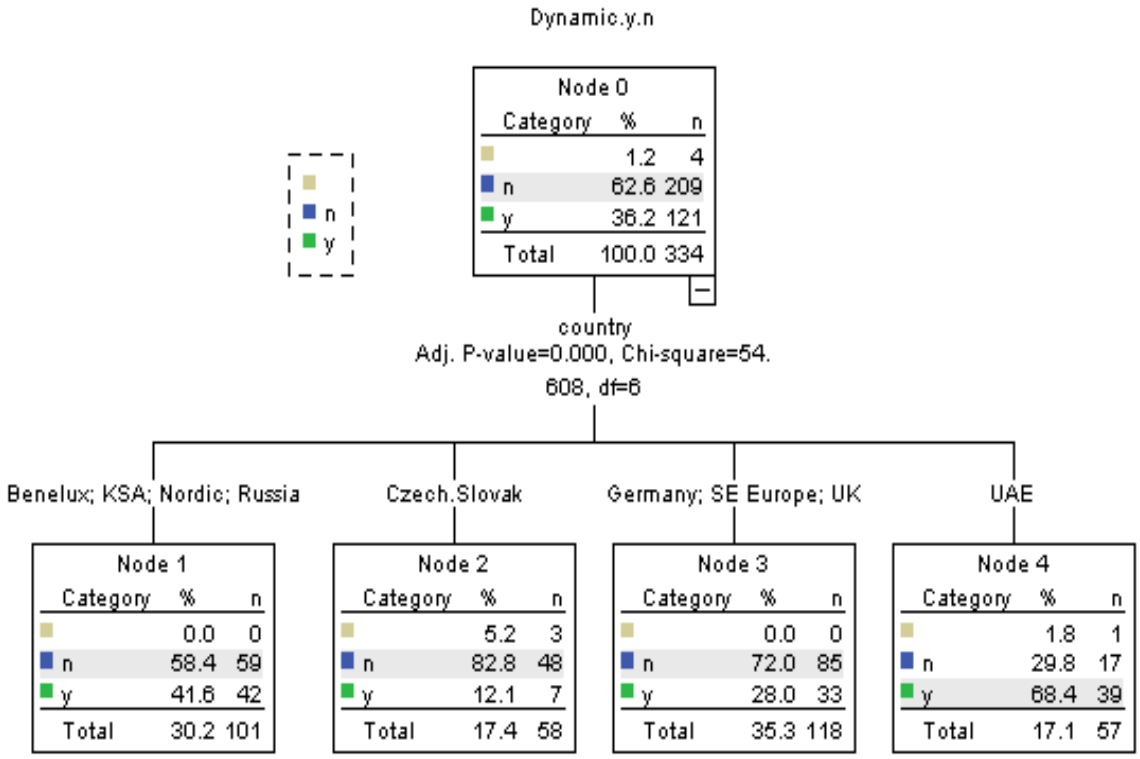
Figure 5.1. Chi-squared Automatic Interaction Detection (CHAID) Decision Tree analysis showing how main method of objective refraction for optometrists was influenced by the country worked in. Optometrists from UK used retinoscopy most (84%) compared with all other countries (18% - 2%). 'Experienced' optometrists (qualified prior to 1995) from Benelux, KSA and Nordic use retinoscopy more as their main method (20%) compared with the 'recently qualified' group (2%) who qualified 1995-2011. (auto = autorefractor, ret = retinoscopy, both =retinoscopy and autorefractor used about equally).



Only 36% of optometrists used dynamic retinoscopy (Figure 5.2). Optometrists from United Arab Emirates used this technique most (68%) and the Czech and Slovak Federal Republic least (12%); Chi = 54, df = 6, P < 0.001. Less than a third (28%) of optometrists from Germany,

UK & SE Europe used this technique. Date of qualification was not an influencing factor. For this analysis, the dynamic retinoscopy response categories of ‘occasional‘ and ‘frequent‘ were re-classified as 'yes' (y) and the response category ‘never’ as 'no'(n).

Figure 5.2. Chi-squared Automatic Interaction Detection (CHAID) Decision Tree analysis showing how use of dynamic retinoscopy by optometrists was influenced by the country worked in. Optometrists from United Arab Emirates (UAE) used this technique most (68%) and the Czech and Slovak Federal Republic least (12%); Chi = 54, df = 6, P < 0.001. (n = dynamic retinoscopy never used, y = dynamic retinoscopy used occasionally or frequently)



The CHAID analyses for main method of objective refraction and reported use of dynamic retinoscopy correctly classified 76% and 69% of the data, respectively, and were statistically significant (P< 0.001).

5.3.2 Ophthalmologist responses

Consideration was also given to both optometrist and ophthalmologist responses. All data from the survey was analysed, after deselection of (1) those respondents not either using retinoscopy, autorefractor or both as main method of objective refraction, (2) dispensing opticians, and (3) those without qualification. Responses from Kuwait (n=1), Kingdom of Bahrain (n=2) and Qatar (n=1) were also deselected as numbers were small. This gave a total of 468 responses (ophthalmologists n=134, optometrists n= 334).

Figure 5.3 shows that SPSS CHAID analysis has determined that locality (country) was an independent variable that influenced what type of objective refraction was used. Retinoscopy was used as a main method most by practitioners from UK (84%) and least by Czech & Slovak Federal Republic (3%).The model correctly classified 74% of the data and was highly statistically significant; Chi = 281, df = 6, P< 0.001. Date of qualification effected retinoscopy use for one group of countries (n= 279). From these countries, the group qualifying between 1995-2011 ('recently qualified') used the autorefractor more (80%), compared with those qualifying prior to 1995 ('experienced')(60%); Chi = 13, df = 2, p< 0.005. Interestingly, profession was been found not to be an influencing factor.

Figure 5.3. Chi-squared Automatic Interaction Detection (CHAID) Decision Tree analysis showing how main method of objective refraction for optometrists and ophthalmologists was influenced by the country worked in. Retinoscopy was used as a main method most by practitioners from UK (84%); Chi = 281., df = 6, P< 0.001. Date of qualification effected retinoscopy use for one group of countries (n= 279). From these countries, the group qualifying 1995-2011 ('recently qualified') used retinoscopy less and autorefractor more, compared with those qualifying prior to 1995 ('experienced'); Chi = 13, df = 2, p< 0.005. (auto = autorefractor, ret = retinoscopy, both =retinoscopy and autorefractor used about equally).

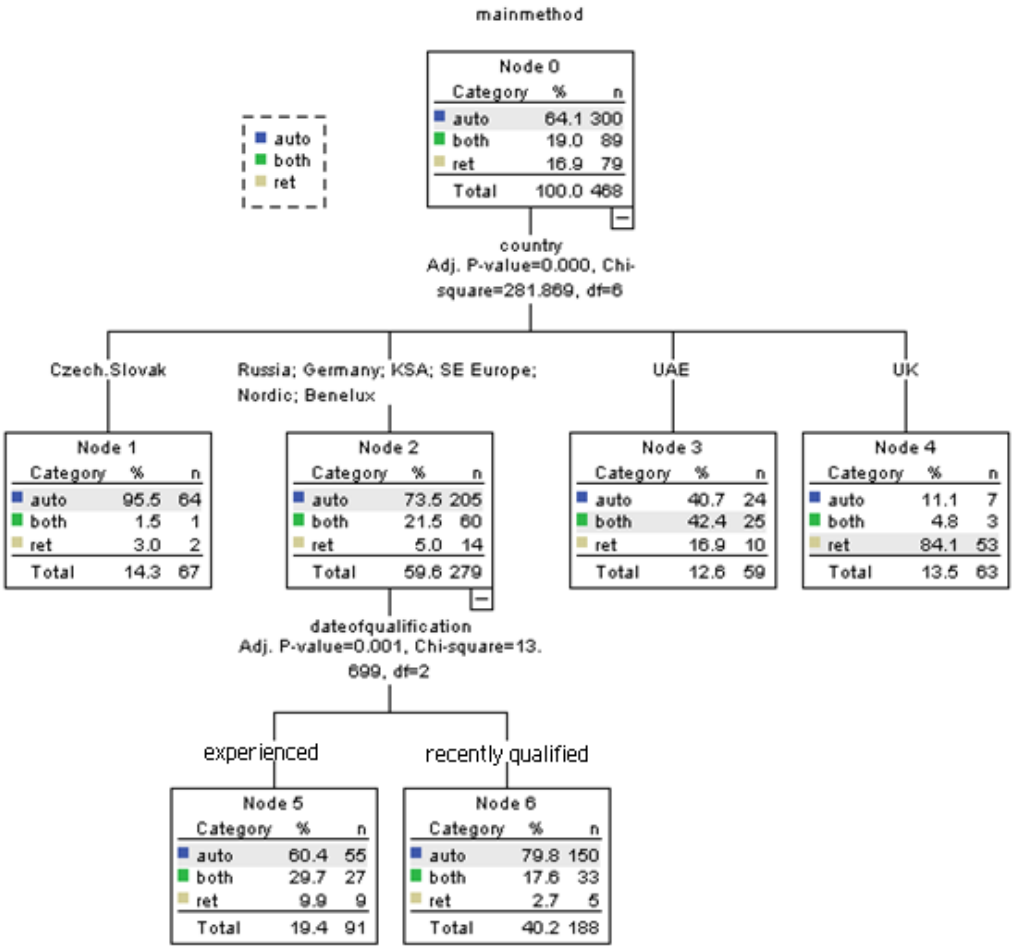
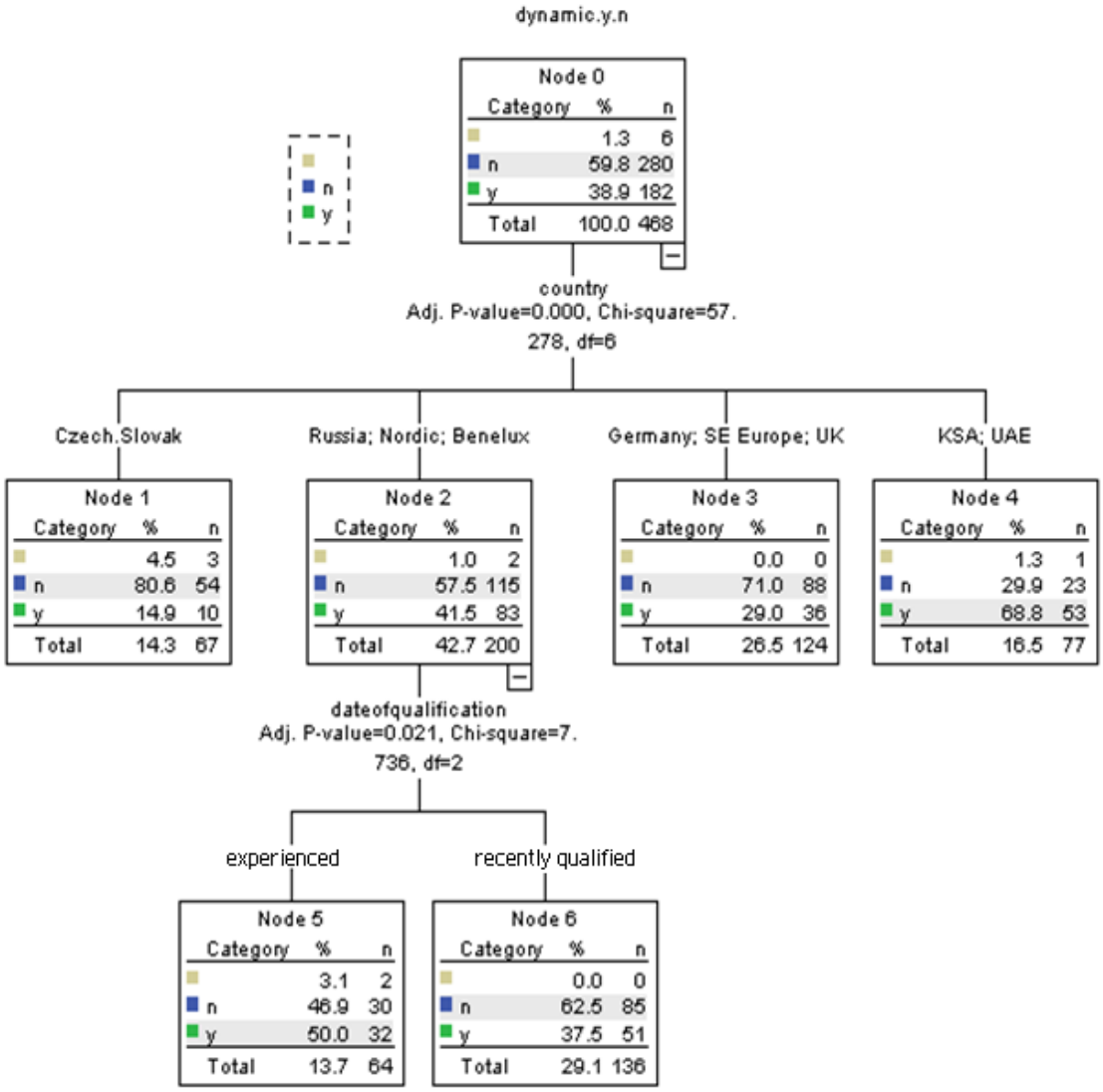


Figure 5.4 shows that dynamic retinoscopy was used by 39% of optometrists and ophthalmologists surveyed. Decision tree analysis showed that locality (country) was an independent variable that influenced whether dynamic retinoscopy was used. The analysis also showed that practitioners from Kingdom of Saudi Arabia (KSA) & United Arab Emirates (UAE) used dynamic ret most (69%) and those from Czech & Slovak Federal Republic (Czech. Slovak) used the technique least (15%). The model correctly classified 67% of the data and was statistically significant (Chi = 57, df = 6, P< 0.001). Date of qualification was an influencing factor for practitioners from Russia, Nordic & Benelux. Here the group qualifying between 1995-2011 ('recently qualified') used dynamic retinoscopy less (38%) compared with those qualifying prior to 1995 ('experienced') (50%)(Chi = 7.7, df = 2, p<0.05). Again, profession was again not an influencing factor.

Figure 5.4. Chi-squared Automatic Interaction Detection (CHAID) Decision Tree analysis showing how use of dynamic retinoscopy by optometrists and ophthalmologists was influenced by the country worked in. Practitioners from Kingdom of Saudi Arabia (KSA) & United Arab Emirates (UAE) used dynamic ret most (69%) and those from Czech & Slovak Federal Republic (Czech. Slovak) the least (15%); Chi = 57, df = 6, P< 0.001. For practitioners from Russia, Nordic & Benelux the group qualifying between 1995-2011 ('recently qualified') used dynamic retinoscopy less (38%) compared with those qualifying prior to 1995 ('experienced') (50%); Chi = 7.7, df = 2, p<0.05. (n = dynamic retinoscopy never used, y = dynamic retinoscopy used occasionally or frequently)



5.4 Discussion

This study provided evidence that optometrists and ophthalmologists working in mainland Europe, Russia and the Middle East were using retinoscopy less as their main method of objective refraction than in the UK. This may be a potential problem if giving less importance to retinoscopy causes a reduction in the accuracy of eye examinations for which autorefraction or subjective refraction is not possible but it must be remembered that the respondents had an interest in contact lenses and may, therefore, come into contact with special needs groups less often. It was not known whether international optometrists were using retinoscopy less frequently and, as mentioned in chapter 3 (section 3.5.2), there does not appear to have been research published that shows whether infrequent use of retinoscopy brings about a loss of accuracy.

It was not possible to say from this short survey whether the profile of respondents was representative of each of the participating countries. All participants were self-selected optometrists with an interest in contact lenses and who happened to attend The Vision Care Institute over a two month period. The findings were thus prone to selection bias and participants may have had different retinoscopy habits to general optometrists, since they have a particular interest in contact lenses. Several countries across the region were not included in this analysis, notably France, Italy and Spain. Therefore, this study is rather limited and the findings outlined below should be considered with this in mind.

5.4.1 Use of autorefractors

The survey showed that autorefraction was widely used. This may save time, especially since these autorefractors can be used by non-optometrists. Dufier et al. (225) estimated that four minutes per patient can be saved during a routine eye examination when using autorefraction instead of retinoscopy. We could hypothesise that 'chair time' pressures might lead practitioners to favour autorefraction over retinoscopy. The results shown in chapter 3 (section 3.5.2) indicated that UK optometrists working in multiple type practice used autorefraction more but still use retinoscopy as frequently as those that work in independent practice. (224) The type of practice worked in was not ascertained in the present survey. This

was another weakness of this survey. At the time of deciding upon the limited number of survey questions that could be asked, early analyses of the UK survey results had indicated that 'date of qualification' was likely to be the most influential factor with respect to the method of static objective refraction used. So this question was included in the international survey. Later analyses of the UK survey showed that practice type was a more important influencing factor but the window of opportunity to make changes to the international survey had passed. On reflection, and with the benefit of the UK retinoscopy survey findings, 'practice type' should have also been included.

Literature showed that autorefractors are accurate but do have limitations, as mentioned in chapter 3 (section 3.5.2).

5.4.2 Potential benefits of retinoscopy in a contact lens examination

Maintenance of retinoscopy skill could be considered useful even for optometrists with an interest in contact lenses for over-refraction, qualitative assessment of the reflex, as an aid to lens fitting and to objectively assess accommodation in some cases. The retinoscope provides qualitative information and can help in the diagnosis of many conditions that may present in a contact lens consultation. Keirl & Christie (226) advocated the importance of retinoscopy in contact lens fitting and aftercare and explained that its use can help with:

- Detection of stomal haze, epithelial waves and keratoconus,
- Location of the optic zone of a rigid lens or position of a bifocal contact lens relative to the pupil, and
- Assessment of soft lens fit.

Retinoscopy over a well fitting soft lens should show a crisp reflex before and after a blink. A flat fitting lens will show a reflex that is crisp in the centre, with peripheral distortion that varied with each blink.(34) Hales (227) described that a steeply fitting soft contact lens exhibits a distorted or variable retinoscopy reflex that appeared crisp immediately after the blink.

5.4.3 International dynamic retinoscopy use

The low reported use of dynamic retinoscopy in the UK, mainland Europe and the Middle East (36%) raises questions about the perceived importance of such techniques and how they are being taught, as discussed in chapter 3, section 3.5.2. Findings are corroborated by Hunter who stated that dynamic retinoscopy is an "often overlooked technique".(228)

It is not clear why optometrists from United Arab Emirates performed dynamic retinoscopy significantly more than practitioners from other countries. The Vice President of The Vision Care Institute and his team, who have experience in this region, found the higher incidence of dynamic retinoscopy in the Middle East surprising, especially given the low reported use of retinoscopy as the primary means of refraction in these countries. They believed this may be a rogue response and that there may have been some misinterpretation of the question. The survey was distributed in the English language for these practitioners.(229) Further study into the retinoscopy habits of optometrists from the Middle East would be necessary to confirm this aspect of the findings of the present study.

The reported infrequent use of dynamic retinoscopy in most countries was corroborated by the UK National Retinoscopy Survey (chapter 3, section 3.4.7) which found about half (48%) of optometrists performed dynamic retinoscopy and this figure was not influenced by date of qualification. (224) The present international study found that only 28% of UK optometrists used dynamic retinoscopy. The lower reported use may be attributable to the cohort being biased due to their interest in contact lenses and is discussed, together with other weaknesses of the study, in chapter 6 (section 6.4.2).

Accommodation is an important aspect of ocular function that can be assessed by dynamic retinoscopy for the potential benefit of patients during an eye examination. There are many patients for whom accommodation needs to be assessed yet subjective techniques may not be possible and so dynamic retinoscopy techniques are most useful. This is especially the case for adults or children with special needs and patients with general health problems, or taking medication, associated with possible accommodative dysfunction, as discussed in chapter 3 (section 3.5.2). It may be possible that an optometrist with an interest in contact lenses could

be presented with a patient for whom an objective measure of accommodation is indicated. It is therefore important that every optometrist examining these vulnerable groups maintains adequate skills in the use of these techniques. Having said this, patients on whom an objective assessment of accommodation is required are unlikely to be seen by optometrists with an interest in contact lenses from the countries mentioned as most work in a more "retail" type environment.(229)

5.4.4 Limitations of this study

This welcome opportunity to collect and analyse international data was complicated by a number of factors including the fact that all delegates had a specific interest in contact lenses rather than, as was the case with the UK survey, being a random selection of optometrists. This potential bias and other weaknesses have been described in the next chapter (section 6.4.2) and mean than these results cannot be reasonably compared the UK Survey data described in Chapter 2. It was not possible to ascertain survey response rates as the total number of practitioners who were invited to participate was not recorded.

5.4.5 Comparison with the UK survey

Contrasts between the UK and international surveys presented in this thesis are shown in Table 5.3.

Table 5.3. Comparison between UK and international retinoscopy surveys presented in this thesis.

Survey description	Number of items	Demographic data	Cohort		
			Professions included	Selection method	Countries included
Survey of habits and attitudes to retinoscopy by optometrists in the UK, 2013(224)	23	date of qualification, practice type, university attended, ethnic background, practice location, workload	optometrists	random selection from College of Optometrists membership database	UK (England, Scotland, Wales & Northern Island)
International retinoscopy survey (this study)	5	date of qualification	optometrists, ophthalmologists, dispensing opticians, unqualified surface providers	attendees of Vision Care Institute contact lens courses	12 countries/regions, influenced by customer base of Johnson & Johnson (Table 5.2 & Appendix 21)

5.5 Conclusion

Though the findings of this opportunistic study were prone to substantial bias, it indicates that there may have been differences in the retinoscopy habits of optometrists working in different countries. Static retinoscopy appeared to be performed infrequently by optometrists in all countries apart from UK. The low use of static and dynamic retinoscopy by some practitioners raises questions about the relevance of retinoscopy in optometric eye examinations carried out internationally. A change of habits in more recently qualified practitioners appeared to be evident in some countries (including Benelux, Nordic and Kingdom of Saudi Arabia) with greater use of autorefraction and retinoscopy being given less importance (sections 5.3.1 and 5.3.2). The international survey corroborated with findings from the UK survey which indicated that usage of dynamic retinoscopy was not influenced by the date of qualification, suggesting that alterations in training at university were not causative. Interestingly, while UK optometrists used retinoscopy most as their primary

method of objective refraction, their use of dynamic techniques was less than in several other countries. Also of interest is that method of objective refraction and use of dynamic techniques was not influenced by whether the respondent is an optometrist or ophthalmologist.

Chapter 6 draws conclusions from all aspects of the research carried out in this thesis. Weaknesses of the study are highlighted and possible future studies discussed.

5.6 Key points:

- A survey of optometrists attending The Vision Care Institute's of Johnson and Johnson Ltd in UK, Prague and Dubai was conducted.
- Responses were received from 334 optometrists who reported using objective refraction, with representation from Germany, Czech and Slovak Federal Republic, Nordic, Russia, SE Europe, Benelux, Kingdom of Saudi Arabia, and United Arab Emirates and the UK.
- The country worked in influenced the primary method of objective refraction and reported use of dynamic retinoscopy.
- UK optometrists used retinoscopy most (84%) as their main method compared with all other countries (18% - 2%). Autorefractors were used as the main method of objective refraction by more than half of the optometrists surveyed (62%). Date of qualification was an influencing factor only for one group of countries; 'experienced' optometrists (qualified prior to 1995) from Benelux, KSA and Nordic use retinoscopy more as their main method (20%) compared with the 'recently qualified' group (2%) who qualified 1995-2011.
- Only 36% of optometrists reported using dynamic retinoscopy. Optometrists from United Arab Emirates used this technique most (68%) and the Czech and Slovak Federal Republic least (12%). Date of qualification was not an influencing factor.
- Responses were also received from 134 ophthalmologists. Analysis using profession as an additional possible influencing factor showed that profession did not have an effect. International optometrists and ophthalmologists with an interest in contact

lenses performed similarly in respect of main method of refraction and use of dynamic retinoscopy.

- Several limitations of this study are present including bias introduced by the respondents having an interest in contact lenses, the absence of piloting the survey on a representative sample, an imbalance between 'recently qualified' and 'experienced' for several countries and not ascertaining the type of practice worked in (a probable confounding influence).
- The low use of static and dynamic retinoscopy by some practitioners raises some concerns relating to testing people with special needs.

6.0 Conclusions and future studies

6.1 Introduction and summary

The author embarked on this study with the hypotheses that (1) retinoscopy was considered to be of less importance and was therefore being used less by more recently qualified practitioners and that (2) newer combined retinoscopes were less accurate than older dedicated types. The research presented in this thesis documents the findings of a series of studies, carried out between October 2008 and December 2013, aimed at testing these initial hypotheses.

A survey of the habits and attitudes to static and dynamic retinoscopy of optometrists throughout the UK was distributed to 1000 optometrists and received 298 responses. The findings showed that optometrists were generally satisfied with their retinoscopes and do not have reservations regarding combined models. Retinoscopes were less likely to be considered as the main method of objective refraction in multiple type practices. Dynamic retinoscopy was used by less than a half of all optometrists surveyed in the UK and internationally. Practice type was found to be an influencing factor with optometrists from UK multiple practices using dynamic retinoscopy less.

6.2 The 15 DF rule

A secondary purpose of this study was to explore the utility of the '15 DF rule'. It has been argued that there is little further statistical power to gain by increasing the sample size in a factorial ANOVA that already has at least 15 degrees of freedom associated with its residual error. (106, 193, 230) The proposed factorial ANOVAs exceed this requirement. An Excel spreadsheet was written to calculate the degrees of freedom associated with the residual error of a factorial ANOVA given any entered sample size (chapter 4, section 4.3.1). This allowed the author to adjust the sample size until the 15 DF rule had been met or exceeded. The same spreadsheet could be utilised by future researchers. However, this approach to power statistics is not generally recognised and The College of Optometrists statistician stated that there is presently insufficient research data upon which these calculations can be

based.(231) It was suggested that conventional power calculations should be carried out but this would have meant that significantly more patients would need to be recruited to achieve a logical medium effect size. (144, 206) A compromise was made to run the above mentioned trial as a pilot study.(232) This study has demonstrated application of the 15DF rule and generated data needed for power calculations for a possible more extensive study in the future. The 15 DF is easy to apply and more clinical researchers might like to know about this rule which has been published but perhaps overlooked by the optometric profession. The '15 DF rule' can thus enable optometrists to achieve adequate power and meaningful results with lower numbers of subjects than calculated using traditional statistical methods. The proposed statistical system is a practical and cost effective method that can be used for practice based investigation of numerous optometric tests.

6.3 Retinoscope accuracy

Results for the accuracy of each type of retinoscope are included in Chapter 4 (section 4.4). The mean data shows that both spot and streak retinoscopy were within 0.50D from the subjective result; spot mean (U) 0.49, streak mean (U) 0.41.To further investigate for difference in accuracy between spot and streak retinoscopy rigorous testing by separate experiment would be necessary. This study could not answer this question as:

1. too few optometrists are included to deliver enough statistical power, and
2. confounding. Different optometrists used spot or streak retinoscopes; any difference found could have been due to optometrist or retinoscope type.

There is no evidence to suggest that changes made by Keeler in the design of their combined retinoscopes make them less accurate. Main error values (U) were found to be not statistically significant for retinoscope type. The study has found high levels of satisfaction with Keeler combined retinoscopes and this, together with the result of the pilot clinical trial, allows the study to refute the principle author's original opinions.

6.4 Limitations of this research

6.4.1 Limitations of the trial

Insufficient data was obtained in the clinical trial to deliver convincing external validity. It is possible that optometrists do not always take retinoscopy results to optimum accuracy each time and may be satisfied to simply establish a starting point prior to subjective refraction, especially if good subjective responses are to be expected. The author had a suspicion that this was the case with the pilot trial. In some instances optometrists finished well within the time allocated and appear not take care to confirm neutralization. This could make the research results less relevant. Each optometrist participating in any future trial could be asked to ensure optimum accuracy with each instrument and confirm the point of neutralization (by any preferred method). The working distance for each retinoscopy episode should have been stipulated and checked to ensure consistency. Sight-hole size for each retinoscope used should have been recorded.

This study used a small range of prescriptions; -0.75DS to +1.00DS and -0.25DC to -1.00DC . It is possible the results would have been different had a larger range been adopted.

6.4.2 Limitations of the surveys

Both the UK and International survey would have benefitted from ascertaining the types of patients attending the practices and asking questions investigating use of dynamic retinoscopy specifically for special groups of patients, such as Down's syndrome and cerebral palsy.

The limitations of the international survey are:

1. The need to restrict the number of questions to just a small subset of the original UK survey. This meant the absence of investigation of type of practice and other possible confounders;

2. The imbalance between the number of 'recently qualified' and 'experienced' respondents from several countries which could have influenced the success of the statistical analyses;
3. The practitioners attending the courses at The Vision Care Institute had applied and were invited without any level of pre-selection. It is a reasonable assumption that the groups had a higher interest in contact lens practice than an unselected random group of practitioners (233);
4. Inadequate piloting of the survey: The pilot should have ideally been tested on a pilot sample (representative of a larger group) in each country to help prevent misinterpretation. A useful test of the accuracy of translation would have been to retranslate into English in each case;
5. The fact that respondents included ophthalmologists, optometrists, dispensing opticians and unqualified service providers, while the UK survey was restricted to optometrists; and
6. The fact that the countries represented was dictated by random factors, unlike the previous survey that had been restricted to UK practitioners.

The different reported use of dynamic retinoscopy by UK optometrists found from the two surveys (48% from the UK study and 28% from the international study) lends evidence to support the idea that the international study was biased. The lower use found in the international survey could be attributed to confounding (for example, practice type was not established) or bias introduced by the self selection of optometrists with an interest in contact lenses.

As participation was voluntary, both the UK and international surveys were prone to selection bias. A further source of bias is that reported practice may not reflect actual clinical practice.(124) An alternative approach to ascertain retinoscopy habits could have been a retrospective study of patient records. This was not pursued as a method of investigation as it would be difficult and expensive to translate sufficient numbers of records to investigate a difference in habits between optometrists from different countries. A study of patient records was also not pursued since the first author had noticed considerable variation among

optometrists in recording of objective refraction details, which is in agreement with Millodot & O'Leary (126).

6.5 Recommendations for further study

6.5.1 Further retinoscopy trials

Proposed future methods to compare retinoscopy accuracy:

1. Scaling up this original trial: Although the small sample had internal validity (i.e. had sufficient power) it lacked external validity in that the results were dependent on just 4 optometrists. A larger study is required to increase the external validity. This method would be time consuming and expensive but likely to produce robust data.
2. Use of a model eye: The overall scalar vector for each type of retinoscope could be compared to the overall average scalar vector for all retinoscopes being considered. Working distance would need to be kept constant and eccentricity avoided. Although attractive due to practical considerations, a significant factor is that there is no way to judge the accuracy of the model eye. No ethical clearance is required for this type of study. This could provide valid results and provide a measure of repeatability. However, this is an artificial task that could lack clinical credibility.
3. Optometrists in clinical practice using different retinoscopes on patients presenting for routine eye examinations: If measurements are taken on the same patient using different types of retinoscope there are, however, two sources of bias: (1) The approximate prescription will be known beforehand when completing at the repeated measurements, and (2) The examiner knows which type of retinoscope he/she is using. To overcome these problems the order of the different retinoscopes could be balanced to avoid carry-over effects. Observer bias would be eliminated if the type of retinoscope could be disguised from the participating optometrists. This would be challenging in a clinical setting but could be attempted in a future trial. If retinoscopy was repeated on each patient using the same type of retinoscope then a measure of repeatability could be established. When the same optometrist repeats

retinoscopy on the same patient it may be necessary to not allow them to see the power of the lenses used for the first episode.

A future trial could involve recruitment of undergraduate or pre-registration optometrists. This would have the benefit of eliminating the bias of experience to date and could involve practitioners who have only ever used either spot or streak types.

Involvement of patients with a wide range of spectacle prescriptions would make future research more clinically relevant. The p-values for spot retinoscopy accuracy (Table 4.11) were close to the statistically significant level (0.05). It is possible that a larger range of refractive errors being represented in the selected patients could have shown a different result.

A trial is likely to be the optimum method of research to investigate accuracy of retinoscopy as it difficult to obtain data from a study of clinical records of retinoscopic and subjective measurements since:

- Many practitioners do not always record both measurements or are not consistent in the recording,
- some practitioners record data with bias that tends to assume that the two measurements are equal (126), and
- other variables may be present e.g. background lighting, inconsistent working distances, accommodation inadequately controlled, opacification of patients ocular media, inconsistent or inaccurate subjective data.

This study has investigated for difference in accuracy between combination and dedicated retinoscopes. Other comparisons in retinoscope performance for future consideration are:

- spot vs streak,
- non-internally illuminated basic mirror retinoscope vs modern instrument. To ascertain whether modern retinoscopes are more accurate than simple and cheaper

designs. This could be of potential interest to optometrists working in under developed countries,

- the effect of uncorrected ametropia of the retinoscopist (Is it best for the practitioner to wear distance or reading spectacles? What is the effect of contact lens induced monovision on retinoscopy accuracy?),
- the effect of various changes to retinoscopes to their accuracy, including
    - sight-hole (peep-hole) diameter, and
    - whether the mirror has a central aperture or is semi-fenestrated.
- a trial investigating for association between frequency of use and accuracy of static and dynamic retinoscopy. Infrequent use of static and dynamic retinoscopy has been demonstrated by some optometrists yet there is to date no evidence that this could cause a reduction in performance.

A study using dynamic retinoscopy to measure accommodative function of children with Autism Spectrum Disorder (ASD) is a consideration. Cubbidge & Whiskens (234) describe the visual characteristics found and conclude, "There is little information available on eye care and visual function in such individuals." A lack of understanding of visual function in children with ASD was also found by Ludlow (235) which was, in part, attributed to the difficulties in carrying out assessment due to limited communication and behavioural difficulties. No reference was made to assessment of accommodation in patients with ASD.

6.5.2 Repeatability

This study was interested in the comparative accuracy of different types of retinoscopes compared with the subjective refraction result and, as such, did not produce repeatability data. Repeatability (or reliability) of refraction is the test-retest variability of the refractive error measurement. Interexaminer reliability is the comparison of results by different examiners and intraexaminer reliability is repeated refraction by the same examiner. (236) A literature review was carried out into repeatability of refraction. Appendix 25 shows details of the electronic data base search. Appendices 26 and 27 list previous studies that have investigated repeatability of refraction and (specifically) retinoscopy respectively. Most studies quantify repeatability by calculating the mean difference (MD) between test-retest

measures, the standard deviation (SD) of the differences and 95% Limits of agreement (LoA). Some authors calculate the Correlation Coefficient (r)(237, 238) or Coefficient of Repeatability (CR)(239-241), which is 1.96 multiplied by the SD of the difference between the test and retest values. Zadnik, Mutti & Adams found retinoscopy to be a "poor choice for the determination of refractive error" due to poor repeatability."(179) A literature review into the reliability of refraction by Goss & Grosvenor concluded that conventional subjective refraction was reliable to within 0.25D to 0.50D.(236)

To measure repeatability in a future study it will be necessary to repeat retinoscopy with the same instrument on the same patient. Repeatability can be gained by repeating the trial using the same optometrists and patients on the same or a separate occasion. As described by Hodi & Wood,(238) repeatability could also have been assessed by each optometrists taking a first measurement 'blind' with lenses supplied by an assistant on a higher or lower basis until a neutral was achieved. The assistant could record this result whilst the retinoscopist proceeds to carry out a second measurement on the same patient in the normal way. The results could be compared to give intraobserver repeatability data.

6.5.3 Further Surveys

Further study of international retinoscopy habits could help determine why retinoscopy is apparently used more in the UK and why optometrists from United Arab Emirates are using dynamic retinoscopy more than practitioners from other countries. It is possible that variations in the type of practice worked in (multiple versus independent), or other unknown influencing factors, could have introduced bias. This study involved analysis of the responses of self-selected optometrists from several countries who attended international contact lens related courses. While this provided an opportunity to gauge retinoscopy use across these countries, a further study would benefit from additional items covering (1) all countries, (2) the type of practice worked in (multiple, independent or hospital), (3) the type of work carried out (e.g. routine tests, contact lens fitting etc), (4) the type of patients seen (e.g. children, adults, individuals with learning difficulties, contact lens aftercare, etc) and (5) the type of training received.

This study investigated the main method of objective refraction and use of dynamic retinoscopy. Once a basic static method of retinoscopy is mastered then an optometrist has various other methods available (Chapter 1, section 1.3.1), including:

- Mohindra method, which provided an accurate measure of ametropia of infants without the need of a cycloplegic drug,
- Binocular method of Barratt, which has the benefit of being performed on the visual axis and is particularly useful for monocular and amblyopic retinoscopists,
- Carter method, which provided magnification of the pupil and is useful for patients with cataract or miosis,
- Radical Retinoscopy, which involved decreasing the working distance to enable the reflex to be seen easier in cases of miotic pupils or opaque medii,
- Estimation techniques, for when it is not possible to use trial lenses,
- Cycloplegic,
- MEM and modified Nott dynamic methods to assess accommodation (242)(Chapter 1, section 1.4.3),

It may be interesting to ascertain frequency of use of some of these other retinoscopy techniques, including which particular dynamic technique is used and use of cycloplegia. Surveys should continue to include practice type, which has been shown to be an influencing factor for some aspects of retinoscopy use.

An alternative method of data analysis could be to use a four point scale for responses to some questions and calculate the median score. Kruskal-Wallis (a non-parametric one-way ANOVA) followed by 'post hoc' Mann-Whitney U-tests could be used to compare the median scores. (243)

Rasch analysis is a method of item-response theory could have been used to make sure that the questionnaire correctly classified a respondent. Some recent studies have used Rasch analysis in their design of patient questionnaires. (244, 245) This was found to be a reliable and valid method and could be considered for future practitioner surveys.

6.8 Conclusion

As stated by Edwards, “It is not easy to assess the accuracy of retinoscopy. It is the examiner who produces the greatest variability, along with the eye under observation and patient cooperation.” (246) , Although the clinical trial had a sample size that had demonstrable internal validity, the study design was, nevertheless, still prone to outcomes from individual participants. A larger clinical trial is necessary to confirm or refute the result that combination retinoscopes are as accurate as designated types. That only 5% of respondents believed combined retinoscopes to be less accurate than designated types suggest this is not a burning issue. The clinical trial has evaluated a relatively unknown method of determining statistical power, the ’15 DF rule’.

The majority of responses and comments received from the survey are positive regarding retinoscopy and consider it to be a most useful test. However, retinoscopy is only used in 25% or less of eye examinations by a third (31%) of optometrists in the UK. Many practitioners in UK and internationally prefer to use autorefractor for objective refraction. Optometrists from multiple type practices in the UK are more likely to use autorefractors and be dissatisfied with their own retinoscope. An opportunity could be present for training institutions and employers to increase awareness of the potential benefits of retinoscopy and dynamic techniques. Interestingly, date of qualification has been shown not to influence the use of static or dynamic retinoscopy use in the UK, other than a preference towards streak and combined models. The UK survey has shown no influence on the habits and attitudes of optometrists from locality of work-place, ethnicity or workload which is in agreement with the literature. As well as providing an insight into the retinoscopy habits and attitudes of UK and international optometrists, the demographic data will be available to serve as a comparison for future studies.

Lenses are used as a starting point when initiating retinoscopy by a third (29%) of UK optometrists but this was not found to be influenced by date of qualification but was influenced by practice type. Hospital optometrists have been found to use this short cut the least. There is no evidence that the use of starting point lenses affects accuracy.

Dynamic retinoscopy is only performed by around a half of UK optometrists even though many authors recommend the technique:

- Weddell finds the monocular estimation dynamic method to be, “an ideal method to assess accommodative function in children as it is entirely objective.”(242)
- As Woodhouse argued, “Accommodation may be the most neglected aspect of children’s vision , since it is easy to assume that children have ample and active accommodation.” (67)
- Kushner finds dynamic retinoscopy to be most useful in children with a neurological impairment, which is a group more likely to have reduced accommodation. He points out that these children may benefit from full hyperopic correction or bifocal lenses. (83)
- Rouse et al (69)state that a lag of accommodation found by MEM dynamic retinoscopy could be a sign of ocular or systemic pathology.
- Findings by Lara et al.(70) further suggests the need for dynamic retinoscopy use in optometric practice. They found 9.4% of symptomatic young patients to have an anomaly of accommodation (with 68% of these exhibiting accommodative excess and the remainder accommodative insufficiency).
- Leon, Medrano & Rosenfield found dynamic retinoscopy produced greater reproducibility compared with subjective methods when measuring amplitude of accommodation and state that, “the dynamic retinoscopy procedure can be performed using standard clinical equipment makes this a valuable technique.”(76)

The infrequent use of dynamic retinoscopy amongst UK and international optometrists could stimulate discussion amongst the profession regarding the relevance and indications for these techniques.

The author had observed that retinoscopy was being used less by some optometrists during routine eye examinations and contact lens aftercares. The hypothesis was that a change in habits was occurring with younger optometrists using retinoscopy less. This has been refuted; date of qualification has been found not to influence retinoscopy habits (apart from a preference towards streak and combined types) in the UK. However, retinoscopy has been

shown to be given less importance in multiple type practices and is used infrequently in many of the countries studied, even though the majority of UK respondents believed it to be a useful test in a routine eye examination. Literature shows the autorefractor to be accurate (177, 187) yet Jorge et al (186) found autorefractor less accurate compared with retinoscopy by an experienced practitioner. The hypothesis that combined retinoscopes are less accurate than designated types has been refuted. The results will likely be of interest to manufacturers, practitioners, training institutions and professional bodies and might prompt further substantive investigation.

The inventor of the streak retinoscope, Jack C. Copeland, stated in 1926 that the retinoscope was “the most valuable and greatest aid to scientific refraction ever devised”. (247) Since that time autorefractors have been invented and are widely used. This research has shown that many optometrists, and respected authors alike, believe the retinoscope still has a role in modern optometric practice.

References

1. Bowman W. Pathology and treatment of conical cornea. Royal London Ophthalmic Hospital. 1859;2:154.
2. Corboy J. The Retinoscopy Book - An Introductory Manual for Eye Care Professionals (5th Edition). Slack Incorporated, NJ, USA. 2003:2-3.
3. Keirl A, Christie C. Clinical Optics and Refraction, A Guide for Optometrists, Contact Lens Opticians and Dispensing Opticians. Butterman Heinemann Elsevier, London. 2007:71-2.
4. Copeland J, inventor Patent for a streak retinoscope. USA, Aug 9, accessed 21 Dec 2013, http://www.google.co.uk/patents?hl=en&lr=&vid=USPAT1648013&id=Hdl5AAAAEBAJ&oi=fnd&dq=Patent+for+a+streak+retinoscope+Copeland+1926+&printsec=abstract#v=onepage&q=Patent%20for%20a%20streak%20retinoscope%20Copeland%201926&f=false.1926.
5. Keirl A, Christie C. Clinical Optics and Refraction, A Guide for Optometrists, Contact Lens Opticians and Dispensing Opticians. . Butterman Heinemann Elsevier, London. 2007:77.
6. Henson D. Optometric Instrumentation. Butterworth Heinemann, Oxford. 1996:162-98.
7. Corboy J. The Retinoscopy Book - An Introductory Manual for Eye Care Professionals (5th Edition). Slack Incorporated, NJ, USA. 2003:4-6.
8. Rosenfield M, Logan N. Optometry: Science, Techniques & Management. Butterworth Heinemann Elsevier, Edinburgh. 2009:451.
9. Little M, Church K. Retinoscope Patent. US Patent number 6,250,761, http://wwwgooglecouk/patents?hl=en&lr=&vid=USPAT6250761&id=T6wHAAAAEBAJ&oi=fnd&dq=Retinoscope+Patent+2001+Little&printsec=abstract#v=onepage&q&f=false. Accessed 21 Dec 2013. 2001.
10. Henson D. Optometric Instrumentation. Butterworth Heinemann, Oxford. 1996:42-3.
11. Hodd F. Some recent advances in Ophthalmic Optics. Transactions of the London Refraction Hospital Jubilee Congress 1947;Hatton Press Ltd.:147-234.
12. Hodd F. The Measurement of spherical refraction by Retinoscopy. Transactions of the International Optical Congress, The British Optical Association 1951:191-231.
13. Borish I. Clinical refraction 3rd Edition. The Professional Press Inc. 1975;Chicago, Illinois, USA:659-713.
14. Valenti C. The full scope of retinoscopy (Introduction to behavioral optometry). Optometric Extension Program. 1990: 6-7.
15. Edwards K, Llewellyn R. Optometry. Butterworth-Heinemann, Reid Elsevier plc group 1988:Chapter 6, page 87.
16. Bennett A, Rabbetts R. Clinical Visual Optics. Second edition. 1989;Butterworth-Heinemann, Edinburgh:Chapter 17, page 394.
17. Corboy J. The Retinoscopy Book - An Introductory Manual for Eye Care Professionals. Slack Incorporated, NJ, USA. 2003:29-30.
18. College of Optometrists. Guideline B02, accessed 21 Dec 2013, The routine eye examination. http://wwwcollege-optometristsorg/en/professional-standards/Ethics_Guidelines. 2012.

19. General Optical Council. Sight Testing, (Examination and Prescription) (no 2) regulations s 3., accessed 21 Dec 2013, http://www.optical.org/en/about_us/legislation/rules_and_regulations.cfm. 1989
20. Drinan I, Gilmour R. Variable retinoscopy. Optometry in Practice. 2012;13(4):163-8.
21. Allen P, Evans B, Wilkins A. Specific Learning Difficulties and Vision; Vision & Reading difficulties Part 1. Optometry Today. 2009(Jan):30-8.
22. Taub M, Rowe S, Baruccio M. Examining special populations, Part 1: Cerebral palsy and Down's syndrome. Optometry Today. 2006(Feb):48-50.
23. Woodhouse M. Development of visual functions 2. Optometry Today. 2012(February):41-5.
24. Miller J, Dobson V, Harvey E, Sherrill D. Astigmatism and Amblyopia among Native American Children (AANAC): design and methods. Ophthalmic Epidemiol. 2000 Sep;7(3):187-207.
25. Azizoglu S, Junghans B, Barutchu A, Crewther S. Refractive errors in students from Middle Eastern backgrounds living and undertaking schooling in Australia. Clin Exp Optom. 2011;94(1):67-75.
26. Plainis S, Moschandreas J, Nikolitsa P, Plevridi E, Giannakopoulou T, Vitanova V, et al. Myopia and visual acuity impairment: a comparative study of Greek and Bulgarian school children. see PDF below. 2009;29(3):312-20.
27. Logan N, Shah P, Rudnicka A, Gilmartin B, Owen C. Childhood ethnic differences in ametropia and ocular biometry: the Aston Eye Study. Ophthalmic Physiol Opt., 2011;31(5):550-8.
28. Charre J, Creedon M. Assessment of Visual Function in Autistic Children. Optometry & Vision Science. 1992;69(6):33-439.
29. Eperjesi F, Bartlett H, Dunne M. Ophthalmic Clinical Procedures. Butterman Heinemann Elsevier, London. 2007; 35-6.
30. Corboy J. The Retinoscopy Book - An Introductory Manual for Eye Care Professionals. Slack Incorporated, NJ, USA. 2003(5th Edition):2-3.
31. Edwards K, Llewellyn R. Optometry Butterworth-Heinemann, Reid Elsevier plc group 1988 (Chapter 6):page 81.
32. Bennett A, Rabbetts R. Clinical Visual Optics. Second edition 1989;Butterworth-Heinemann, Oxford:Chapter 17, page 410.
33. Keirl A, Christie C. Clinical Optics and Refraction, A Guide for Optometrists, Contact Lens Opticians and Dispensing Opticians. Butterman Heinemann Elsevier, London. 2007:83-4.
34. Stafford M, Morris J. Retinoscopy in the Eye Examination. Pamphlet, based on a Optometry Today article (date unknown); Accessed 17 Dec 2013 via College of Optometrists online library catalogue , http://www.college-optometrists.org/en/CPD/Library/library-catalogue/index.cfm:pages 2-4. 1994.
35. Mohindra I. A non-cycloplegic refraction technique for infants and young children. J Am Optom Assoc. 1977;48(4):518-23.
36. Mohindra I. A technique for infant vision examination. Am J Optom physiol Opt. 1975: 867 - 70.
37. Corboy J. The Retinoscopy Book - An Introductory Manual for Eye Care Professionals. 2003;Slack Incorporated, NJ, USA(5th edition, Chapter 9):83-93.
38. Weinstock S, Wirtschafter J. A decision orientated manual of retinoscopy. Thomas books, Illinois, USA. 1976:pages 5-6.

39. Wallace D, Carlin D, Wright J. Evaluation of the accuracy of estimation retinoscopy. Journal of AAPOS : the official publication of the American Association for Pediatric Ophthalmology and Strabismus / American Association for Pediatric Ophthalmology and Strabismus. 2006 Jun;10(3):232-6.
40. Carter J. A system of retinoscopy for the aged eye. American journal of optometry and physiological optics. 1986;63(4):298-9.
41. Allen R, Fletcher R, Still D. Eye Examination and refraction. Blackwell Scientific Publications, London. 1991:80-1.
42. Eperjesi F, Bartlett H, Dunne M. Ophthalmic Clinical Procedures, a multimedia guide. Butterworth Heinemann Elsevier, Edinburgh. 2007:45-7.
43. Eperjesi F, Jones K. Cycloplegic Refraction in Optometric Practice. Optometry in Practice 2005;6:107-20.
44. Lens A. Optics, Retinoscopy and Refractometry. Slack Incorporated, NJ, USA. 1999:Chapter 2, page 37.
45. Eperjesi F, Bartlett H, Dunne M. Ophthalmic Clinical Procedures. Butterman Heinemann Elsevier, London. 2007:55-6, 169-72.
46. Borish I. Clinical Refraction 3rd Edition. the Professional Press Inc. 1975;Chicago, Illinois, USA:149-88.
47. Daum K. Accommodative dysfunction. Documenta Ophthalmol. 1983;55(3):177-98.
48. Allen R, Fletcher R, Still D. Eye Examination and Refraction. Blackwell Scientific Publications, London. 1991; 105-15.
49. Bennett A, Rabbetts R. Clinical Visual Optics. Butterworth Heineman Elsevier, Edinburgh. 2007;4th Edition:132-6.
50. Daum KM. Accommodative dysfunction. Documenta Ophthalmologica. 1983;55(3):177-98.
51. Dressler D, Benecke R. Autonomic Side Effects of Botulinum Toxin Type B Treatment of Cervical Dystonia and Hyperhidrosis. Eur Neurol. 2003;49:34–8.
52. Ochsendorf F, Runne U. Chloroquine and hydroxychloroquine: side effect profile of important therapeutic drugs. Hautarzt. 1991;Mar;42(3): 140-6.
53. Charakida A, Mouser P, Chu A. Safety and side effects of the acne drug, oral isotretinoin. Expert Opinion on Drug Safety. 2004;3(2):119-29.
54. Peters N. Snipping the thread of life: Antimuscarinic side effects of medications in the elderly. Archives of Internal Medicine. 1989;149(11):2414-20.
55. Frucht J, Freimann I, Merin S. Ocular side effects of disopyramide. Br J Ophthalmol. 1984 December 1, 1984;68(12):890-1.
56. Leucht S, Hackl HJ, Steimer W, Angersbach D, Zimmer R. Effect of adjunctive paroxetine on serum levels and side-effects of tricyclic antidepressants in depressive inpatients. Psychopharmacology. 2000;147(4):378-83.
57. Keks N. Minimizing the non-extrapyramidal side-effects of antipsychotics. Acta Psychiatrica Scandinavica. 1996;94:18-24.
58. Shayler G. Near Point Accommodation and Educational Performance: Childhood Visual Problems and Education Part 1. Optometry Today. 2003(Oct):43-5.
59. Evans B, Allen P, Wilkins A. Optometric Correlates of Reading Difficulties;Vision & Reading difficulties Part 2. Optometry Today. 2009(Feb):30-8.
60. Evans B. Dyslexia & Vision. Whurr Publishers Ltd. 2003;London, p 31.
61. Leat S. Reduced accommodation in children with cerebral palsy. Ophthalmic Physiol Optics. 1996;16(5):385-90.

62. Woodhouse J, Cregg M, Gunter H, Sanders D, Saunders K, Pakeman V, et al. The Effect of Age, Size of Target, and Cognitive Factors on Accommodative Responses of Children with Down Syndrome. Invest Ophthalmol Vis Sci. August 1, 2000;41(9):2479-85.
63. Woodhouse J, Meades J, Leat S, Saunders K. Reduced accommodation in children with Downs syndrome. Invest Ophthalmol Vis Sci. June 1, 1993;34(7):2382-7.
64. Nandakumar K, Leat S. Bifocals in children with Down syndrome (BiDS) – visual acuity, accommodation and early literacy skills. Acta Ophthalmologica. 2010;88(6):196-204.
65. Al-Bagdady M, Stewart R, Watts P, Murphy P, Woodhouse J. Bifocals and Down's syndrome: correction or treatment? Ophthalmic Physiol Optics. 2009;29(4):416-21.
66. Taub M, Rowe S, Baruccio M. Examining special populations, Part 3: Examination techniques. Optometry Today. 2006(March):49-52.
67. Woodhouse M. Assessing visual function 1; Young childrens vision Part 3. Optometry Today. 2012(March):45-9.
68. Holland K. The Science of Behaioural Optometry. Optometry Today. 2002(March): 36-8.
69. Rouse M, Hutter R, Shiftlett R. A normative study of the accommodative lag in elementary school children. Am J Optom Physiol Opt. 1984;61(11):693-7.
70. Lara F, Cacho P, García Á, Megías R. General binocular disorders: prevalence in a clinic population. Ophthalmic and Physiological Optics. 2001;21(1):70-4.
71. Chen A, O'Leary D. Validity and repeatability of the modified push-up method for measuring the amplitude of accommodation. Clin Exp Optom. 1998;81(2):63-71.
72. Chen A-H, O'Leary APDJ. Validity and repeatability of the modified push-up method for measuring the amplitude of accommodation. Clinical and Experimental Optometry. 1998;81(2):63-71.
73. Chen A, O'Leary D, Howell E. Near visual function in young children. Part I: near point of convergence. Part II: amplitude of accommodation. Part III: near heterophoria. Ophthal Physiol Optics. 2000;20(3):185-98.
74. Chen AH, O'Leary DJ, Howell ER. Near visual function in young children. Part I: near point of convergence. Part II: amplitude of accommodation. Part III: near heterophoria. Ophthalmic and Physiological Optics. 2000;20(3):185-98.
75. Eperjesi F, Bartlett H, Dunne M. Ophthalmic Clinical Procedures. Butterman Heinemann Elsevier, London. 2007:Page 55-6.
76. León A, Medrano S, Rosenfield M. A comparison of the reliability of dynamic retinoscopy and subjective measurements of amplitude of accommodation. 2012;32(2):133-41.
77. Rosenfield M, Cohen A. Repeatability of clinical measurements of the amplitude of accommodation.1996;16(3):247-9.
78. León AÁ, Medrano SM, Rosenfield M. A comparison of the reliability of dynamic retinoscopy and subjective measurements of amplitude of accommodation. Ophthalmic and Physiological Optics. 2012;32(2):133-41.
79. Eperjesi F, Bartlett H, Dunne M. Ophthalmic Clinical Procedures. Butterman Heinemann Elsevier, London. 2007:170-1.
80. Eperjesi B, Dunne. Ophthalmic Clinical Procedures. Butterman Heinemann Elsevier, London. 2007:70-1.
81. Leat S, Gargon J. Accommodative response in children and young adults using dynamic retinoscopy. 1996;16(5):375-84.

82. Whitefoot H, Charman W. Dynamic retinoscopy and accommodation. 1992;12(1):8-17.
83. Kushner B. Dynamic retinoscopy a useful test. Ophthalmology Times Conference Brief. (Oct 23) 2011.
84. Nielsen V. Computer retinoscopy. Optometry Today. 2002(Jan):24.
85. Alderson A, Mankowska A, Cufflin M, Mallen E. Simultaneous measurement of objective refraction, accommodation response and axial length of the human eye. Ophthalmic Physiol Optics. 2011;31(1):100-8.
86. Davis B, Collins M, Atchison D. Calibration of the Canon Autoref R-1 for continuous measurement of accommodation. Ophthalmic Physiol Optics. 1993;13(2):191-8.
87. AlMubrad T, Ogbuehi T. Nott and MEM dynamic retinoscopy: Can they be used interchangeably? Arch Med Sci. 2006;2(2):85-9.
88. Elliott D. Clinical Procedures in Primary Eye Care. 4th edition. 2013;Elsevier:6.11.3.
89. Campbell F, Westheimer G. Dynamics of accommodation responses of the human eye. J Physiol 1960;151(2):285–95.
90. Tassinari J. Monocular Estimate Method Retinoscopy: Central Tendency Measures and Relationship to Refractive Status and Heterophoria. Optometry and Vision Science. 2002;79(11):pp 708-14.
91. del Pilar Cacho M, Garcia-Munoz A, Garcia-Bernabeu J, Lopez A. Comparison between MEM and Nott dynamic retinoscopy. Optom Vis Sci. 1999 Sep;76(9):650-5.
92. Garcia A, Cacho P. MEM and Nott dynamic retinoscopy in patients with disorders of vergence and accommodation. Ophthalmic Physiol Opt. 2002 May;22(3):214-20.
93. Antona B, Sanchez I, Barrio A, Barra F, Gonzalez E. Intra-examiner repeatability and agreement in accommodative response measurements. Ophthalmic Physiol Opt. 2009 Nov;29(6):606-14.
94. Whitefoot H, Charman WN. Dynamic retinoscopy and accommodation. Ophthalmic and Physiological Optics. 1992;12(1):8-17.
95. Scheiman M, Wick B. Clinical Management of Binocular Vision: Heterophoric, Accommodative and Eye Movement Disorders. 3rd edition;Lippincott, Williams & Wilkins:463. 2008.
96. Pflugfelder SC, Liu Z, Feuer W, Verm A. Corneal thickness indices discriminate between keratoconus and contact lens-induced corneal thinning. Ophthalmology. 2002;109(12):2336-41.
97. Elkington A, Frank H, editors. Clinical Optics, Third Edition. Oxford: Blackwell Publishing; 1999;235.
98. Stafford M, Morris J. Retinoscopy in the Eye Examination. Pamphlet, based on a Optometry Today article (date unknown). 1994; Accessed 17 Dec 2013 via College of Optometrists online library catalogue , http://www.college-optometrists.org/en/CPD/Library/library-catalogue/index.cfm:pages 5-6.
99. Gaitan-yanguas M. Retinoblastoma: Analysis of 235 cases. International Journal of Radiation Oncology, Biology, Physics. 1978;4(5–6):359-65.
100. Edwards K, Llewellyn R. Optometry. Butterworth-Heinemann, Reid Elsevier plc group 1988:Chapter 6, page 90.
101. Hartnett M, editor. Pediatric Retina: Lippincott, Williams & Wilkins; 2005.
102. Corboy J. The Retinoscopy Book - An Introductory Manual for Eye Care Professionals, Slack Incorporated, NJ, USA.2003; 119.
103. Roe L, Guyton D. An ophthalmoscope is not a retinoscope. The difference is in the red reflex. Survey of ophthalmology. 1984;28(5):405-8.

104. Keeler UK Ltd. Unpublished data; Various manufacturer brochures and discussions with Keeler Ltd. employees Laura Haverley, Adrian Beasley, Ken Church and Jim Matthews, including meeting 17 December 2008.
105. Wirtschafter J, Schwartz G. Duane, Ophthalmology. CD-ROM Edition. 2006;Lippincott, Williams and Wilkins(Chapter 37).
106. Ridgeman W. Experimentation in Biology. Blackie, London. 1975:44.
107. International Epidemiological Association. Good Epidemiological Practice, GUIDELINES FOR PROPER CONDUCT IN EPIDEMIOLOGIC RESEARCH. http://wwwieaweborg, website accessed 2/11/10. 2007.
108. O'Leary C, Evans B. Criteria for prescribing optometric interventions: literature review and practitioner survey. see PDF below. 2003;23(5):429-39.
109. Edwards P, Roberts I, Clarke M, DiGuiseppi C, Wentz R, Kwan I, et al. Methods to increase response to postal and electronic questionnaires. Cochrane Database Syst Rev. (Jul 8;(3)). 2009.
110. Suri S, Verma N. Questionnaire Validation Made Easy. European Journal of Scientific Research. 2010;46(2):172-8.
111. College of Optometrists, Medix U. The College of Optometrists Clinical Practice Survey: Market Research Report. London: Medix UK. College library. 2008.
112. Turner A, Layton C, Bron A. Survey of eye practitioners' attitudes towards diagnostic tests and therapies for dry eye disease. Clin Exp Ophthalmol. 2005 Aug;33(4):351-5.
113. Warburton T, Wass C, Wilkes B. A survey of specified recall intervals for eye examinations. Optometry Today. 2000:30-1.
114. Craig D, Warburton T. New survey on visual field screening in the domiciliary setting. Optometry Today. 2011;25 March:42-3.
115. Kammer R, Sell C, Jamara R, Kollbaum E. Survey of optometric low vision rehabilitation training methods for the moderately visually impaired. Optometry. 2009;80(4):185-92.
116. Myint J, Edgar D, Kotecha A, Murdoch I, Lawrenson J. A national survey of diagnostic tests reported by UK community optometrists for the detection of chronic open angle glaucoma. 2011;31(4):353-9.
117. Gill F, Murphy P, Purslow C. A survey of UK practitioner attitudes to the fitting of rigid gas permeable lenses. Ophthalmic Physiol Optics. 2010;30(6):731-9.
118. Leece P, Bhandari M, Sprague S, Swiontkowski M, Schemitsch E, Tornetta P, et al. Internet Versus Mailed Questionnaires: A Controlled Comparison (2). J Med Internet Res. 2004 6(4):39.
119. Alwitry A, Chen H, Wigfall S. Optometrists' examination and referral practices for patients presenting with flashes and floaters. Ophthalmic Physiol Optics. 2002 May;22(3):183-8.
120. Tan C, Tang W, Tan S, Eong K. Visual experience during cataract surgery: a nation-wide survey on the knowledge of optometry students, 2005;25(3):219-23.
121. Silverman M, Woodruff C, Hardigan P. The future of optometric practice? The results of a survey of optometrists and optometry students. Optometry. 2004 Oct;75(10):615-23.
122. Port M, Pope C. Referrals and notifications by British optometrists. 1988;8(3):323-6.
123. Needle J, Petchey R, Lawrenson J. A survey of the scope of therapeutic practice by UK optometrists and their attitudes to an extended prescribing role. 2008;28(3):193-203.

124. Shah R, Edgar DF, Spry PG, Harper RA, Kotecha A, Rughani S, et al. Glaucoma detection: the content of optometric eye examinations for a presbyopic patient of African racial descent. Br J Ophthalmol. April 1, 2009;93(4):492-6.
125. Ebbert D, Connors H. Standardized patient experiences: evaluation of clinical performance and nurse practitioner student satisfaction. Nurs Educ Perspect 2004;25(1):12-5.
126. Millodot M, O'Leary D. The discrepancy between retinoscopic and subjective measurements: Effects of age. . Am J Optom Physiol Opt. 1978 (55):309-16.
127. Bowen M. College of Optometrists, Director of Research, unpublished. 2010.
128. Bowen M. College of Optometrists, unpublished observations. 2013.
129. Bowen M. College of Optometrists, re College database. unpublished observations; email correspondence 23 & 25 January. 2013.
130. Hallam P. Head of Registration, General Optical Council. Details of General Optical Council Registrants, unpublished observations; telephone discussions 24 & 29 Jan 2013.
131. Sherlock C. College of Optometrists, Information Specialist (Library). unpublished observations; email corresondance 16/8/10. 2010.
132. Kegel-Flom P. Identifying the potential rural optometrist. Am J Optom Physiol Opt 1976;Sep;53(9 Pt 1):479-82.
133. Carnt N, Keay L, Willcox M, Evans V, Stapleton F. Pilot study of contact lens practitioner risk-taking propensity. Optom Vis Sci. 2011 88(8):981-7.
134. Long J, Naduvilath T, Hao L, Li A, Ng W, Yip W, et al. Risk Factors for Physical Discomfort in Australian Optometrists. Optom Vis Sci. 2011;88(2):317-26.
135. Long J. Optometry – a comfortable job for life: a review. Optometry in Practice. 2012;13(1):33-4.
136. Long J, Burgess-Limerick R, Stapleton F. What do clinical optometrists like about their job? Clin Exp Optom. 2013;Feb 5(Epub ahead of print).
137. Prajapati B, Dunne M, Bartlett H, Cubbidge R. The influence of learning styles, enrolment status and gender on academic performance of optometry undergraduates. 2011;31(1):69-78.
138. Kegel-Flom P. Predicting the academic performance of Asian, black, and Hispanic optometry students. Optom Vis Sci 1990;67(3):207-13.
139. General Optical Council. Registrants details from website accesssed 3 Nov 2010. http://annualreport08-09opticalorg/registrants/. 2010.
140. Creative Research Systems. Sample Size Calculator. Accessed online 10 May. http://www.surveysystem.com/sscalc.htm. 2014.
141. ten Kleij F, Musters P. Text analysis of open-ended survey responses: a complementary method to preference mapping. Food Quality and Preference. 2003;14(1):43-52.
142. Loran D. Sports eyewear and eyecare A survey of UK and US practitioners. Optometry Today. 2003:41-4.
143. Frederikson L, Chamberlain K, Sangster A. New Zealand optometrists 2006: demographics, working arrangements and hours worked. Clin Exp Optom. 2008;91(4):353-63.
144. Prajapati B, Dunne M, Armstrong R. Sample size estimation and statistical power analyses. Optometry Today. July, 2010.
145. Salkind N. Statistics for People Who Think They Hate Statistics 2nd Edition Sage Publications, 2010: 322.

146. Ritschard G. CHAID and Earlier Supervised Tree Methods.Dept. of Economics, University of Geneve, Switzerland, No 201002, July. 2010.
147. IBM. SPSS Statistics. accessed 9 april 2013, http://www-01ibmcom/software/analytics/spss/products/statistics/. 2013.
148. Kass G. An Exploratory Technique for Investigating Large Quantities of Categorical Data, . Applied Statistics. 1980;29(2):pp. 119–27.
149. Wikipedia. CHAID (CHi-squared Automatic Interaction Detection). http://enwikipediaorg/wiki/CHAID, accessed 3 Dec 2012.
150. SPSS. IBM SPSS Help;Tree Growing Criteria, accessed 11/12/12. http://dunstone-01:3289/help/indexjsp?topic=/comibmspssstatisticscoach/statcoach_mainhtm. 2012.
151. Anderson T. An Introduction to Multivariate Statistical Analysis. Wiley, New York, ISBN 0471026409. 1958:262.
152. Owens H, Gamble G. A Profile of Keratoconus in New Zealand. Cornea. 2003;22(2):122-5.
153. Danesh-Meyer H, Deva N, Slight C, Tan Y, Tarr K, Carroll S, et al. What do people with glaucoma know about their condition? A comparative cross-sectional incidence and prevalence survey. Clin Exp Ophthalmol. 2008;36(1):13-8.
154. Buckley J, Timmis M, Scally A, Elliott D. When Is Visual Information Used to Control Locomotion When Descending a Kerb? PLoS ONE. 2011;6(4):e19079.
155. Chapman G, Scally A, Elliott D. Adaptive gait changes in older people due to lens magnification. Ophthal Physiol Optics. 2011;31(3):311-7.
156. Heasley K, Buckley J, Scally A, Twigg P, Elliott D. Falls in Older People: Effects of Age and Blurring Vision on the Dynamics of Stepping. Invest Ophthalmol Vis Sci. 2005 October 1, 2005;46(10):3584-8.
157. Heasley K, Buckley J, Scally A, Twigg P, Elliott D. Stepping Up to a New Level: Effects of Blurring Vision in the Elderly. Invest Ophthalmol Vis Sci. July 1, 2004;45(7):2122- 8.
158. Johnson L, Buckley J, Scally A, Elliott D. Multifocal Spectacles Increase Variability in Toe Clearance and Risk of Tripping in the Elderly. Invest Ophthalmol Vis Sci. 2007 April 1, 2007;48(4):1466-71.
159. Guillon M. Dry Eye Symptomatology of Soft Contact Lens Wearers and Nonwearers. Optom Vis Sci. 2005;82(9):pg. 829-34.
160. Yu J, Asche C, Fairchild C. The Economic Burden of Dry Eye Disease in the United States: A Decision Tree Analysis. Cornea. 2011;30(4):379-87.
161. Twa M, Parthasarathy S, Roberts C, Mahmoud A, Raasch T, Bullimore M. Automated Decision Tree Classification of Corneal Shape. Optom Vis Sci. 2005;December;82(12): 1038–46.
162. Quinlan J. C4.5: Programs for machine learning. Morgan Kaufmann Publishers Inc , San Mateo. 1993;Chapter 2, pp 17-25.
163. Bailey N. Statistical Methods in Biology. Cambridge University Press, Cambridge UK. 1995;Third Edition(ISBN: 0-521-47032-3):28 (For significance of n=30 : Section 3.2-3.3, pages 26-8.
164. SPSS Inc. PASWDecisionTrees18. http://wwwsussexacuk/its/pdfs/SPSS18_Decision_Treespdf. 2013;accessed 13 Nov 2013:8-9.
165. Shah R, Edgar D, Evans B. Measuring clinical practice. Ophthalmic and Physiological Optics. 2007;27(2):113-25.
166. General Optical Council. Annual Reports. http://annualreport10-11opticalorg/the-goc-at-a-glance/. 2013; website accessed 24/1/2013.

167. Saward E. Environment, location and styles of practice. J Am Optom Assoc 1975;46(5):464-6.
168. Alderson A, Davey C. Your peers and their decision making. Optometry Today. 2013;5 April:48-57.
169. Strang N, Winn B, Gray L, Pugh J. The reliability of subjective refraction. Ophthalmic and Physiological Optics. 1996;16(3):251.
170. Efron N, Morgan P, Jagpal R. The combined influence of knowledge, training and experience when grading contact lens complications. Ophthalmic Physiol Optics. 2003;23(1):79-85.
171. Sudesh S, Moseley M, Thompson J. Accuracy of Goldmann tonometry in clinical practice. Acta Ophthalmologica. 1993;71(2):185-8.
172. van Rossum A, van Erkel A, van Meerten E, Ton E, Rebergen S, Pattynama P. Accuracy of helical CT for acute pulmonary embolism: ROC analysis of observer performance related to clinical experience. European Radiology. 1998;8(7):1160-4.
173. Ericsson K. Deliberate Practice and the Acquisition and Maintenance of Expert Performance in Medicine and Related Domains. Academic Medicine. 2004;79(10):70-81.
174. Shah R, Edgar DF, Rabbetts R, Blakeney SL, Charlesworth P, Harle DE, et al. The content of optometric eye examinations for a young myope with headaches. Ophthalmic and Physiological Optics. 2008;28(5):404-21.
175. Wolffsohn J, Davies L, Naroo S, Buckhurst P, Gibson G, Gupta N, et al. Evaluation of an open-field autorefractor's ability to measure refraction and hence potential to assess objective accommodation in pseudophakes. Br J Ophthalmol. 2011 April 1, 2011;95(4):498-501.
176. Cleary G, Spalton D, Patel P, Lin P, Marshall J. Diagnostic accuracy and variability of autorefraction by the Tracey Visual Function Analyzer and the Shin-Nippon NVision-K 5001 in relation to subjective refraction. Ophthalmic Physiol Optics. 2009;29(2):173-81.
177. Mallen E, Wolffsohn J, Gilmartin B, Tsujimura S. Clinical evaluation of the Shin-Nippon SRW-5000 autorefractor in adults. 2001;21(2):101-7.
178. Wood M, Mazow M, Prager T. Accuracy of the Nidek ARK-900 objective refractor in comparison with retinoscopy in children ages 3 to 18 years. Am J Ophthalmol. 1998;126(1):100-8.
179. Zadnik K, Mutti DO, Adams AJ. The repeatability of measurement of the ocular components. Invest Ophthalmol Vis Sci. 1992 June 1, 1992;33(7):2325-33.
180. Drance S, Mitchell D, Schulzer M. Studies of an automatic refraction machine. Can J Ophthalmol 1975;10(4):462-8.
181. Grosvenor T, Perrigin D, Perrigin J. Three-way comparison of retinoscopy, subjective, and Dioptron Nova refractive findings. Am J Optom Physiol Opt 1985;62(1):63-5.
182. Guillon M. Automated Refraction in Aphakia- its repeatability and accuracy compared to conventional techniques. Ophthalmic Physiol Optics. 1986;6(1):85-9.
183. Choong Y, Chen A, Goh P. A Comparison of Autorefraction and Subjective Refraction With and Without Cycloplegia in Primary School Children. American Journal Ophthal. 2006;142(1):68-74.
184. Wübbolt I, von Alven S, Hülssner O. Comparisons of manual and automatic refractometry with subjective results. Klin Monbl Augenheilkd 2006;223(11):904-7.

185. Belkin M, Horev G. Aphakic ultrasonographic refraction in adults. Comparison with retinoscopy and subjective refraction. Metab Pediatr Syst Ophthalmol. 1982;6(3-4):269-72.
186. Jorge J, Queiros A, Almeida J, Parafita M. Retinoscopy/Autorefraction: Which Is the Best Starting Point for a Noncycloplegic Refraction? Optom Vis Sci. 2005;82(1):64-8.
187. Strang N, Gray L, Winn B, Pugh J. Clinical evaluation of patient tolerance to autorefractor prescriptions. Clin Exp Optom. 1998;81(3):112-8.
188. Funarunart P, Tengtrisorn S, Sangsupawanich P, Siangyai P. Accuracy of Noncycloplegic Refraction in Primary School Children in Southern Thailand. J Med Assoc Thai 2009;92(6):806-12.
189. Rotsos T, Grigoriou D, Kokkolaki A, Manios N. A comparison of manifest refractions, cycloplegic refractions and retinoscopy on the RMA-3000 autorefractometer in children aged 3 to 15 years. Clin Ophthalmol. 2009;3:429–31.
190. Prabakaran S, Dirani M, Chia A, Gazzard G, Fan Q, Leo S, et al. Cycloplegic refraction in preschool children: comparisons between the hand-held autorefractor, table-mounted autorefractor and retinoscopy. see PDF below. 2009;29(4):422-6.
191. Dahlmann-Noor A, Comyn O, Kostakis V, Misra A, Gupta N, Heath J, et al. Plusoptix Vision Screener: the accuracy and repeatability of refractive measurements using a new autorefractor. Br J Ophthalmol. 2009 March 1, 2009;93(3):346-9.
192. Werner D, Press L. Clinical pearls in refractive care. Butterman Heinemann, Boston. 2002:13-6.
193. Armstrong R, Eperjesi F. Data methods in optometry - Part 9: Experimental design and analysis of variance. Optometry Today. www.otmagazine.co.uk. October 2009.
194. Corboy J. The Retinoscopy Book - An Introductory Manual for Eye Care Professionals (5th Edition). Slack Incorporated, NJ, USA. 2003:10-1.
195. Safir A, Hyams L, Philpot J, Jagerman LS. Studies in refraction: I. the precision of retinoscopy. Archives of Ophthalmology. 1970;84(1):49-61.
196. Hyams L, A S, J P. Studies in refraction: bias and accuracy of retinoscopy. Archives of Ophthalmology. 1971;85(1):33-41.
197. Armstrong RA. Statistical guidelines for the analysis of data obtained from one or both eyes. Ophthalmic and Physiological Optics. 2013;33(1):7-14.
198. Jackson D, Paysse E, Wilhelmus K, Hussein M, Rosby G, Coats D. The effect of off-the-visual-axis retinoscopy on objective refractive measurement. Am J Ophthalmol. 2004;137(6):1101-4.
199. Rabbetts R. Scalar representation of astigmatism. Ophthal Physiol Opt 1996 (16 (3):257-60.
200. Rabbetts R. Bennett & Rabbetts' Clinical Visual Optics. Fourth Edition Butterworth Heinemann Elsevier, Oxford 2007; 97.
201. Thibos L, Wheeler W, Horner D. Power vectors: an application of Fourier analysis to the description and statistical analysis of refractive error. Optom Vis Sci 1997(74(6)):367-75.
202. Bennett A. A new approach to the statistical analysis of ocular astigmatism and astigmatic prescriptions. Trans First Int Congr British College of Ophthalmic Opticians (Optometrists). 1984;London, UK:35-42.
203. Harris W. Torsional analogue of Prentice's equation and torsional prismatic effect in astigmatic lenses. see PDF below. 1990 ref from Rabbetts 1996;10:203-4.
204. Miller J. Clinical applications of power vectors. Optom Vis Sci. 2009(86(6)):599-602.

205. Bullimore M, Fusaro R, Adams C. The Repeatability of Automated and Clinician Refraction. Optom Vis Sci. 1998; 75(8):617-22.
206. Cohen J. Statistical power analysis for the behavioral sciences. Lawrence Erlbaum Associates Inc. 1988;Publishers, New Jersey.
207. Erdfelder E, Faul F, Buchner A. GPOWER: A general power analysis program. . Behavior Research Methods, Instruments, & Computers. 1996;28:1-11.
208. Faul F, Erdfelder E, Buchner A, Lang A. Statistical power analyses using GPower 3.1: Tests for correlation and regression analyses. . Behavior Research Methods. 2009. 41:1149-60.
209. Faul F, Erdfelder E, Lang A, Buchner A. GPower 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behavior Research Methods. 2007;39:175-91.
210. College of Optometrists. Assessment Framework for Trainees starting from June 2012, Additional Guidance Stage 1 Assessment. http://wwwcollege-optometristsorg/en/qualifying-as-an-optometrist/pre-registration-scheme/indexcfm. Accessed 4 May 2013.
211. Charman W. Some sources of discrepancy between static retinoscopy and subjective refraction. Br J Physiol Opt. 1975(30):108-18.
212. Glickstein M, Millodot M. Retinoscopy and eye size. Science. 1970; 168: 605 - 6.
213. Allen R, Fletcher R, Still D. Eye examination and refraction. Blackwell Scientific Publications, London. 1991:79.
214. Mohindra I. Comparison of “near retinoscopy” and subjective refraction in adults. Am J Optom physiol Opt. 1977(54,):319-22.
215. Dunne M, Armstrong R. email correspondence March 9th. 2009.
216. World Council of Optometry. Definition of optometry. http://wwwworldoptometryorg/en/about-wco/who-is-an-optometrist/indexcfm. 2013;accessed 9 April 2013.
217. Little J. Unpublished communication. email correspondence 11 July from President of European Council of Optometry and Optics. 2013.
218. European Council of Optics and Optometry. Blue Book. 2008;http://www.ecoo.info/wp-content/uploads/2012/07/ECOO_BlueBook2008.pdf, Accessed 26 July 2013.
219. European Council ofOptics and Optometry (ECOO). European Diploma in Optometry, Syllabus http://wwwecooinfo/european-diploma/information-for-students/. 2007; Accessed 26 July 2013.
220. Thomas D, Weegen L, Walendzik A, Wasem J, Jahn R. Comparative Analysis of Delivery of Primary Eye Care in Three European Countries. IBES DISKUSSIONSBEITRAG, Nr 189. 2011.
221. German Optomety Regulations A. Work and Quality Guidelines for Ophthalmic Optics and Optometry, Published 9 October 2010 Received by email from Julie-Anne Little, President of European Council of Optometry & Optics 11 July 2013. 2010.
222. Society of Ophthalmologists (Russia). Importance of sciascopy wwwoorru. 2013; Accessed and translated by Anna Zagvozdina 1/5/2013.
223. Rosenblum Y. Optometry in Russia & the former USSR. J Am Optm Assov 1993;64(10):685-6.
224. Dunstone D, Armstrong R, Dunne M. Survey of habits and attitudes to retinoscopy by optometrists in the UK. Optometry in Practice. 2013;14(2):45-53.

225. Dufier J, Abitbol M, Pigamo F, Prete T, Paris J, Poiyrenaud O. Performance Evaluation of a refractometer Auto lens. J Fr Ophthalmol. 1987;10(7):301–8.
226. Keirl A, Christie C. Clinical Optics and Refraction, A Guide for Optometrists, Contact Lens Opticians and Dispensing Opticians. Butterman Heinemann Elsevier, London. 2007;Chapter 8; 86.
227. Hales R. Contact Lenses, A Clinical Approach to Fitting. 2nd edition. 1982;Williams & Wilkins, Baltimore, USA, Chapter 13:page 207.
228. Hunter D. Dynamic retinoscopy: the missing data. Surv Ophthalmol. 2001 Nov-Dec;46(3):269-74.
229. Davies I. ,Ian P Davies,MCOptom, DCLP, FAAO, Vice President The Vision Care InstituteTM, Johnson and Johnson Medical Ltd,Europe, Middle East Africa, Johnson & Johnson Medical Ltd, Pinewood Campus, Nine Mile Ride, Wokingham, RG40 3EW, unpublished data; email correspondence 8 & 9 April 2013.
230. Armstrong R, Davies L, Dunne M, Gilmartin B. Statistical guidelines for clinical studies of human vision. Ophthalmic Physiol Optics. 2011;31(2):123-36.
231. Haque M. Unpublished personal communication with statistical advisor for the College of Optometrists, Learning Centre, Birmingham University, meeting on 30 September. 2009.
232. Hancock B. Personal communication with advisor for the College of Optometrists, Learning Centre, Birmingham University; meeting 30 September.2009.
233. Davies I, Veys J. The use of fluorescein in contact lens aftercare. Contact Lens and Anterior Eye. 2009;32(4):187–9.
234. Cubbidge R, Whiskens A. Vision and the autistic spectrum. Optician: No 6070(Sept 22). 2006; 22-24.
235. Ludlow A. Visual factors in autistic spectrum disorder. Optometry Today. 2013(15 Nov):46-9.
236. Goss D, Grosvenor T. Reliability of refraction--a literature review. J Am Optom Assoc. 1996;67(10):619-30.
237. Chen J, Xie A, Hou L, Su Y, Thorn F. Cycloplegic and noncycloplegic refractions of Chinese neonatal infants. Invest Ophthalmol Vis Sci. 2011;52(5):2456-61.
238. Hodi S, Wood I. Comparison of the techniques of videorefraction and static retinoscopy in the measurement of refractive error in infants. Ophthalmic Physiol Optics. 1994;14(1):20-4.
239. Elliott M, Simpson T, Richter D, Fonn D. Repeatability and Accuracy of Automated Refraction: A Comparison of the Nikon NRK-8000, the Nidek AR-1000, and Subjective Refraction. Optom Vis Sci. 1997;74(6):434-8.
240. Leinonen J, Laakkonen E, Laatikainen L. Repeatability (test-retest variability) of refractive error measurement in clinical settings. Acta Ophthalmologica Scandinavica. 2006;84(4):532-6.
241. Bland M, Altman D. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet. 1986;1(8476):307-10.
242. Weddell L. Assessment of binocular vision in community practice. Optometry in Practice 2013;14(3):115-24.
243. Armstrong R. Non-Normally Distributed Data and Non-Parametric Statistics. Optometry Today. 19th Aug, http://www.optometry.co.uk/uploads/exams/articles/online_article_19th_august_2011_armstrong.pdf. 2011

244. Buckhurst J, Wolffsohn J, Gupta N, Naroo S, Davies L, Shah S. Development of a questionnaire to assess the relative subjective benefits of presbyopia correction. Journal of Cataract & Refractive Surgery. 2012;38(1):74-9.
245. Gupta N, Wolffsohn J, Naroo S, Davies L, Gibson G, Shah S. Development of a near activity visual questionnaire to assess accommodating intraocular lenses. Contact Lens and Anterior Eye. 2007;30(2):134-43.
246. Edwards K, Llewellyn R, Optometry. Butterworth-Heinemann, Reid Elsevier plc group, London. 1988; 81-87.
247. Garcia G. Handbook of refraction. Little, Brown & Company. 1979;Chapter 7:43.
248. College of Optometrists. The College of Optometrists Clinical Practice Survey: Market Research Report. MedixUK(Medix Intelligent Information). 2008.
249. Yeow P, Taylor S. Clinical evaluation of the Humphrey auto refractor. 1989;9(2):171-5.
250. Rosenfield M, Chiu N. Repeatability of subjective and objective refraction. Optom Vis Sci 1995;72(8):577-9.
251. Davis L, Schechtman K, Begley C, Shin J, Zadnik K. Repeatability of Refraction and Corrected Visual Acuity in Keratoconus. Optom Vis Sci. 1998;75(12):887-96.
252. Chat S, Edwards M. Clinical evaluation of the Shin-Nippon SRW-5000 autorefractor in children. Ophthal Physiol Optics. 2001;21(2):87-100.
253. Raasch T, Schechtman K, Davis L, Zadnik K, The Clek Study Group. Repeatability of subjective refraction in myopic and keratoconic subjects: results of vector analysis. 2001;21(5):376-83.
254. Allen P, Radhakrishnan H, O'Leary D. Repeatability and Validity of the PowerRefractor and the Nidek AR600-A in an Adult Population with Healthy Eyes. Optometry and Vision Science. 2003;80(3):pp 245-51.
255. Davies L, Mallen E, Wolffsohn J, Gilmartin B. Clinical Evaluation of the Shin-Nippon NVision-K 5001/Grand Seiko WR-5100K Autorefractor. Optom Vis Sci. 2003;80(4):320-4.
256. Dave T, Fukuma Y. Clinical Evaluation of the Topcon BV-1000 Automated Subjective Refraction System. Optom Vis Sci. 2004;81(5):pp 323-33.
257. Sheedy J, Schanz P, Bullimore M. Evaluation of an Automated Subjective Refractor. Optom Vis Sci. 2004;81(5):pp 334-40.
258. Nissman S, Tractenberg R, Saba C, Douglas J, Lustbader J. Accuracy, Repeatability, and Clinical Application of Spherocylindrical Automated Refraction Using Time-Based Wavefront Aberrometry Measurements. Ophthalmology. 2006;113(4):570-577.
259. Sheppard A, Davies L. Clinical evaluation of the Grand Seiko Auto Ref/Keratometer WAM-5500. 2010;30(2):143-51.
260. de Juan V, Herreras J, Martin R, Morejon A, Perez I, Cristobal A, et al. Repeatability and agreement of ARK-30 autorefraction after cataract surgery. Clin ExpOphthalmol. 2012;40(2):134-40.
261. Saunders K, Westall C. Comparison between Near Retinoscopy and Cycloplegic Retinoscopy in the Refraction of Infants and Children. Optom Vis Sci. 1992;69(8): 615-22.
262. Walline J, Kinney K, Zadnik K, Mutti D. Repeatability and validity of astigmatism measurements. J Refract Surg. 1999 Jan-Feb;15(1):23-31.

Appendices

Appendix 1. Summary of Ophthalmic Doctorate completed modules and marks achieved. The total notional effort for each module is 200 hours. APL = Approved Prior Learning.

Module title	Date of completion	Marks (%)			Course work description	Credits
		MCQ Exam	Course work	Module		
Research methods	Spring 2009	78	72	76	Research project description/application	20
Glaucoma	Sept 2009	80 (& 70 for short answers)	80	78	5 Case Records	20
Advanced Contact Lenses	Feb 2010	84	60	72	5 Case Records	20
Retinal & Macular disorders	Feb 2012	93	82	84	5 Case Records	20
Advanced Ophthalmic Examination	July 2012	77	78	78	Essay: Assessment of ocular accommodation (3290 words)	20
Refractive Surgery	Feb 2013	81	75	77	Essay: Dry eye & refractive surgery (4100 words)	20
APL; City University Certificates (Glaucoma & Low Vision Rehabilitation)	2004 (Approved Feb 2011)	N/A	N/A	N/A	N/A	40
APL; prior CET	2008 (Approved Feb 2011)	N/A	N/A	N/A	N/A	20

Appendix 2. Conference presentations and published papers regarding this research.

Conference presentations

Czech Republic, Prague 7 May 2011:
Oral Presentation, European Academy of Optometry & Optics, Annual Conference.

East Anglia, Ipswich 22 October 2013: Oral presentation to Suffolk optometrists,
CET accredited lecture organised by the Suffolk Local Optometric Committee.

Publication related to this study

Survey of habits and attitudes to retinoscopy by optometrists in the UK; published June 2013:
Dunstone DJ, Armstrong RM & Dunne M. Survey of habits and attitudes to retinoscopy by optometrists in the UK. Optometry in Practice, 2013. 14(2): p. 45-53.

Appendix 3. Ethics application form.

Aston University
Life & Health Sciences

ETHICS FORM

All parts of the *Ethics Application* must be written concisely using terminology that would be understandable to an educated lay person on an ethics committee.

Title:

An investigation into the routine use and accuracy of retinoscopy

Principal Investigator:

Mark Dunne

Contact Details:

Ophthalmic Research Group, Vision Sciences, Room 141, Extension 4113, m.c.m.dunne@aston.ac.uk

Other Staff / Students involved:

Richard Armstrong, Ophthalmic Research Group

Derek Dunstone, Ophthalmic Doctorate student

A. PROJECT OBJECTIVES / BACKGROUND

A1. What are the primary research questions / objective?

1. To carry out a national survey in order to determine:
    i. How often retinoscopy is carried out;
    ii. What type of retinoscope (spot, steak, standard or combined) is used;
    iii. The level of satisfaction with currently used retinoscope;
    iv. Whether retinoscopy is considered to be an important part of the eye examination;
    v. Respondent details; gender, age, number of years of post-qualification experience, location of practice;
    vi. Willingness to participate in a clinical trial.
2. To carry out a clinical pilot study in order to provide:

i. Data for power calculations that will indicate whether a future larger study is necessary;

ii. Pilot data on the accuracy of retinoscopy;

ii. Pilot data on how accuracy is influenced by the type of retinoscope (standard or combined) used;

iii. Pilot data on how accuracy is influenced by how experienced the user is.

A2. Where will the study take place?

The study will take place at Derek Dunstone's optometry practice in Hadleigh, Ipswich. Statistical analyses will be performed at Aston University.

A3. Describe the statistical methods and/or other relevant methodological approaches to be used in the analysis of the results *(e.g. methods of masking / randomization)*

The national survey questionnaire will be designed in collaboration with the Local Optical Committee attended by Derek Dunstone and co-investigators at Aston University. Statistical analysis is not applicable to this form of exploratory data. Should the need for statistical analysis arise, then Chi-square tests will be used to determine whether frequency variations are statistically significant at the 95% level.

The clinical pilot study will involve collection of data relating to the accuracy of retinoscopy. Briefly, optometrists use subjective refraction to refine the results of retinoscopy before generating a spectacle prescription. Derek Dunstone will determine the spectacle prescription on all of the patients recruited in this trial. The optometrists recruited in this trial will then perform retinoscopy on all patients with no knowledge of the spectacle prescription in each case. The accuracy of retinoscopy will be determined by comparing each retinoscopic result to the corresponding spectacle prescription. This will involve performing Fourier analysis on both sets of data prior to generating a single figure scalar vector that represents the retinoscopic error. This approach is currently advocated by researchers in this field. Optometrist will be recruited according to (1) whether they prefer to use spot or streak retinoscopy and (2) whether they are deemed to be relatively experienced or inexperienced in the use of retinoscopy. Each optometrist will perform only their preferred form of retinoscopy (spot or streak) but using three different instruments. Separate factorial ANOVAs will be performed for the results of spot and streak retinoscopy to determine whether any variations in accuracy are statistically significant at the 95% level. These ANOVAs will indicate whether the factors of interest (1 - the instrument used and 2 – how experienced the user is) influence the observed accuracy and will provide the means of carrying out power calculations aimed at determining whether a larger study is needed.

A4. List the clinical techniques to be conducted on patients as part of the study and indicate whether they fall within the scope of normal professional practice of the individual to perform them

Retinoscopy and subjective refraction are the only clinical techniques that will be used in this study. Both fall within the scope of normal professional practice of the optometrists.

OUTLINE OF STUDY RATIONALE AND METHODOLOGY ENCLOSED

B. RESEARCH PARTICIPANTS

B1. How many participants will be recruited? Please provide justification (power analysis software available from http://www.psycho.uni-duesseldorf.de/abteilungen/aap/gpower3/)

Statistical analysis is not applicable to the form of exploratory data collected during the national survey. However, if statistical analysis is required, appropriate power calculations will be carried out to ensure that statistical power of at least 80% is achieved.

The clinical pilot study will involve performing factorial ANOVAs. It has advocated that an ANOVA has adequate statistical power if at least 15 degrees of freedom are associated with its residual error. The proposed factorial ANOVAs exceed this requirement. However, this approach to power statistics is not generally accepted. Yet, there is presently no data upon which to perform conventional power

calculations. Advisors to the College of Optometrists have, therefore, recommended that the proposed clinical study serves as a pilot study that can provide data for power calculations designed to indicate whether a larger study is necessary in the future.

B2. What restrictions will there be on participation (age, gender, language comprehension etc)?

All UK optometrists will be eligible to take part in the national survey. The clinical trial includes two types of participant; optometrists and patients. Participating optometrists must meet the following inclusion/exclusion criteria: (1) are practicing optometrists, (2) have indicated a preference for either spot or streak retinoscopy, (3) are right hand and right eye dominant (as retinoscopy is being carried out on the right eye of each patient), (4) have indicated how experienced they are at using retinoscopy (5) are local to Derek Dunston's practice and (6) are available to attend the clinical trial. The 6 patients used for this study must meet the following inclusion/exclusion criteria: (1) are aged between 46 and 55 years, (2) have no cataract or other media opacification, (3) do not wear contact lenses, (4) are not using eye drops (5) have attended for a private (non NHS) eye examination at Derek Dunston's practice, (6) Derek Dunstone has judged that they have a good retinoscopic reflex and subjective responses and (7) are available to attend the clinical trial.

B3. How will potential research participants in the study be (i) identified, (ii) approached and (iii) recruited? *If research participants will be recruited via advertisement then attach a copy of the advertisement in the appendix of the ethics report.*

The national survey will involve emailing a questionnaire to 1000 UK optometrists identified in the College of Optometrists' database. Responses will be made on a voluntary basis so some degree of selection bias is unavoidable.

Derek Dunstone will recruit the optometrists and patients participating in the clinical trial. Optometrists who, after completing the national survey, are deemed to meet the inclusion/exclusion criteria will receive a consent form in the post. Patients who, after attending an eye examination with Derek Dunstone, are deemed to meet the inclusion/exclusion criteria will be asked to fill a consent form at the time of the eye examination.

B4. Will the participants be from any of the following groups? *Tick as appropriate and justify any affirmative answers.*

Children under 16:	No
Adults with learning disabilities:	No
Adults who are unconscious or very severely ill:	No
Adults who have a terminal illness:	No
Adults in emergency situations:	No
Adults with mental illness (particularly if detained under Mental Health Legislation):	No
Adults suffering from dementia:	No
Prisoners:	No
Young Offenders:	No
Healthy volunteers:	YES
Those who could be considered to have a particularly dependent relationship with the investigator, e.g. those in care homes, audiology students:	No
Other vulnerable groups:	No

B5. What is the expected total duration of participation in the study for each participant?

The national survey questionnaire will be designed so that it takes no more that 20 minutes to complete. It will be feasible and most efficient to complete the clinical trial within half a day. This also avoids the need for multiple visits by participating optometrists and patients. Derek Dunstone, 4 optometrists and 6 patients will be on site at the same time. Each optometrist will be required to perform 18 (3 instruments used on 6 patients) retinoscopy assessments (a procedure that takes up to 7 minutes); just over 2 hours of retinoscopy. Each patient will have the spectacle prescription confirmed in their right eye by Derek Dunstone (note that these are Derek Dunstone's patients so that this confirmation will take no more than 7 minutes) prior to sitting for 12 (3 instruments used by 4 optometrists) further retinoscopy assessments; just over 1.5 hours of assessment.

B6. Will the activity of the volunteer be restricted in any way either before or after the procedure (e.g. diet or ability to drive)? *If so then give details.*

No.

B7. What is the potential for pain, discomfort, distress, inconvenience or changes to life-style for research participants during and after the study?

There is very little potential for any of the above with the exception of inconvenience. This is minimal for participation in the national survey questionnaire that should take up to 20 minutes to complete but is more substantial for the clinical trial that is likely to last for half a day. One could argue that some pain, discomfort or distress could be experienced by patients sitting for the clinical pilot study, involving 1.5 hours of retinoscopy assessment. However, undergraduates and senior citizens, who attend training clinics at Aston University, frequently experience lengthy and repetitive visual assessments of this kind. Yet, reports of pain, discomfort and distress are very rare indeed and are easily overcome after a brief rest. There is no potential for discomfort and distress for optometrists participating in the clinical trial as their normal duties far exceed the demands made of them in this study.

B8. What levels of risk are involved with participation and how will they be minimized?

The risks of inconvenience will be minimized by careful design of the national survey questionnaire and the clinical trial (see section B5). The unlikely risk of pain, discomfort and distress for patients participating in the clinical trial will by offset by allowing them resting time should these complaints arise. Data collected during the national survey and the clinical trial will be kept confidential. The risk of breaching confidentiality can never be entirely eliminated but will be minimized. Derek Dunstone will ensure that (1) data is stored in anonymised form, (2) research participants will never be identified in connection with discussions about the research data, (3) publications based on the data will never divulge the identity of the research participants.

B9. What is the potential for benefit for research participants?

There is very little potential for benefit for research participants. However, this research will benefit the profession, optometric education and, in turn, patient care.

B10. If your research involves individual or group interviews/questionnaires, what topics or issues might be sensitive, embarrassing or upsetting? Is it possible that criminal or other disclosures requiring action could take place during the study?

The national survey questionnaire does not cover issues that might be sensitive, embarrassing or upsetting. There is no possibility that criminal or other disclosures requiring action will take place during the study.

C. CONSENT

C1. Will a signed record of informed consent be obtained from the research participants? *If consent is not to be obtained, please explain why not.*

A signed record of informed consent will not be sought for participation in the national survey as responses are made on a voluntary basis. Derek Dunstone will, however, seek a signed record of informed consent for all participants of clinical trial.

PARTICIPANT'S INFORMATION SHEETS (OPTOMETRIST & PATIENT VERSIONS & CONSENT FORM ENCLOSED

C2. Who will take consent and how it will be done?

Derek Dunstone will mail information sheets and consent forms to optometrists invited to participate in the clinical trial (see section B3). He will also hand information sheets and consent forms to patients attending an eye examination in his practice who are invited to participate in the clinical trial (see section B3).

C3. How long will the participant have to decide whether to take part in the research? *Justify your answer.*

A deadline will given for (1) receipt of responses to the national survey questionnaire and (2) agreement to participate in the clinical trial. This is reasonable because the entire research project has to be completed in 18 months. This research does not make heavy demands on its participants so the decision to participate is likely to be almost immediate. Nevertheless, no person will be pressurized to respond immediately or to agree to participate. Therefore, questionnaires and consent forms will be handed to potential participants at least a fortnight in advance of the decision deadline. Derek Dunstone will also ensure that any person invited to participate understands that no sanctions will be taken against them if they do not wish to take part or if they withdraw from the study at any time.

C4. What arrangements are in place to ensure participants receive any information that becomes available during the course of the research that may be relevant to their continued participation?

No arrangements have been made as it is inconceivable that such an event will occur in this study.

C5. Will individual research participants receive any *payments/reimbursements* or any other *incentives* or *benefits* for taking part in this research*? If so, then indicate how much and on what basis this has been decided?*

Derek Dunstone has applied for funds from iPRO (Innovation in Practice-based Research for Optometrists). This is a research support facility funded by the College of Optometrists. Funding will cover payments to participants in the clinical trial. It is anticipated that optometrists will receive about £100 (Typical locum fees for half a day which also covers travelling expenses) and patients will receive about £20 (typical payments to clinical research participants at Aston University for half a day which also covers travelling expenses). No payments will be made to participants of the national survey. This is because optometrists regularly receive calls to participate in surveys of this sort which are aimed at improving clinical practice. Advisors to the College of optometrists have provisionally indicated that funding for assistance with the national survey and for expenses incurred by during the clinical pilot study are likely to be be forthcoming.

C6. How will the results of research be made available to research participants and communities from which they are drawn?

The findings of this research will be published in professional journals, such as Optometry Today, and academic journals, such as Ophthalmic and Physiological Optics. All articles published in Optometry Today can be downloaded by anybody who has internet access. Therefore, research participants, or any other enquirer, wishing to see the results may contact Derek Dunstone via email to receive the web address.

D. DATA PROTECTION

D1. Will the research involve any of the following activities? *Delete as appropriate and justify any affirmative answers.*

Examination of medical records by those outside the NHS, or within the NHS by those who would not normally have access:	No
Electronic transfer of data by e-mail:	Yes
Sharing of data with other organizations:	No
Use of personal addresses, postcodes, faxes, emails or telephone numbers:	No
Publication of direct quotations from respondents:	No
Publication of data that might allow identification of individuals:	No
Use of audio/visual recording devices:	No

Justification: Electronic transfer of data between Derek Dunstone's practice in Hadleigh and co-investigators at Aston University is the most efficient way of monitoring research progress. Only anonymous data will be transferred in this manner. This offsets the risk of revealing the identity of research participants. The data is also not of a sensitive nature.

D2. Will data be stored in any of the following ways? *Delete as appropriate and justify any affirmative answers.*

Manual files:			No
Home	or	other	computers: Anonymised data
University			computers: Anonymised data

Justification: Anonymised data from the national survey and the clinical trial will be stored on Derek Dunstone's practice/home computers and Mark Dunne's University/home computer. Being anonymised data, this poses no risk to research participant confidentiality but does facilitate data analysis. Emailed individual responses to the national survey will be destroyed as soon as the data has been transferred into an anonymised database. Raw clinical trial data will be initially recorded in manual form. This data will also be destroyed as soon as it has been transferred into an anonymised database.

D3. What measures have been put in place to ensure confidentiality of personal data? *Give details of whether any encryption or other anonymisation procedures will be used, and at what stage.*

Sections B8 and D2 have covered this aspect of the study. Only anonymous data will be stored. That is, any information that can identify individual research participants will be removed.

D4. If the data is not anonymised, where will the analysis of the data from the study take place and by whom will it be undertaken?

Not applicable

D5. Other than the study staff, who will have access to the data generated by the study?

Nobody

D6. Who will have control of, and act as the custodian for, the data generated by the study?

Derek Dunstone

D7. For how long will data from the study be stored [minimum 5 years]? *Give details of where and how the data will be stored.*

Data will be stored for a minimum of 15 years after cessation of this study, as stipulated in the College of Optometrists' research ethics guidelines. Only anonymised data will be stored and located on Derek Dunstone's practice computer.

E. GENERAL ETHICAL CONSIDERATIONS

E1. What do you consider to be the main ethical issues or problems that may arise with the proposed study, and what steps will be taken to address these?

The main ethical issues or problems that may arise with the proposed study, and the steps taken to address these, are:

i. Inconvenience to participants – minimized by (1) limiting national survey questionnaire to 20 minutes, (2) carrying out clinical trial in half a day;

ii. Very unlikely possibility of pain, discomfort or distress to patients participating in clinical trial – minimized by allowing rest period should these complaints arise;

iii. Very unlikely possibility of revealing the identity of research participants – minimized by (1) storing data in anonymised form, (2) never revealing the identity of research participants when discussing data, (3) never revealing the identity of research participants in publications based on the data.

Although these aspects of the study mean that this protocol has ethical issues, the scientific information to be gained is important because:

i. The national survey will inform the profession and optometric educators about the use and perceived importance of retinoscopy;
ii. The clinical trial will indicate whether the type of retinoscope used or the level of post-qualification experience of the optometrist influences the accuracy of retinoscopy.

By taking the steps described above, the risks have been appropriately minimized, and a reasonable and ethically acceptable balance between risks and benefits has been established.

Appendix 4. Outline of study rationale and methodology.

OUTLINE OF STUDY RATIONALE AND METHODOLOGY

An investigation into the routine use and accuracy of retinoscopy

Study rationale

Retinoscopes are used by optometrists to estimate the spectacle prescription during an eye examination. Retinoscopy is described as being objective because the optometrist does not require the patient to respond. This makes retinoscopy invaluable for estimating the spectacle prescription in patients incapable of verbal communication; very young children or adults who either speak another language or have severe cognitive impairment. In these individuals, the spectacle prescription is based on the retinoscopic result. In all other individuals, the optimum spectacle prescription is determined after refining the retinoscopic result using subjective techniques that require the patient to respond.

In the absence of any prior knowledge of a person's spectacle prescription, retinoscopy provides a rapid means of determining the lenses that maximise vision. However, most people attending an eye examination already wear spectacles. The optometrist can, therefore, bypass retinoscopy by either looking up the current spectacle prescription in the patient's records or using a focimeter to take measurements from the patient's spectacles. Added to this, autorefractors are now widely used in practice. These also bypass the need for retinoscopy in the vast majority of patients. This prompts the question as to how many optometrists are gradually losing the ability to perform retinoscopy. Such a loss of skill could lead to problems when faced with the occasional patient that cannot be tested using an autorefractor, whose spectacle prescription cannot be determined from previous records or current spectacles and whose responses to subjective techniques are unreliable. A national survey would help us to answer this question by asking how often retinoscopy is carried out.

Intensive training in the use of retinoscopy is a particularly challenging part of the early stages of optometric education and often leads students to question the need for retinoscopy, given their knowledge of the existence of autorefractors. Many students seek regular work experience throughout the optometry degree course. Many also have parents, siblings and cousins in the profession. There is, therefore, the potential for students to become influenced by optometrists that may have developed the notion that retinoscopy is largely redundant. A national survey would help here as well by asking whether retinoscopy is considered to be an important part of the eye examination.

Even for training and qualified optometrists that need no convincing about the importance of retinoscopy, questions often arise about the relative accuracy of different types of retinoscope. This is of particular concern for optometry students who are required to buy their own retinoscopes in the first year of the optometry degree course. Essentially, there are two major types of retinoscope; spot and streak. Both types have their advantages and disadvantages in different circumstances. Until about 9

years ago, one had to purchase separate spot or streak retinocopes (referred to as standard retinoscopes from now on). This was costly so students would often choose between purchasing one or the other. Now, there are retinoscopes capable of both modes of operation (referred to as combined retinoscopes from now on). Several experienced practitioners have reported a preference for using their older standard retinoscopes after having purchasing the newer combined types. Keeler Ltd (a major manufacturer of retinoscopes) acknowledges that compromises may have been made in the design of their combined retinoscopes. As far as we are aware, there has been no research on the relative accuracy of standard and combined retinoscopes. Research of this type would inform training and qualified optometrists prior to making decisions about what type of retinoscope to buy.

A national survey would establish (1) what types of retinoscopes are preferred by practising optometrists and (2) the relative levels of satisfaction with different types of retinoscope. A clinical pilot trial would seek to determine the relative accuracy of standard and combined retinoscopes.

Methodology

National survey

One thousand UK optometrists will be invited to participate in the national survey. These individuals will be identified using the College of Optometrists' database.

The national survey questionnaire will be designed in collaboration with (1) The Local Optical Committee attended by Derek Dunstone; (2) Co-investigators at Aston University (Mark Dunne and Richard Armstrong).

Questions will explore: (1) How often retinoscopy is carried out; (2) What type of retinoscope is used/preferred (spot, streak, standard, combined, manufacturer and model); (3) The level of satisfaction with the retinoscope used; (4) Whether retinoscopy is considered to be an important part of the examination; (5) Respondent details (gender, age, number of years of post-qualification experience, location of practice); (6) Willingness to participate in a clinical trial.

In order to minimise any inconvenience to respondents, the questionnaire will be designed so that it takes no more than 20 minutes to complete. It will be emailed to potential participants. Participation will be voluntary. This is unavoidable and means that this part of the study is prone to selection bias.

Results of the survey will be presented in the form of frequency distribution histograms. Chi-square tests will be used, as appropriate, to test whether any frequency variations are statistically significant at the 95% level. Power calculations will be performed to ensure that any analyses found not to be statistical significant have at least 80% power.

Clinical trial: pilot study

This will include two types of participant; optometrists and patients.

Participating optometrists must meet the following inclusion/exclusion criteria: (1) Are practicing optometrists; (2) Have indicated a preference for either spot or streak retinoscopy; (3) Are right hand and right eye dominant (as retinoscopy is only being carried out on the right eye of each patient); (4) Have indicated how experienced they are at using retinoscopy (during the national survey); (5) Are local to Derek Dunston's practice; (6) Are available to attend the clinical trial. Two of the participating optometrists will have been selected because they prefer spot retinoscopy, the other two because they prefer streak retinoscopy. Each pair of optometrists will include one with less post-qualification experience of using retinoscopy compared to the other.

The 6 patients recruited for this study must meet the following inclusion/exclusion criteria: (1) Are aged between 46 and 55 years (as this age group shows least discrepancy between retinoscopy and the final spectacle prescription, according to Millodot and O'Leary (1978)); (2) Have no cataract or other media opacification (that could complicate retinoscopy and the subjective determination of spectacle prescription); (3) Do not wear contact lenses (that could lead to variable spectacle prescription), (4) are not using eye drops (that could lead to variable spectacle prescription); (5) Are private (non-NHS) patients (participation would otherwise require NHS ethical clearance); (6) Have attended for an eye examination at Derek Dunston's practice; (7) Derek Dunstone has judged that they have a good retinoscopic reflex and subjective responses; (8) Are available to attend the clinical trial.

All 4 optometrists will perform only their preferred type of retinoscopy but using 3 different instruments: (1) Their own instrument; (2) A standard instrument; (3) A combined instrument. The rationale behind using their instrument is that this wil give a truer picture of the accuracy of retinoscopy; an optometrist is most likely to perform better with an instrument that they are familiar with. However, each optometrist will inevitable prefer different retinoscopes and this will confound comparisons between instruments. Therefore, all optometrist will also be required to repeat retinoscopy with the same standard and combined instruments. Both instruments will have been selected by Derek Dunstone as being the retinoscopes, identified by the national survey, that are most commonly used. One can expect that this will slightly reduce the accuracy of the retinoscopic assessments carried out with these instruments but this approach will remove confounding.

In order to minimize inconvenience and to remove the need for follow-up appointments, the clinical trial will be complete in just half a day on optometrists and patients that live or work close to the to Derek Dunstone's practice; the site of the clinical trial. The 4 optometrists will be asked to perform 18 retinoscopic assessments in total (3 types of retinoscope on the right eyes of 6 patients). The 6 patients will have had the spectacle prescription determined for their right eye by Derek Dunstone prior to sitting for 12 further retinoscopic assessments (carried out by the 4 optometrists using 3 instruments).

The spectacle prescription of each patient will not be made known to the 4 optometrists during the clinical trial. Accuracy will be determined by comparing each retinoscopic result to the corresponding spectacle prescription and expressing the difference separate Fourier components and as a combined scalar vector. This treatment of the results is currently advocated to overcome the difficulties of comparing prescriptions expressed in spherocylindrical form (Rabbetts, 1996, 2007; Thibos et al., 1997; Cleary et al., 2009).

Separate factorial ANOVAs will be performed on the results of spot retinoscopy and streak retinoscopy. These will determine whether any variations in accuracy (in the form of Fourier components and combined scalar vectors) are statistically significant at the 95% level. These ANOVAs have been designed to explore how accuracy is influenced by (1) the type of retinoscope used, (2) how experienced the optometrist is and (3) interactions between both factors.

It has been advocated that an ANOVA has adequate statistical power if at least 15 degrees of freedom are associated with its residual error (Ridgeman, 1975). The proposed factorial ANOVAs exceed this requirement. However, this approach to power statistics is not generally recognised (Haque, personal communication). The College's statistician (Saeed Haque) has suggested that conventional power calculations should be carried out but understands that there is presently no research data upon which these calculations can be based. A compromise has, therefore, been recommended (Hancock, personal communication). This is to run the above mentioned clinical trial as a pilot study. The primary aim of this pilot study would be to generate the data needed for power calculations for a future more extensive study. If, however, the findings of the pilot study should turn out to be statistically significant, a more extensive study will not be needed.

Appendix 4 continued.

References:

Cleary G, Spalton DJ, Patel PM, Lin PF, Marshall J. Diagnostic accuracy and variability of autorefraction by the Tracey Visual Function Analyzer and the Shin-Nippon NVision-K 5001 in relation to subjective refraction. Ophthal. Physiol. Opt. 2009 29:173-181

Haque, MS. Personal communication with statistical advisor for the College of Optometrists, Learning Centre, Birmingham University.

Hancock, B. Personal communication with advisor for the College of Optometrists, Learning Centre, Birmingham University.

Millodot M, O'Leary D. The discrepancy between retinoscopic and subjective measurements: Effects of age. Am. J. Optom. Physiol. Opt. 1978 55:309-316.

Rabbetts RB. Scalar representation of astigmatism. Ophthal. Physiol. Opt. 1996 16:257-260.

Rabbetts RB. Bennett & Rabbetts' Clinical Visual Optics. Fourth Edition. Butterworth Heinemann Elsevier, Oxford. 2007 Pp 97.

Thibos LN, Wheeler W, Horner D. Power vectors: an application of Fourier analysis to the description and statistical analysis of refractive error. Optom. Vis. Sci. 1997 74:367-380.

Ridgeman WJ (1975) Experimentation in Biology. Blackie, London, 1975. Pp 44.

Appendix 5. Clinical trial participants' information sheet: optometrist

PARTICIPANT'S INFORMATION SHEET: OPTOMETRIST

RESEARCH WORKERS

Derek Dunstone, Hadleigh, Ipswich
Mark Dunne, Life & Health Sciences, Ophthalmic Research Group, Aston University
Richard Armstrong, Life & Health Sciences, Ophthalmic Research Group, Aston University

PROJECT TITLE

An investigation into the routine use and accuracy of retinoscopy: Clinical trial

INVITATION

You are being invited to take part in a clinical pilot study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

WHAT IS THE PURPOSE OF THE STUDY?

The purpose of this clinical pilot study is to determine how the accuracy of retinoscopy is influenced by the type of retinoscope used and by how experienced the optometrist is. As you know, one had to, in the past, purchase separate spot and streak retinocopes; we will call these standard retinoscopes. For some time now, there have been retinoscopes capable of both modes of operation; we will call these combined retinoscopes. We have become aware of anecdotal reports of optometrists expressing a preference for using their older standard retinoscopes after having purchasing the newer combined types. Keeler Ltd acknowledges that compromises may have been made in the design of their combined retinoscopes. As far as we are aware, however, there has been no research on the relative accuracy of standard and combined retinoscopes. Research of this type would inform training and qualified optometrists prior to making decisions about what type of retinoscope to buy.

WHY HAVE I BEEN CHOSEN?

Four optometrists have been selected to take part in this clinical trial. All of you have completed our national survey on the use of retinoscopy during the eye examination. You have been chose because your responses to this survey indicate that you: (1) are a practicing optometrist, (2) have a preference for either spot or streak retinoscopy, (3) are right hand and right eye dominant, (4) have indicated how experienced you are at using retinoscopy (5) are local to Derek Dunston's practice (the site of the clinical trial) and (6) have indicated that you are available to attend the clinical trial.

WHAT WILL HAPPEN TO ME IF I TAKE PART?

The clinical trial will take place at Derek Dunstone's practice in Hadleigh. Derek Dunstone will be in attendance along with yourself, three other optometrists and six patients. This will allow completion of the entire clinical trial within half a day. You will be required to perform 18 retinoscopy assessments using your preferred form of retinoscope (spot or steak). These retinoscopy assessments will be carried out on the right eyes of 6 patients. The current spectacle prescriptions of these patients will not be made known to you at the time of the trial. On each patient, you will perform retinoscopy using three instruments: (1) your own instrument, (2) a standard retinoscope and (3) a combined retinoscope. Your retinoscopic findings will be compared to the corresponding spectacle prescription, determined by Derek Dunstone.

ARE THERE ANY POTENTIAL RISKS IN TAKING PART IN THE STUDY?

Apart from the inconvenience of taking part, there is almost no risk involved in this study. You will not be required to perform any procedure that is not within your capabilities as an optometrist. There is absolutely no risk that your performance in this clinical trial will affect your continued entitlement to practise as an optometrist.

DO I HAVE TO TAKE PART?

You do not have to take part in this study if you do not wish to. No sanctions will be taken against you if you do not wish to take part or if you withdraw from the study at any time. We would, however, be grateful if you could let us know your decision within a fortnight of receiving this letter.

Appendix 5 continued.

EXPENSES AND PAYMENTS

You will receive £100 (to be confirmed) for participating in this study. This sum has been set to cover your fees and expenses.

WILL MY TAKING PART IN THIS STUDY BE KEPT CONFIDENTIAL?

Your privacy and confidentiality will be vigorously protected to the maximum extent permissible by law. Your results will not be stored with any personal details, such as your name and address. This step has been taken to protect your anonymity in the unlikely event that your data, stored on a computer, are unintentionally revealed.

WHAT WILL HAPPEN TO THE RESULTS OF THE RESEARCH STUDY?

Your results will be analyzed by Derek Dunstone. Mark Dunne and Richard Armstrong will only have access to your data after your personal details have been removed. The results of this study will form part of Derek Dunstone's doctoral thesis and will be published in appropriate academic and professional journals. Your identity will not be revealed in the thesis or any publication. The College of Optometrists' guidelines on research ethics dictate that the database containing your results, without personal details, will be stored for 15 years. Please contact Derek Dunstone if you want a copy of the published research.

WHO IS ORGANIZING AND FUNDING THE RESEARCH?

Derek Dunstone is carrying out this clinical trial as part of his postgraduate research with the School of Life and Health Sciences at Aston University. He has applied for funds from iPRO (Innovation in Practice-based Research for Optometrists) which is a research support facility funded by the College of Optometrists.

WHO HAS REVIEWED THE STUDY?

The study has been submitted for review and approval by Aston University's Research Ethics Committee.

WHO DO I CONTACT IF SOMETHING GOES WRONG OR I NEED FURTHER INFORMATION?

Please feel free to contact Mark Dunne (m.c.m.dunne@aston.ac.uk, 0121 204 4113) or Derek Dunstone (INSERT EMAIL & TELEPHONE NUMBER).

WHO DO I CONTACT IF I WISH TO MAKE A COMPLAINT ABOUT THE WAY IN WHICH THE RESEARCH IS CONDUCTED?

If you have any concerns about the way in which this study has been conducted, then you should contact Secretary of Aston University's Research Ethics Committee (j.g.walter@aston.ac.uk, 0121 204 4869).

Appendix 6. Clinical trial participants information sheet: patient

PARTICIPANT'S INFORMATION SHEET: PATIENT

RESEARCH WORKERS

Derek Dunstone, Hadleigh, Ipswich
Mark Dunne, Life & Health Sciences, Ophthalmic Research Group, Aston University
Richard Armstrong, Life & Health Sciences, Ophthalmic Research Group, Aston University

PROJECT TITLE

An investigation into the routine use and accuracy of retinoscopy: Clinical trial

INVITATION

You are being invited to take part in a clinical pilot study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

WHAT IS THE PURPOSE OF THE STUDY?

The purpose of this clinical pilot study is to determine how the accuracy of retinoscopy, a routine procedure carried out by optometrists to estimate your spectacle prescription, is influenced by the type of retinoscope used and by how experienced the optometrist is. Research of this type will help training and qualified optometrists make informed decisions about what type of retinoscope to use and should, in turn, contribute to our continued efforts to improve eye care.

WHY HAVE I BEEN CHOSEN?

Six patients have been selected to take part in this clinical trial. All of you have had your eye's examined by Derek Dunstone at his optometry practice in Hadleigh. You have been chosen because you: (1) are aged between 46 and 55 years, (2) have eye conditions such as cataract, (3) do not wear contact lenses, (4) are not using eye drops (5) have attended for a non-NHS eye examination at Derek Dunston's practice, (6) give clear responses during the eye examination and (7) have indicated, during your eye examination, that you are available to attend the clinical trial.

WHAT WILL HAPPEN TO ME IF I TAKE PART?

The clinical pilot stidy will take place at Derek Dunstone's practice. Derek Dunstone will be in attendance along with yourself, five other patients and four optometrists. This will allow completion of the entire clinical trial within half a day. Your will wear a trial frame which is routinely used for eye examinations. Derek Dunstone will perform a quick confirmation of the spectacle prescription of your right eye. You will then sit for further retinoscopic assessments on your right eye. These will be carried out by four different optometrists, each using three different kinds of retinoscope. Each retinoscopy assessment will involve having a light shone into your right eye and will last just 4 minutes. All assessments should be complete in just over 1.5 hours.

Appendix 6 continued.

ARE THERE ANY POTENTIAL RISKS IN TAKING PART IN THE STUDY?

Apart from the inconvenience of taking part, there is almost no risk involved in this study. Retinoscopy is routinely used by optometrists and only fully qualified optometrists will be testing your eyes. Do not be unduly concerned about having lights shone in your eyes during the 12 retinoscopy assessments. Patients who attend clinics for training optometrists frequently have repetitive visual assessments of this kind. Yet, reports of pain, discomfort and distress are very rare indeed and are easily overcome after a brief rest. Participation in this study will not restrict your activities for the rest of the day.

DO I HAVE TO TAKE PART?

You do not have to take part in this study if you do not wish to. No sanctions will be taken against you if you do not wish to take part or if you withdraw from the study at any time. We would, however, be grateful if you could let us know your decision within a fortnight of receiving this letter.

EXPENSES AND PAYMENTS

You will receive £20 (To be confirmed) for participating in this study. This sum has been set as a token of our gratitude and to cover any expenses.

WILL MY TAKING PART IN THIS STUDY BE KEPT CONFIDENTIAL?

Your privacy and confidentiality will be vigorously protected to the maximum extent permissible by law. Your results will not be stored with any personal details, such as your name and address. This step has been taken to protect your anonymity in the unlikely event that your data, stored on a computer, are unintentionally revealed.

WHAT WILL HAPPEN TO THE RESULTS OF THE RESEARCH STUDY?

Your results will be analyzed by Derek Dunstone. Mark Dunne and Richard Armstrong will only have access to your data after your personal details have been removed. The results of this study will form part of Derek Dunstone's doctoral thesis and will be published in appropriate academic and professional journals. Your identity will not be revealed in the thesis or any publication. The College of Optometrists' guidelines on research ethics dictate that the database containing your results, without personal details, will be stored for 15 years. Please contact Derek Dunstone if you want a copy of the published research.

WHO IS ORGANIZING AND FUNDING THE RESEARCH?

Derek Dunstone is carrying out this clinical trial as part of his postgraduate research with the School of Life and Health Sciences at Aston University. He has applied for funds from iPRO (Innovation in Practice-based Research for Optometrists) which is a research support facility funded by the College of Optometrists.

Appendix 6 continued.

WHO HAS REVIEWED THE STUDY?

The study has been submitted for review and approval by Aston University's Research Ethics Committee.

WHO DO I CONTACT IF SOMETHING GOES WRONG OR I NEED FURTHER INFORMATION?

Please feel free to contact Mark Dunne (m.c.m.dunne@aston.ac.uk, 0121 204 4113) or Derek Dunstone (INSERT EMAIL & TELEPHONE NUMBER).

WHO DO I CONTACT IF I WISH TO MAKE A COMPLAINT ABOUT THE WAY IN WHICH THE RESEARCH IS CONDUCTED?

If you have any concerns about the way in which this study has been conducted, then you should contact Secretary of Aston University's Research Ethics Committee (j.g.walter@aston.ac.uk, 0121 204 4869).

Appendix 7. Consent form for the clinical trial.

Personal Identification Number for this study:
_____

CONSENT FORM

Title of Project:

An investigation into the routine use and accuracy of retinoscopy: Clinical trial

Research Venue:

Derek Dunstone's optometry practice, Hadleigh, Ipswich

Name of Investigator(s):

Derek Dunstone, Hadleigh, Ipswich
Mark Dunne, Life & Health Sciences, Ophthalmic Research Group, Aston University
Richard Armstrong, Life & Health Sciences, Ophthalmic Research Group, Aston University

Please initial box

Appendix 7 continued.

1. I confirm that I have read and understand the information sheet dated ..... ☐ (version .....) for the above study and have had the opportunity to ask questions.

2. I understand that my participation is voluntary and that I am free to withdraw at any time, ☐ without giving any reason, without my legal rights being affected.

3. I agree to take part in the above study. ☐

_____	_____ _____	
Name of Research Participant	Date	Signature
_____	_____ _____	
Name of Person taking Consent	Date	Signature

Appendix 8. Invite to participate in the clinical trial (included in the Suffolk LOC Newsletter distributed to all Suffolk optometrists in October 2009).

INVITATION BY DEREK DUNSTONE

An investigation into the accuracy of different types of retinoscope: Clinical trial

I am conducting practice based research comparing the accuracy of different types of retinoscope and am looking for four Optometrists to each participate on the afternoon or early evening of Thursday 10 December 2009. Only optometrists who are right handed and right eye dominant are required.

If you are interested in taking part in this clinical pilot study please contact me by Friday 23 October 2009. You will then be sent an application form and questionnaire, which will ask about your use of retinoscopy. From the applications received, four practitioners will be chosen to give a suitable spread of retinoscopy preference and use (ascertained from answers to the questionnaire).

This project is being supervised by Mark Dunne and Richard Armstrong of Aston University and supported by the College of Optometrists and iPRO (Innovation in Practice-based Research for Optometrists).

Appendix 8 continued.

The clinical trial will take place at my practice in Hadleigh. Derek Dunstone will be in attendance along with yourself, three other optometrists and six patients. You will be required to perform 18 retinoscopy assessments using your preferred form of retinoscope (spot or steak). These retinoscopy assessments will be carried out on the right eyes of 6 patients. The current spectacle prescriptions of these patients will not be made known to you at the time of the trial. On each patient, you will perform retinoscopy using three instruments: (1) your own instrument, (2) a standard retinoscope and (3) a dual purpose retinoscope (model that can be used as spot or streak just by changing the bulb). Your retinoscopic findings will be compared to the corresponding spectacle prescription, determined by Derek Dunstone.

If selected for the trial, you will receive £150 (plus travel expenses) for participating in this study to cover your fees and expenses. You do not have to take part in this study if you do not wish to.

If you take part, your privacy and confidentiality will be vigorously protected to the maximum extent permissible by law. Your results will not be stored with any personal details, such as your name and address. Your results will be analyzed by Derek Dunstone. Mark Dunne and Richard Armstrong will only have access to your data after your personal details have been removed. The results of this study will form part of Derek Dunstone's doctoral thesis and will be published in appropriate academic and professional journals. Your identity will not be revealed in the thesis or any publication.

Please feel free to contact Derek Dunstone if you have any questions.

Derek Dunstone BSc(Hons)MCOptom
3 Queen Street, Hadleigh, Ipswich IP7 5DZ
01473 823755
derek@dunstoneinsight.com

Appendix 9. Invite to participate in UK survey; sent by email, with introduction from Michael Bowen.

Dear College Member,

As you may be aware the College has been developing its involvement with and contribution to research.

As part of our work to promote and develop research into Optometry, Optics, Vision Science and related areas, we are continuing to deliver the Innovation in Practice-based Research in Optometry (iPRO) programme. From time to time the projects that iPRO researchers are working on require the support of fellow professionals through the provision of responses to research surveys.

The email above is from Derek Dunstone, a College Member and iPRO grant recipient, inviting you to participate in the project that he is working on to investigate the use of retinoscopy. The outputs of this project will be enhanced by a good response to this survey. I realise that you are extremely busy, but would ask you to please take the time to go to the online survey and to complete this – I have run through this and it really should take you around 10 minutes.

Thank you for your time and continued support.

Appendix 9 continued.

With kind regards,

Michael Bowen
Head of Research

Dear Colleague

You are invited to participate in a National Retinoscopy Survey which has been sent to you as a member of The College of Optometrists.

We aim to determine the retinoscopy habits of qualified UK Optometrists. The purpose of this is to ascertain whether Optometrists feel that retinoscopy is an important test and if modern instruments are considered appropriate. The results of the survey will be published and may be the stimulus for debate regarding the relevance or otherwise of this test in a routine Optometric examination.

This study forms part of a project supported by the College of Optometrists, iPRO (Innovation in Practice-based Research for Optometrists), Rodenstock UK and Keeler (UK) Ltd.

It is also part of my Ophthalmic Doctorate which is being supervised by Mark Dunne and Richard Armstrong at Aston University.

The survey questionnaire has been designed in collaboration with my supervisors at Aston University and has been discussed and piloted by members of the Suffolk Local Optometric Committee.

Your participation is voluntary but would be much appreciated and the questionnaire will only take around 10 minutes to complete.

In recognition of the time taken to complete the survey your name will be entered in a prize draw to win a retinoscope, direct ophthalmoscope and charger. You only need to provide your name and contact details if you wish to be entered in the draw.

Your privacy and confidentiality will be vigorously protected and your identity will not be revealed in my thesis or any publication.

The survey can be accessed from the following link
http://www.surveymonkey.com/s/FPWT9GX

The closing date for submission is April 5 2010.

I hope you are willing to participate. Please contact me if you have any questions regarding this research.

Kind regards

Derek

Derek Dunstone BSc(Hons)MCOptom
3 Queen Street, Hadleigh, Ipswich IP7 5DZ
derek@dunstoneinsight.com
01473 823755

Appendix 10. The invitation to the international retinoscopy survey, which was distributed with the questionnaire.

Dear Colleague

As a delegate of THE VISION CARE INSTITUTE®, you are invited to participate in a short four question Retinoscopy Survey.

We aim to determine the retinoscopy habits of eye care practitioners like you from around the region. The purpose of this is to ascertain whether practitioners feel that retinoscopy is an important test and if modern instruments are considered appropriate. The results of the survey will be published and may be the stimulus for debate regarding the relevance or otherwise of this test in a routine eye examination.

This study forms part of a project supported by the British College of Optometrists, iPRO (Innovation in Practice-based Research for Optometrists). It is also part of my Ophthalmic Doctorate which is being supervised by Mark Dunne and Richard Armstrong at Aston University in the UK.

The survey questionnaire has been designed in collaboration with Co-investigators (Dr Mark Dunne and Dr Richard Armstrong). This element of the study has been discussed and agreed with Ian Davies, Vice President, THE VISION CARE INSTITUTE®.

Your participation is voluntary but would be much appreciated and the questionnaire will take around one minute to complete.

If you take part your privacy and confidentiality will be vigorously protected and your identity will not be revealed in my thesis or any publication.

I hope you are willing to participate. Please contact me if you have any questions regarding this research - my details are included after the questions.

Kind regards

Derek Dunstone BSc(Hons)MCOptom

Many thanks for completing this questionnaire. The results will be published in due course and the link will be available from The Vision Care Institute website.

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Appendix 11. Ethical approval notification.

Aston University
Life & Health Sciences

Response from AOREC

20th November 2009

Project title: *An investigation into the routine use and accuracy of retinoscopy*

Reference Number: Dunstone OD

Researchers: Mark Dunne, Richard Armstrong and Derek Dunstone

I am pleased to inform you that the Audiology / Optometry Research Ethics Committee has approved the above named project.

The details of the investigation will be placed on file. You should notify The Committee of any difficulties experienced by the volunteer subjects, and any significant changes which may be planned for this project in the future.

Yours sincerely

AOREC

Appendix 12. Queries raised following piloting with members of Suffolk Local Optometric Committee which resulted in amendments to survey items

Query raised	Amendment to item
Practitioner likely to be unsure whether their own retinoscope is a combination type	Features of combination type described
One university teaching optometry absent	Anglia Ruskin added
Optometrists likely to use several methods of objective refraction	Word 'primary' added when asking about method of objective refraction
Retinoscopy can detect crystalline 'changes' as well as 'opacities'	Word 'Changes' added
Some optometrists use both retinoscope and auto refractor	Option of 'both' added to means of objective refraction and method prescribing spectacles

Appendix 13. The full survey showing questions with alternative answers.

When did you qualify as an Optometrist? Before 1965, 1965-1979, 1980-1994, 1995-2010.
Ethnic Group (This information is for statistical purposes only. Complete this question only if you wish to do so). White, Mixed, Asian or Asian British, British, Chinese, Other ethnic group.
Where is the practice in which you spend most of your time? England-Eastern, England-East Midlands, England-London Boroughs, England-North East, England- North West, England-South East, England-South West, England-West Midlands, England-Yorkshire and Humber, Northern Ireland, Scotland, Wales.
Which type of practice do you consider to be your principal work? Independent (less than 3 practices), joint venture/multiple, locum, hospital, academic/research, training/education, management.
At which university did you study Optometry? City, Manchester, Cardiff, Glasgow, Aston, Anglia Ruskin, Bradford, Ulster, Other.
How many eye examinations do you carry out in any typical week? 0-20, 21-40, 41-80, 81 or more.
In what percentage of your eye examinations do you perform retinoscopy? 0%, 1 - 25%, 26 - 50%, 51 - 75%, 76 - 100%.
What is your primary method of objective refraction? Retinoscopy, Autorefractor, both about equally.
Do you ever prescribe spectacles based on your objective refraction result alone e.g. for infants or learning difficulty patients? YES using retinoscopy findings, YES using both retinoscopy and autorefractor findings, YES using autorefractor findings, No.
What type of retinoscope do you use? Spot, Streak, Retinoscope not used.
Does your retinoscope have the facility to change from spot to streak design, or visa versa, by simply changing the bulb? (Sometimes described as Combination, Combi, dual mode or bimodal retinoscopes) Yes, No, Not sure.
Which company manufactured your retinoscope? Keeler, Welch Allyn, Heini, None of these, Not sure.
How old is your retinoscope? 0-5 years, 6-9 years, 10 years or older.

How satisfied are you with the performance of your own retinoscope? Very dissatisfied, Dissatisfied, Satisfied, Very satisfied, No opinion.
Combination retinoscopes (that have the facility to change from spot to streak design, or visa versa, by simply changing the bulb) are not as accurate as the older/designated models. Do you: strongly agree, agree, disagree, strongly disagree, no opinion?
Retinoscopy is NOT an important aspect of an Optometric examination. Do you strongly agree, agree, disagree, strongly disagree, no opinion?
Retinoscopy is useful for detecting keratoconus. Do you strongly agree, agree, disagree, strongly disagree, no opinion?
Ignore the use of a working distance allowance lens in this question. When initiating retinoscopy, I prefer to use starting point lenses in the trial frame (i.e. the previous prescription or autorefractor result). Do you: strongly agree, agree, disagree, strongly disagree, no opinion?
Retinoscopy is NOT useful for detecting crystalline lens changes or opacities. Do you strongly agree, agree, disagree, strongly disagree, no opinion?
Dynamic retinoscopy (i.e. use of a retinoscope to give information regarding accommodation) is used: Occasionally, Frequently, Never.
Do you own a more recently purchased retinoscope which you do not use, as you prefer an older model? No, Yes.
If you have answered Yes to this question, who is your newer, unused, retinoscope manufactured by? Keeler, Welch Allyn, Heini, None of these, Not sure.
If you have any comments on retinoscopy in practice please use the space below:

Appendix 14. Raw data from the UK survey, excluding respondent identification details.

Response number	When did you qualify as an Optometrist?	Ethnic Group	Where is the practice in which you spend most of your time?
1	1980 - 1994	Asian or Asian British	England – London Boroughs
2	1995 – 2010	Asian or Asian British	England – South East
3	1995 – 2010	Asian or Asian British	England – London Boroughs
4	1995 – 2010	White	England – London Boroughs
5	1980 - 1994	White	England – Eastern
6	1980 - 1994	White	England – Eastern
7	1980 - 1994	White	England – West Midlands
8	1995 – 2010	White	England – North East
9	1980 - 1994	Asian or Asian British	England – Yorkshire and Humber
10	1980 - 1994	Asian or Asian British	England – East Midlands
11	1995 – 2010	White	England – Yorkshire and Humber
12	1980 - 1994	White	England – South West
13	1995 – 2010	White	England – Eastern
14	1995 – 2010	Asian or Asian British	England – East Midlands
15	1980 - 1994	White	England – North West
16	1995 – 2010	Asian or Asian British	England – London Boroughs
17	1995 – 2010	White	Scotland
18	1995 – 2010	White	Scotland
19	1980 - 1994	Chinese	England – South East
20	1995 – 2010	Asian or Asian British	England – North West
21	1980 - 1994	White	England – West Midlands
22	1995 – 2010	Asian or Asian British	England – West Midlands
23	1980 - 1994	White	England – South West
24	1995 – 2010	White	England – West Midlands
25	1995 – 2010	Asian or Asian British	England – North West
26	1995 – 2010	White	England – South East
27	1980 - 1994	White	England – South West
28	1995 – 2010	White	Scotland
29	1995 – 2010	White	England – North West
30	1995 – 2010	White	England – South West
31	1980 - 1994	White	England – Yorkshire and Humber
32	1980 - 1994	White	England – Yorkshire and Humber
33	1980 - 1994	White	Wales
34	1995 – 2010	White	Northern Ireland
35	1980 - 1994	White	England – North West
36	1980 - 1994	White	England – East Midlands
37	1965 - 1979	White	England – Yorkshire and Humber
38	1995 – 2010		England – London Boroughs
39	1995 – 2010	White	Scotland
40	1995 – 2010	White	Scotland
41	1995 – 2010	White	England – North West
42	1995 – 2010	Asian or Asian British	England – London Boroughs
43	1980 - 1994	White	Scotland
44	1995 – 2010	White	England – South West
45	1980 - 1994	Asian or Asian British	England – East Midlands
46	1995 – 2010	Asian or Asian British	England – London Boroughs

Appendix 14 continued

47	1965 - 1979	White	England – South East
48	1995 – 2010	White	England – East Midlands
49	1980 - 1994	White	England – North West
50	1995 – 2010	Asian or Asian British	England – London Boroughs
51	1995 – 2010	White	England – North East
52	1980 - 1994	White	Scotland
53	1980 - 1994	Asian or Asian British	England – East Midlands
54	1980 - 1994	White	England – West Midlands
55	1995 – 2010	White	England – South West
56	1995 – 2010	Asian or Asian British	England – South East
57	1980 - 1994	White	Scotland
58	1995 – 2010	Asian or Asian British	England – London Boroughs
59	1980 - 1994	White	Scotland
60	1995 – 2010	White	Scotland
61	1980 - 1994	Asian or Asian British	England – Yorkshire and Humber
62	1980 - 1994	White	Scotland
63	1995 – 2010	White	England – East Midlands
64	1995 – 2010	Chinese	England – Yorkshire and Humber
65	1980 - 1994	White	Scotland
66	1980 - 1994	White	England – South East
67		Asian or Asian British	England – London Boroughs
68	1980 - 1994	Asian or Asian British	England – North East
69	1995 – 2010	White	Scotland
70	1995 – 2010	White	England – Eastern
71	1980 - 1994	White	England – South East
72	1995 – 2010	White	England – East Midlands
73	1980 - 1994	White	Northern Ireland
74	1995 – 2010	White	England – East Midlands
75	1995 – 2010	Asian or Asian British	England – South East
76	1995 – 2010	White	England – North West
77	1995 – 2010	White	Northern Ireland
78	1980 - 1994	White	Scotland
79	1980 - 1994	White	England – South East
80	1995 – 2010	Asian or Asian British	England – London Boroughs
81	1995 – 2010	Asian or Asian British	England – West Midlands
82	1980 - 1994	White	England – South West
83	1995 – 2010	White	England – South West
84	1980 - 1994	White	England – Yorkshire and Humber
85	1980 - 1994	White	England – South East
86	1980 - 1994	White	England – Yorkshire and Humber
87	1980 - 1994	White	England – North East
88	1980 - 1994	White	England – North West
89	1995 – 2010	White	England – West Midlands
90	1980 - 1994	White	England – North West
91	1980 - 1994	Asian or Asian British	England – South East
92	1995 – 2010	Other ethnic group	Scotland
93	1980 - 1994	White	England – London Boroughs
94	1980 - 1994	White	England – North East
95	1995 – 2010	Asian or Asian British	England – West Midlands
96	1995 – 2010	White	Northern Ireland

Appendix 14 continued

97	1995 – 2010	Black or Black British	England – Eastern
98	1980 - 1994	White	Wales
99	1995 – 2010	White	Scotland
100	1980 - 1994	Asian or Asian British	England – South East
101	1980 - 1994	Asian or Asian British	England – South East
102	1995 – 2010	White	Scotland
103	1995 – 2010	Asian or Asian British	England – North West
104	1995 – 2010	Asian or Asian British	England – South East
105	1980 - 1994	White	Scotland
106	1995 – 2010	White	Scotland
107	1995 – 2010	White	England – North West
108	1980 - 1994		England – South East
109	1980 - 1994	White	Scotland
110	1980 - 1994	White	Scotland
111	1980 - 1994	Asian or Asian British	England – South East
112	1980 - 1994	White	England – North West
113	1980 - 1994	White	England – East Midlands
114	1995 – 2010	White	England – North East
115	1980 - 1994	White	England – South East
116	1980 - 1994	White	Wales
117	1995 – 2010	Asian or Asian British	England – London Boroughs
118	1980 - 1994	White	England – South East
119	1995 – 2010	White	England – North West
120	1980 - 1994	Asian or Asian British	England – West Midlands
121	1995 – 2010	Asian or Asian British	England – South East
122	1995 – 2010	White	England – South West
123	1995 – 2010	White	England – East Midlands
124	1980 - 1994	White	England – North West
125	1995 – 2010	White	England – Eastern
126	1980 - 1994	White	England – Yorkshire and Humber
127	1980 - 1994	White	England – South West
128	1995 – 2010	Asian or Asian British	England – London Boroughs
129	1995 – 2010	White	England – West Midlands
130	1980 - 1994	White	England – South West
131	1995 – 2010		England – South East
132	1980 - 1994	Asian or Asian British	England – South East
133	1995 – 2010	White	Scotland
134	1995 – 2010	Mixed	England – London Boroughs
135	1995 – 2010	Asian or Asian British	England – South East
136	1980 - 1994	White	England – South West
137	1995 – 2010	White	Scotland
138	1980 - 1994	White	England – South West
139	1995 – 2010	Asian or Asian British	England – South East
140	1995 – 2010	White	England – North West
141	1995 – 2010	Asian or Asian British	England – Eastern
142	1980 - 1994	White	England – North West
143	1995 – 2010	White	England – South East
144	1980 - 1994	White	England – South West
145	1995 – 2010	White	England – South West
146	1980 - 1994	White	England – West Midlands
147	1980 - 1994	White	England – South West
148	1980 - 1994	White	England – East Midlands
149	1995 – 2010	White	England – South West

Appendix 14 continued

150	1995 – 2010	Asian or Asian British	England – East Midlands
151	1980 - 1994	Asian or Asian British	England – West Midlands
152	1995 – 2010	White	England – London Boroughs
153	1980 - 1994	White	England – North East
154	1980 - 1994	Asian or Asian British	England – North East
155	1980 - 1994	White	England – South East
156	1995 – 2010	White	England – London Boroughs
157	1980 - 1994	White	England – North West
158	1980 - 1994	White	England – East Midlands
159	1995 – 2010	White	England – London Boroughs
160	1995 – 2010	Asian or Asian British	England – South East
161	1980 - 1994	White	Scotland
162	1980 - 1994	Chinese	England – South West
163	1995 – 2010	Asian or Asian British	England – South West
164	1995 – 2010	White	Scotland
165	1995 – 2010	Asian or Asian British	England – London Boroughs
166	1980 - 1994	White	England – North East
167	1995 – 2010	Chinese	Scotland
168	1995 – 2010	Asian or Asian British	England – London Boroughs
169	1995 – 2010	White	England – North West
170	1995 – 2010	Asian or Asian British	England – London Boroughs
171	1995 – 2010	Asian or Asian British	England – Eastern
172	1980 - 1994	White	England – North West
173	1995 – 2010	Asian or Asian British	England – London Boroughs
174	1980 - 1994	White	England – North West
175	1980 - 1994	White	Scotland
176	1980 - 1994	White	Wales
177	1995 – 2010	Asian or Asian British	England – London Boroughs
178	1995 – 2010	White	England – West Midlands
179	1980 - 1994	White	England – West Midlands
180	1995 – 2010	Asian or Asian British	England – South East
181	1995 – 2010	White	England – North West
182	1995 – 2010	Asian or Asian British	England – London Boroughs
183	1980 - 1994	White	England – West Midlands
184	1995 – 2010	White	England – South East
185	1995 – 2010	White	England – South East
186	1995 – 2010	White	Northern Ireland
187	1980 - 1994	Chinese	England – London Boroughs
188	1995 – 2010	White	Scotland
189	1995 – 2010	Asian or Asian British	England – London Boroughs
190	1980 - 1994		England – South West
191	1995 – 2010	White	Northern Ireland
192	1980 - 1994	White	England – West Midlands
193	1980 - 1994	White	England – East Midlands
194	1980 - 1994	White	England – South East
195	1995 – 2010	Asian or Asian British	Scotland
196	1980 - 1994	White	England – West Midlands
197	1995 – 2010	White	England – East Midlands
198	1995 – 2010	White	England – North West
199	1995 – 2010	White	England – Eastern
200	1980 - 1994	Asian or Asian British	England – South East
201	1980 - 1994	White	England – South East
202	1980 - 1994	White	England – London Boroughs
203	1980 - 1994	White	England – North East

Appendix 14 continued

204	1980 - 1994	White	England – West Midlands
205	1995 – 2010	White	England – West Midlands
206	1995 – 2010		England – Eastern
207	1980 - 1994	Asian or Asian British	England – South East
208	1980 - 1994	White	Northern Ireland
209	1995 – 2010	White	Wales
210	1980 - 1994	White	England – Eastern
211	1980 - 1994	White	England – South West
212	1980 - 1994	White	England – South East
213	1995 – 2010	White	England – London Boroughs
214	1980 - 1994	Asian or Asian British	England – London Boroughs
215	1995 – 2010	White	England – Eastern
216	1980 - 1994	White	England – North West
217	1995 – 2010	White	England – North West
218	1995 – 2010		England – South East
219	1995 – 2010	White	England – North East
220	1980 - 1994	Asian or Asian British	England – North East
221	1995 – 2010	Black or Black British	England – South West
222	1980 - 1994	White	England – Yorkshire and Humber
223	1980 - 1994	White	England – Yorkshire and Humber
224	1995 – 2010	Asian or Asian British	England – North West
225	1995 – 2010	Asian or Asian British	England – South West
226	1995 – 2010	White	England – South East
227	1995 – 2010		England – London Boroughs
228	1980 - 1994	Asian or Asian British	England – West Midlands
229	1995 – 2010	Asian or Asian British	England – South East
230	1995 – 2010	White	Northern Ireland
231	1995 – 2010	White	England – North East
232	1980 - 1994	White	England – South East
233	1995 – 2010	Asian or Asian British	England – South East
234	1980 - 1994	White	England – North West
235	1965 - 1979		
236	1980 - 1994	Asian or Asian British	England – South East
237			
238	1980 - 1994	White	England – London Boroughs
239	1995 – 2010	White	Scotland
240	1995 – 2010	Asian or Asian British	England – West Midlands
241	1995 – 2010	White	England – North West
242	1995 – 2010	Asian or Asian British	England – Yorkshire and Humber
243	1995 – 2010	Asian or Asian British	England – London Boroughs
244	1980 - 1994	White	England – North West
245	1980 - 1994	Asian or Asian British	England – London Boroughs
246	1995 – 2010	Asian or Asian British	England – London Boroughs
247	1995 – 2010	White	England – West Midlands
248	1995 – 2010	Asian or Asian British	England – South East
249	1980 - 1994	Asian or Asian British	England – London Boroughs
250	1980 - 1994	White	England – West Midlands
251	1980 - 1994	White	Scotland
252	1995 – 2010	White	Northern Ireland
253	1980 - 1994	White	Scotland
254	1965 - 1979	White	England – South West

Appendix 14 continued

255	1995 – 2010	White	Scotland
256	1995 – 2010	Asian or Asian British	England – West Midlands
257	1995 – 2010	Asian or Asian British	England – London Boroughs
258	1980 - 1994	White	England – South East
259	1995 – 2010	White	England – North East
260	1980 - 1994	Asian or Asian British	England – South West
261	1995 – 2010	White	England – North West
262	1995 – 2010	White	England – South East
263	1980 - 1994	White	England – East Midlands
264	1980 - 1994	White	England – Yorkshire and Humber
265	1995 – 2010	Asian or Asian British	England – South East
266	1980 - 1994	White	England – Yorkshire and Humber
267	1980 - 1994	White	England – North West
268	1980 - 1994	White	Wales
269	1995 – 2010	White	Scotland
270	1995 – 2010	Asian or Asian British	England – London Boroughs
271	1995 – 2010	White	England – East Midlands
272	1995 – 2010	Asian or Asian British	England – Eastern
273	1980 - 1994	White	England – West Midlands
274	1995 – 2010	Asian or Asian British	England – West Midlands
275	1995 – 2010	White	Scotland
276	1980 - 1994	White	Scotland
277	1995 – 2010	White	Northern Ireland
278	1980 - 1994	White	England – West Midlands
279	1980 - 1994	White	England – Yorkshire and Humber
280	1995 – 2010	White	England – Yorkshire and Humber
281	1995 – 2010	White	England – South East
282	1995 – 2010	White	England – Yorkshire and Humber
283	1995 – 2010	White	England – Yorkshire and Humber
284	1995 – 2010	Asian or Asian British	England – West Midlands
285	1980 - 1994	White	Scotland
286	1980 - 1994	White	England – South East
287	1995 – 2010	Chinese	Northern Ireland
288	1980 - 1994	White	England – North West
289	1995 – 2010	Asian or Asian British	England – London Boroughs
290	1980 - 1994	Asian or Asian British	England – South East
291	1995 – 2010	Asian or Asian British	England – London Boroughs
292	1980 - 1994	Asian or Asian British	England – London Boroughs
293	1995 – 2010	White	England – South West
294	1980 - 1994	White	England – East Midlands
295	1995 – 2010	Mixed	England – North West
296	1995 – 2010	Asian or Asian British	England – South East
297	1980 - 1994	White	England – South East
298	1995 – 2010	White	England – West Midlands
299	1980 - 1994	Asian or Asian British	England – London Boroughs

Appendix 14 continued

Response number	Which type of practice do you consider to be your principal work?	At which university did you study Optometry?	How many eye examinations do you carry out in any typical week?
1	Community practice – independent(less than 3 practices)	City	41- 60
2	Community practice – joint venture/multiple	City	61 – 80
3	Community practice – independent(less than 3 practices)	City	21- 40
4	Community practice – independent(less than 3 practices)	Cardiff	0- 20
5	Community practice – independent(less than 3 practices)	City	41- 60
6	Community practice – independent(less than 3 practices)	Aston	41- 60
7	Hospital	Aston	21- 40
8	Community practice – independent(less than 3 practices)	Bradford	41- 60
9	Hospital	Bradford	21- 40
10	Community practice – joint venture/multiple	Manchester	41- 60
11	Community practice – joint venture/multiple	Bradford	81 or more
12	Community practice – joint venture/multiple	Cardiff	21- 40
13	Community practice – joint venture/multiple	Anglia Ruskin	61 – 80
14	Community practice – locum	Aston	81 or more
15	Community practice – independent(less than 3 practices)	Manchester	41- 60
16	Community practice – locum	Aston	41- 60
17	Community practice – independent(less than 3 practices)	Glasgow	61 – 80
18	Community practice – joint venture/multiple	Glasgow	21- 40
19	Community practice – independent(less than 3 practices)	Cardiff	21- 40
20	Community practice – independent(less than 3 practices)	Manchester	41- 60
21	Community practice – independent(less than 3 practices)	Cardiff	0- 20
22	Community practice – joint venture/multiple	Aston	61 – 80
23	Hospital	Cardiff	0- 20
24	Community practice – independent(less than 3 practices)	Aston	41- 60
25	Community practice – locum	Manchester	61 – 80
26	Community practice – joint venture/multiple	Aston	61 – 80
27	Community practice – locum	Aston	41- 60
28	Community practice – locum	Glasgow	0- 20
29	Community practice – independent(less than 3 practices)	Bradford	61 – 80
30	Community practice – joint venture/multiple	Cardiff	21- 40
31	Community practice – independent(less than 3 practices)	Aston	21- 40
32	Academic/research	Manchester	0- 20
33	Community practice – independent(less than 3 practices)	Aston	41- 60
34	Community practice – joint venture/multiple	Ulster	61 – 80
35	Hospital	Manchester	41- 60

Appendix 14 continued

36	Community practice – independent(less than 3 practices)	City	21- 40
37	Community practice – joint venture/multiple	Bradford	41- 60
38	Community practice – locum	Anglia Ruskin	41- 60
39	Community practice – independent(less than 3 practices)	Aston	41- 60
40	Community practice – independent(less than 3 practices)	Glasgow	41- 60
41	Hospital	Ulster	41- 60
42	Community practice – joint venture/multiple	City	81 or more
43	Community practice – joint venture/multiple	Glasgow	61 – 80
44	Community practice – locum	Cardiff	61 – 80
45	Community practice – independent(less than 3 practices)	Aston	81 or more
46	Community practice – joint venture/multiple	Anglia Ruskin	21- 40
47	Community practice – independent(less than 3 practices)	Other	41- 60
48	Community practice – joint venture/multiple	Aston	61 – 80
49	Community practice – independent(less than 3 practices)	Aston	41- 60
50	Community practice – joint venture/multiple	Anglia Ruskin	41- 60
51	Community practice – joint venture/multiple	Bradford	61 – 80
52	Community practice – joint venture/multiple	Glasgow	0- 20
53	Community practice – independent(less than 3 practices)	Aston	41- 60
54	Community practice – locum	City	21- 40
55	Community practice – independent(less than 3 practices)	Cardiff	61 – 80
56	Community practice – joint venture/multiple	City	61 – 80
57	Community practice – joint venture/multiple	Glasgow	21- 40
58	Community practice – independent(less than 3 practices)	City	41- 60
59	Community practice – joint venture/multiple	Glasgow	41- 60
60	Community practice – joint venture/multiple	Glasgow	41- 60
61	Community practice – independent(less than 3 practices)	Glasgow	21- 40
62	Community practice – independent(less than 3 practices)	Glasgow	21- 40
63	Community practice – independent(less than 3 practices)	Aston	61 – 80
64	Community practice – joint venture/multiple	Bradford	81 or more
65	Community practice – independent(less than 3 practices)	Glasgow	21- 40
66	Community practice – joint venture/multiple	Manchester	41- 60
67		City	41- 60
68	Community practice – joint venture/multiple	Cardiff	81 or more
69	Hospital	Glasgow	41- 60
70	Community practice – joint venture/multiple	Aston	41- 60
71	Community practice – independent(less than 3 practices)	Aston	61 – 80
72	Community practice – joint venture/multiple	Ulster	61 – 80
73	Community practice – independent(less than 3 practices)	Aston	21- 40
74	Community practice – independent(less than 3)	Aston	61 – 80

Appendix 14 continued

75	Community practice – independent(less than 3 practices)	City	61 – 80
76	Community practice – joint venture/multiple	Manchester	81 or more
77	Community practice – independent(less than 3 practices)	Ulster	0- 20
78	Hospital	Glasgow	61 – 80
79	Community practice – joint venture/multiple	Aston	41- 60
80	Community practice – joint venture/multiple	Aston	61 – 80
81	Community practice – independent(less than 3 practices)	Glasgow	81 or more
82	Community practice – independent(less than 3 practices)	Bradford	41- 60
83	Community practice – independent(less than 3 practices)	Aston	21- 40
84	Community practice – independent(less than 3 practices)	Manchester	21- 40
85	Community practice – independent(less than 3 practices)	City	21- 40
86	Community practice – joint venture/multiple	Bradford	41- 60
87	Community practice – independent(less than 3 practices)	Glasgow	81 or more
88	Community practice – independent(less than 3 practices)	Aston	21- 40
89	Community practice – independent(less than 3 practices)	Aston	21- 40
90	Community practice – independent(less than 3 practices)	City	41- 60
91	Community practice – locum	Aston	61 – 80
92	Community practice – joint venture/multiple	Glasgow	61 – 80
93	Community practice – joint venture/multiple	Other	41- 60
94	Community practice – joint venture/multiple	Bradford	21- 40
95	Community practice – joint venture/multiple	Bradford	61 – 80
96	Community practice – independent(less than 3 practices)	Ulster	61 – 80
97	Community practice – joint venture/multiple	Anglia Ruskin	81 or more
98	Community practice – locum	Aston	21- 40
99	Hospital	Glasgow	61 – 80
100	Community practice – independent(less than 3 practices)	Glasgow	41- 60
101	Community practice – joint venture/multiple	Aston	61 – 80
102	Community practice – joint venture/multiple	Glasgow	41- 60
103	Community practice – joint venture/multiple	Aston	81 or more
104	Community practice – locum	Anglia Ruskin	61 – 80
105	Community practice – joint venture/multiple	Glasgow	0- 20
106	Community practice – independent(less than 3 practices)	Glasgow	61 – 80
107	Community practice – locum	Bradford	61 – 80
108	Community practice – independent(less than 3 practices)	Manchester	21- 40
109	Community practice – independent(less than 3 practices)	Glasgow	61 – 80
110	Community practice – joint venture/multiple	Cardiff	21- 40
111	Community practice – joint venture/multiple	Manchester	21- 40
112	Community practice – locum	Manchester	61 – 80
113	Community practice – independent(less than 3)	Aston	21- 40

Appendix 14 continued

114	Community practice – joint venture/multiple	Aston	61 – 80
115	Community practice – locum	Cardiff	0- 20
116	Community practice – joint venture/multiple	Aston	61 – 80
117	Community practice – joint venture/multiple	Aston	81 or more
118	Community practice – independent(less than 3 practices)	City	21- 40
119	Community practice – joint venture/multiple	Manchester	61 – 80
120	Community practice – independent(less than 3 practices)	Aston	41- 60
121	Community practice – joint venture/multiple	City	81 or more
122	Community practice – joint venture/multiple	Manchester	61 – 80
123	Community practice – joint venture/multiple	Manchester	61 – 80
124	Community practice – joint venture/multiple	Cardiff	61 – 80
125	Community practice – joint venture/multiple	Aston	41- 60
126	Community practice – independent(less than 3 practices)	Glasgow	41- 60
127	Hospital	Aston	41- 60
128	Community practice – locum	City	61 – 80
129	Community practice – independent(less than 3 practices)	Bradford	41- 60
130	Community practice – joint venture/multiple	Aston	61 – 80
131	Community practice – locum	Bradford	61 – 80
132	Community practice – independent(less than 3 practices)	City	21- 40
133	Hospital	Glasgow	41- 60
134	Hospital	Aston	0- 20
135	Community practice – joint venture/multiple	Aston	81 or more
136	Community practice – independent(less than 3 practices)	Aston	21- 40
137	Community practice – independent(less than 3 practices)	Glasgow	61 – 80
138	Community practice – joint venture/multiple	City	61 – 80
139	Community practice – joint venture/multiple	Aston	61 – 80
140	Community practice – joint venture/multiple	Aston	81 or more
141	Community practice – locum	City	61 – 80
142	Community practice – independent(less than 3 practices)	Bradford	21- 40
143	Community practice – independent(less than 3 practices)	Anglia Ruskin	41- 60
144	Community practice – joint venture/multiple	Aston	41- 60
145	Community practice – locum	Anglia Ruskin	61 – 80
146	Community practice – independent(less than 3 practices)	Aston	41- 60
147	Community practice – joint venture/multiple	City	21- 40
148	Community practice – locum	Cardiff	61 – 80
149	Community practice – joint venture/multiple	Cardiff	41- 60
150	Community practice – joint venture/multiple	Aston	81 or more
151	Training education	Aston	21- 40
152	Community practice – locum	Manchester	0- 20
153	Community practice – independent(less than 3 practices)	Aston	0- 20
154	Community practice – locum	Aston	21- 40
155	Community practice – independent(less than 3 practices)	Cardiff	61 – 80

Appendix 14 continued

156	Community practice – locum	City	81 or more
157	Hospital	Manchester	41- 60
158	Community practice – independent(less than 3 practices)	Bradford	21- 40
159	Community practice – independent(less than 3 practices)	Aston	41- 60
160	Community practice – joint venture/multiple	City	81 or more
161	Training education	Aston	0- 20
162	Community practice – joint venture/multiple	City	21- 40
163	Community practice – joint venture/multiple	Manchester	21- 40
164	Community practice – joint venture/multiple	Glasgow	41- 60
165	Community practice – independent(less than 3 practices)	Aston	21- 40
166	Community practice – locum	Bradford	21- 40
167	Community practice – joint venture/multiple	Bradford	21- 40
168	Community practice – joint venture/multiple	City	21- 40
169	Hospital	Cardiff	41- 60
170	Community practice – joint venture/multiple	City	21- 40
171	Community practice – locum	City	41- 60
172	Community practice – independent(less than 3 practices)	Bradford	0- 20
173	Community practice – independent(less than 3 practices)	Anglia Ruskin	41- 60
174	Community practice – locum	Cardiff	21- 40
175	Community practice – joint venture/multiple	Glasgow	21- 40
176	Community practice – independent(less than 3 practices)	Aston	61 – 80
177	Academic/research	City	21- 40
178	Community practice – independent(less than 3 practices)	Aston	61 – 80
179	Community practice – locum	Cardiff	0- 20
180	Hospital	City	21- 40
181	Academic/research	Cardiff	0- 20
182	Community practice – independent(less than 3 practices)	City	41- 60
183	Community practice – independent(less than 3 practices)	Bradford	41- 60
184	Community practice – joint venture/multiple	Cardiff	61 – 80
185	Community practice – independent(less than 3 practices)	City	21- 40
186	Community practice – independent(less than 3 practices)	Ulster	21- 40
187	Community practice – independent(less than 3 practices)	City	61 – 80
188	Community practice – independent(less than 3 practices)	Manchester	61 – 80
189	Community practice – locum	City	61 – 80
190	Community practice – independent(less than 3 practices)	City	21- 40
191	Community practice – joint venture/multiple	Aston	41- 60
192	Community practice – joint venture/multiple	Aston	41- 60
193	Community practice – locum	Manchester	0- 20
194	Community practice – joint venture/multiple	Aston	61 – 80
195	Community practice – locum	Glasgow	41- 60
196	Academic/research	Bradford	0- 20

Appendix 14 continued

197	Community practice – independent(less than 3 practices)	Bradford	21- 40
198	Hospital	Bradford	41- 60
199	Community practice – joint venture/multiple	City	81 or more
200	Community practice – joint venture/multiple	City	61 – 80
201	Community practice – independent(less than 3 practices)	Aston	41- 60
202	Community practice – locum	City	0- 20
203	Community practice – independent(less than 3 practices)	Bradford	21- 40
204	Community practice – independent(less than 3 practices)	Manchester	21- 40
205	Community practice – joint venture/multiple	Glasgow	21- 40
206	Community practice – locum	Cardiff	61 – 80
207	Community practice – locum	Other	81 or more
208	Community practice – independent(less than 3 practices)	Bradford	41- 60
209	Community practice – independent(less than 3 practices)	Aston	41- 60
210	Community practice – independent(less than 3 practices)	City	0- 20
211	Community practice – independent(less than 3 practices)	City	0- 20
212	Hospital	Aston	41- 60
213	Hospital	Aston	21- 40
214	Community practice – independent(less than 3 practices)	Bradford	0- 20
215	Community practice – independent(less than 3 practices)	Cardiff	61 – 80
216	Community practice – locum	Aston	81 or more
217	Community practice – joint venture/multiple	Ulster	61 – 80
218	Community practice – locum	Bradford	41- 60
219	Community practice – independent(less than 3 practices)	Manchester	41- 60
220	Community practice – joint venture/multiple	Cardiff	61 – 80
221	Community practice – independent(less than 3 practices)	Bradford	81 or more
222	Community practice – joint venture/multiple	Aston	61 – 80
223	Community practice – independent(less than 3 practices)	Manchester	41- 60
224	Community practice – locum	Bradford	81 or more
225	Community practice – independent(less than 3 practices)	Anglia Ruskin	21- 40
226	Community practice – joint venture/multiple	City	21- 40
227	Community practice – joint venture/multiple	Anglia Ruskin	41- 60
228	Community practice – locum	Cardiff	41- 60
229	Community practice – joint venture/multiple	City	61 – 80
230	Community practice – independent(less than 3 practices)	Cardiff	41- 60
231	Community practice – locum	Bradford	21- 40
232	Community practice – locum	Cardiff	41- 60
233	Community practice – joint venture/multiple	City	81 or more
234	Community practice – independent(less than 3 practices)	Bradford	0- 20
235			

Appendix 14 continued

236	Community practice – independent(less than 3 practices)	Aston	81 or more
237			
238	Community practice – locum	Glasgow	41- 60
239	Community practice – independent(less than 3 practices)	Glasgow	41- 60
240	Community practice – independent(less than 3 practices)	Aston	41- 60
241	Community practice – joint venture/multiple	Manchester	61 – 80
242	Community practice – joint venture/multiple	Bradford	81 or more
243	Community practice – locum	Aston	21- 40
244	Academic/research	City	0- 20
245	Community practice – joint venture/multiple	Aston	21- 40
246	Community practice – locum	City	41- 60
247	Community practice – independent(less than 3 practices)	Bradford	41- 60
248	Community practice – joint venture/multiple	Aston	61 – 80
249	Community practice – joint venture/multiple	City	61 – 80
250	Community practice – joint venture/multiple	Bradford	21- 40
251	Community practice – independent(less than 3 practices)	Glasgow	41- 60
252	Community practice – joint venture/multiple	Ulster	81 or more
253	Community practice – joint venture/multiple	Glasgow	81 or more
254	Community practice – joint venture/multiple	Cardiff	61 – 80
255	Hospital	Glasgow	21- 40
256	Community practice – joint venture/multiple	Anglia Ruskin	81 or more
257	Community practice – joint venture/multiple	City	61 – 80
258	Community practice – independent(less than 3 practices)	City	41- 60
259	Community practice – joint venture/multiple	Bradford	81 or more
260	Community practice – joint venture/multiple	Aston	81 or more
261	Community practice – independent(less than 3 practices)	Aston	81 or more
262	Community practice – joint venture/multiple	Ulster	61 – 80
263	Community practice – locum	Cardiff	21- 40
264	Community practice – locum	Bradford	61 – 80
265	Community practice – joint venture/multiple	City	61 – 80
266	Community practice – locum	Aston	21- 40
267	Community practice – independent(less than 3 practices)	Manchester	21- 40
268	Community practice – independent(less than 3 practices)	Cardiff	41- 60
269	Community practice – joint venture/multiple	City	41- 60
270	Community practice – joint venture/multiple	Manchester	21- 40
271	Community practice – independent(less than 3 practices)	Bradford	41- 60
272	Community practice – joint venture/multiple	Aston	41- 60
273	Community practice – independent(less than 3 practices)	Aston	21- 40
274	Community practice – locum	Anglia Ruskin	81 or more
275	Community practice – joint venture/multiple	Glasgow	41- 60
276	Hospital	Glasgow	21- 40
277	Hospital	Ulster	41- 60
278	Community practice – joint venture/multiple	Manchester	41- 60

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279	Community practice – joint venture/multiple	Bradford	61 – 80
280	Community practice – joint venture/multiple	Bradford	61 – 80
281	Community practice – joint venture/multiple	Aston	81 or more
282	Community practice – independent(less than 3 practices)	Aston	41- 60
283	Community practice – independent(less than 3 practices)	Bradford	21- 40
284	Community practice – joint venture/multiple	Aston	0- 20
285	Community practice – independent(less than 3 practices)	City	81 or more
286	Community practice – joint venture/multiple	City	61 – 80
287	Community practice – independent(less than 3 practices)	Aston	61 – 80
288	Community practice – independent(less than 3 practices)	Other	81 or more
289	Community practice – independent(less than 3 practices)	City	61 – 80
290	Community practice – locum	Aston	61 – 80
291	Community practice – joint venture/multiple	City	61 – 80
292	Community practice – joint venture/multiple	Glasgow	61 – 80
293	Community practice – independent(less than 3 practices)	Anglia Ruskin	61 – 80
294	Community practice – independent(less than 3 practices)	Aston	21- 40
295	Academic/research	Manchester	0- 20
296	Community practice – locum	City	21- 40
297	Community practice – locum	City	0- 20
298	Community practice – joint venture/multiple	Aston	81 or more
299	Community practice – joint venture/multiple	City	41- 60

Response number	In what percentage of your eye examinations do you perform retinoscopy?	What is your primary method of objective refraction?	Do you ever prescribe spectacles based on your objective refraction result alone e.g. for infants or learning difficulty patients?
1	1 - 25%	Retinoscopy	YES using retinoscopy findings
2	1 - 25%	Autorefractor	NO
3	76 - 100%	Retinoscopy	YES using retinoscopy findings
4	1 - 25%	Retinoscopy	YES using retinoscopy findings
5	26 - 50%	Retinoscopy	YES using retinoscopy findings
6	1 - 25%	Retinoscopy	YES using retinoscopy findings
7	76 - 100%	Retinoscopy	YES using retinoscopy findings
8	51 - 75%	Retinoscopy	YES using retinoscopy findings
9	26 - 50%	Retinoscopy	YES using retinoscopy findings
10	76 - 100%	Retinoscopy	YES using retinoscopy findings
11	1 - 25%	Both about equally	YES using both retinoscopy and autorefractor findings
12	1 - 25%	Retinoscopy	YES using retinoscopy findings
13	1 - 25%	Both about equally	YES using both retinoscopy and autorefractor findings
14	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
15	76 - 100%	Retinoscopy	YES using retinoscopy findings

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16	1 - 25%	Retinoscopy	YES using retinoscopy findings
17	26 - 50%	Retinoscopy	YES using retinoscopy findings
18	51 - 75%	Retinoscopy	YES using retinoscopy findings
19	1 - 25%	Autorefractor	YES using retinoscopy findings
20	51 - 75%	Retinoscopy	YES using retinoscopy findings
21	1 - 25%	Retinoscopy	YES using retinoscopy findings
22	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
23	51 - 75%	Retinoscopy	YES using retinoscopy findings
24	51 - 75%	Retinoscopy	YES using retinoscopy findings
25	51 - 75%	Both about equally	YES using retinoscopy findings
26	1 - 25%	Retinoscopy	YES using retinoscopy findings
27	26 - 50%	Retinoscopy	YES using retinoscopy findings
28	1 - 25%	Both about equally	YES using retinoscopy findings
29	51 - 75%	Retinoscopy	YES using retinoscopy findings
30	51 - 75%	Retinoscopy	YES using retinoscopy findings
31	1 - 25%	Retinoscopy	YES using retinoscopy findings
32	76 - 100%	Retinoscopy	YES using retinoscopy findings
33	26 - 50%	Retinoscopy	YES using retinoscopy findings
34	1 - 25%	Autorefractor	YES using retinoscopy findings
35	76 - 100%	Retinoscopy	YES using retinoscopy findings
36	26 - 50%	Both about equally	YES using both retinoscopy and autorefractor findings
37	76 - 100%	Retinoscopy	YES using retinoscopy findings
38	51 - 75%	Both about equally	YES using retinoscopy findings
39	76 - 100%	Retinoscopy	YES using retinoscopy findings
40	51 - 75%	Retinoscopy	YES using retinoscopy findings
41	76 - 100%	Retinoscopy	YES using retinoscopy findings
42	26 - 50%	Retinoscopy	YES using retinoscopy findings
43	76 - 100%	Retinoscopy	YES using retinoscopy findings
44	76 - 100%	Retinoscopy	YES using retinoscopy findings
45	76 - 100%	Retinoscopy	YES using retinoscopy findings
46	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
47	1 - 25%	Both about equally	YES using retinoscopy findings
48	51 - 75%	Both about equally	YES using both retinoscopy and autorefractor findings
49	26 - 50%	Retinoscopy	YES using retinoscopy findings
50	26 - 50%	Both about equally	YES using retinoscopy findings
51	1 - 25%	Both about equally	YES using retinoscopy findings
52	1 - 25%	Autorefractor	YES using retinoscopy findings
53	76 - 100%	Retinoscopy	YES using retinoscopy findings
54	76 - 100%	Retinoscopy	YES using retinoscopy findings
55	51 - 75%	Retinoscopy	YES using retinoscopy findings
56	26 - 50%	Autorefractor	YES using retinoscopy findings
57	76 - 100%	Retinoscopy	YES using retinoscopy findings
58	76 - 100%	Retinoscopy	YES using retinoscopy findings
59	1 - 25%	Autorefractor	YES using retinoscopy findings
60		Autorefractor	YES using both retinoscopy and autorefractor findings
61	1 - 25%	Retinoscopy	YES using retinoscopy findings
62	76 - 100%	Retinoscopy	YES using retinoscopy findings
63	26 - 50%	Retinoscopy	YES using retinoscopy findings
64	76 - 100%	Retinoscopy	YES using retinoscopy findings

Appendix 14 continued

65	51 - 75%	Retinoscopy	YES using retinoscopy findings
66	26 - 50%	Both about equally	YES using both retinoscopy and autorefractor findings
67	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
68	1 - 25%	Autorefractor	YES using retinoscopy findings
69	76 - 100%	Retinoscopy	YES using retinoscopy findings
70	76 - 100%	Retinoscopy	YES using retinoscopy findings
71	76 - 100%	Retinoscopy	YES using retinoscopy findings
72	76 - 100%	Both about equally	YES using retinoscopy findings
73	1 - 25%	Retinoscopy	YES using retinoscopy findings
74	76 - 100%	Retinoscopy	YES using retinoscopy findings
75	26 - 50%	Both about equally	NO
76	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
77	76 - 100%	Retinoscopy	YES using retinoscopy findings
78	76 - 100%	Retinoscopy	YES using retinoscopy findings
79	76 - 100%	Retinoscopy	YES using retinoscopy findings
80	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
81	26 - 50%	Autorefractor	NO
82	1 - 25%	Retinoscopy	YES using retinoscopy findings
83	1 - 25%	Retinoscopy	YES using retinoscopy findings
84	26 - 50%	Retinoscopy	YES using retinoscopy findings
85	1 - 25%	Retinoscopy	YES using retinoscopy findings
86	76 - 100%	Retinoscopy	YES using retinoscopy findings
87	1 - 25%	Both about equally	YES using retinoscopy findings
88	51 - 75%	Retinoscopy	YES using retinoscopy findings
89	26 - 50%	Retinoscopy	YES using retinoscopy findings
90	26 - 50%	Retinoscopy	YES using retinoscopy findings
91	76 - 100%	Retinoscopy	YES using retinoscopy findings
92	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
93	76 - 100%	Retinoscopy	YES using retinoscopy findings
94	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
95	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
96	76 - 100%	Retinoscopy	YES using retinoscopy findings
97	51 - 75%	Retinoscopy	YES using retinoscopy findings
98	76 - 100%	Retinoscopy	YES using retinoscopy findings
99	76 - 100%	Retinoscopy	YES using retinoscopy findings
100	76 - 100%	Retinoscopy	YES using retinoscopy findings
101	1 - 25%	Autorefractor	YES using retinoscopy findings
102	76 - 100%	Retinoscopy	YES using retinoscopy findings
103	76 - 100%	Retinoscopy	YES using retinoscopy findings
104	0%	Autorefractor	YES using retinoscopy findings
105	76 - 100%	Retinoscopy	YES using retinoscopy findings
106	26 - 50%	Retinoscopy	YES using retinoscopy findings
107	51 - 75%	Both about equally	YES using retinoscopy findings
108	76 - 100%	Retinoscopy	YES using retinoscopy findings
109	1 - 25%	Retinoscopy	YES using retinoscopy findings
110	51 - 75%	Retinoscopy	YES using retinoscopy findings
111	76 - 100%	Retinoscopy	YES using retinoscopy findings

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112	51 - 75%	Both about equally	YES using retinoscopy findings
113	76 - 100%	Retinoscopy	YES using retinoscopy findings
114	76 - 100%	Retinoscopy	YES using retinoscopy findings
115	76 - 100%	Retinoscopy	YES using retinoscopy findings
116	76 - 100%	Retinoscopy	YES using retinoscopy findings
117	51 - 75%	Retinoscopy	YES using retinoscopy findings
118	76 - 100%	Retinoscopy	YES using retinoscopy findings
119	76 - 100%	Retinoscopy	YES using retinoscopy findings
120	76 - 100%	Retinoscopy	YES using retinoscopy findings
121	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
122	1 - 25%	Autorefractor	YES using retinoscopy findings
123	51 - 75%	Retinoscopy	YES using retinoscopy findings
124	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
125	1 - 25%	Retinoscopy	YES using retinoscopy findings
126	26 - 50%	Both about equally	YES using retinoscopy findings
127	76 - 100%	Retinoscopy	YES using retinoscopy findings
128	1 - 25%	Retinoscopy	YES using retinoscopy findings
129	1 - 25%	Retinoscopy	YES using retinoscopy findings
130	76 - 100%	Retinoscopy	YES using retinoscopy findings
131	1 - 25%	Both about equally	YES using both retinoscopy and autorefractor findings
132		Retinoscopy	YES using retinoscopy findings
133	76 - 100%	Retinoscopy	YES using retinoscopy findings
134	76 - 100%	Retinoscopy	YES using retinoscopy findings
135	26 - 50%	Autorefractor	YES using retinoscopy findings
136	76 - 100%	Retinoscopy	YES using retinoscopy findings
137	76 - 100%	Retinoscopy	YES using retinoscopy findings
138	1 - 25%	Retinoscopy	YES using retinoscopy findings
139	26 - 50%	Retinoscopy	YES using retinoscopy findings
140	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
141	26 - 50%	Retinoscopy	YES using retinoscopy findings
142	51 - 75%	Retinoscopy	YES using retinoscopy findings
143	1 - 25%	Retinoscopy	YES using retinoscopy findings
144	76 - 100%	Retinoscopy	YES using retinoscopy findings
145	76 - 100%	Retinoscopy	YES using retinoscopy findings
146	76 - 100%	Retinoscopy	YES using retinoscopy findings
147	76 - 100%	Retinoscopy	YES using retinoscopy findings
148	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
149	76 - 100%	Retinoscopy	YES using retinoscopy findings
150	26 - 50%	Retinoscopy	YES using retinoscopy findings
151	26 - 50%	Both about equally	YES using retinoscopy findings
152	76 - 100%	Both about equally	YES using retinoscopy findings
153	76 - 100%	Retinoscopy	YES using retinoscopy findings
154	76 - 100%	Retinoscopy	YES using retinoscopy findings
155	1 - 25%	Both about equally	YES using retinoscopy findings
156	51 - 75%	Retinoscopy	YES using retinoscopy findings
157	76 - 100%	Retinoscopy	YES using retinoscopy findings
158	1 - 25%	Autorefractor	YES using retinoscopy findings
159	26 - 50%	Retinoscopy	YES using retinoscopy findings
160	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor

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161	76 - 100%	Retinoscopy	YES using retinoscopy findings
162	51 - 75%	Retinoscopy	YES using retinoscopy findings
163	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
164	26 - 50%	Autorefractor	YES using retinoscopy findings
165	76 - 100%	Retinoscopy	YES using retinoscopy findings
166	76 - 100%	Retinoscopy	YES using retinoscopy findings
167	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
168	1 - 25%	Both about equally	NO
169	76 - 100%	Retinoscopy	YES using retinoscopy findings
170	1 - 25%	Autorefractor	YES using retinoscopy findings
171	51 - 75%	Both about equally	YES using both retinoscopy and autorefractor findings
172	1 - 25%	Retinoscopy	YES using retinoscopy findings
173	51 - 75%	Retinoscopy	YES using retinoscopy findings
174	76 - 100%	Retinoscopy	YES using retinoscopy findings
175	76 - 100%	Retinoscopy	YES using retinoscopy findings
176	76 - 100%	Retinoscopy	YES using retinoscopy findings
177	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
178	76 - 100%	Retinoscopy	YES using retinoscopy findings
179	51 - 75%	Retinoscopy	YES using retinoscopy findings
180	1 - 25%	Retinoscopy	YES using retinoscopy findings
181	76 - 100%	Retinoscopy	YES using retinoscopy findings
182	76 - 100%	Retinoscopy	YES using retinoscopy findings
183	76 - 100%	Retinoscopy	YES using retinoscopy findings
184	1 - 25%	Autorefractor	YES using retinoscopy findings
185	26 - 50%	Retinoscopy	YES using retinoscopy findings
186	76 - 100%	Retinoscopy	YES using retinoscopy findings
187	1 - 25%	Both about equally	YES using retinoscopy findings
188	1 - 25%	Retinoscopy	YES using retinoscopy findings
189	26 - 50%	Retinoscopy	YES using retinoscopy findings
190	1 - 25%	Retinoscopy	YES using retinoscopy findings
191	26 - 50%	Autorefractor	YES using retinoscopy findings
192	76 - 100%	Retinoscopy	YES using retinoscopy findings
193	1 - 25%	Both about equally	YES using retinoscopy findings
194	76 - 100%	Retinoscopy	YES using retinoscopy findings
195	76 - 100%	Retinoscopy	YES using retinoscopy findings
196	76 - 100%	Retinoscopy	YES using retinoscopy findings
197	1 - 25%	Retinoscopy	YES using retinoscopy findings
198	76 - 100%	Retinoscopy	YES using retinoscopy findings
199	1 - 25%	Autorefractor	YES using retinoscopy findings
200	76 - 100%	Retinoscopy	YES using retinoscopy findings
201	26 - 50%	Retinoscopy	YES using retinoscopy findings
202	76 - 100%	Retinoscopy	YES using retinoscopy findings
203	51 - 75%	Retinoscopy	YES using retinoscopy findings
204	76 - 100%	Retinoscopy	YES using retinoscopy findings
205	1 - 25%	Retinoscopy	YES using retinoscopy findings
206	76 - 100%	Both about equally	YES using retinoscopy findings
207	76 - 100%	Retinoscopy	YES using retinoscopy findings
208	76 - 100%	Retinoscopy	YES using retinoscopy findings
209	76 - 100%	Retinoscopy	YES using retinoscopy findings
210	1 - 25%	Retinoscopy	YES using retinoscopy findings

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211	26 - 50%	Retinoscopy	YES using retinoscopy findings
212	76 - 100%	Retinoscopy	YES using retinoscopy findings
213	76 - 100%	Retinoscopy	YES using retinoscopy findings
214	0%	Autorefractor	NO
215	76 - 100%	Retinoscopy	YES using retinoscopy findings
216	1 - 25%	Retinoscopy	YES using both retinoscopy and autorefractor findings
217	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
218	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
219	1 - 25%	Retinoscopy	YES using retinoscopy findings
220	26 - 50%	Autorefractor	NO
221	1 - 25%	Autorefractor	YES using retinoscopy findings
222	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
223	76 - 100%	Retinoscopy	YES using retinoscopy findings
224	76 - 100%	Retinoscopy	YES using both retinoscopy and autorefractor findings
225	1 - 25%	Retinoscopy	YES using retinoscopy findings
226	26 - 50%	Autorefractor	YES using retinoscopy findings
227	51 - 75%	Both about equally	YES using retinoscopy findings
228	51 - 75%	Retinoscopy	YES using retinoscopy findings
229	1 - 25%	Autorefractor	YES using retinoscopy findings
230	76 - 100%	Retinoscopy	YES using retinoscopy findings
231	76 - 100%	Retinoscopy	YES using retinoscopy findings
232	26 - 50%	Retinoscopy	NO
233	51 - 75%	Retinoscopy	YES using retinoscopy findings
234	51 - 75%	Retinoscopy	YES using retinoscopy findings
235			
236	76 - 100%	Retinoscopy	YES using retinoscopy findings
237	76 - 100%		
238	76 - 100%	Both about equally	YES using both retinoscopy and autorefractor findings
239	26 - 50%	Retinoscopy	YES using retinoscopy findings
240	1 - 25%	Autorefractor	YES using retinoscopy findings
241	51 - 75%	Both about equally	YES using retinoscopy findings
242	26 - 50%	Both about equally	YES using retinoscopy findings
243	1 - 25%	Retinoscopy	YES using retinoscopy findings
244	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
245	26 - 50%	Retinoscopy	YES using retinoscopy findings
246	76 - 100%	Retinoscopy	YES using retinoscopy findings
247	1 - 25%	Retinoscopy	NO
248	26 - 50%	Autorefractor	NO
249	51 - 75%	Autorefractor	YES using both retinoscopy and autorefractor findings
250	76 - 100%	Retinoscopy	YES using retinoscopy findings
251	1 - 25%	Retinoscopy	YES using retinoscopy findings
252	51 - 75%	Autorefractor	YES using retinoscopy findings
253	51 - 75%	Retinoscopy	YES using retinoscopy findings
254	26 - 50%	Retinoscopy	YES using retinoscopy findings
255	76 - 100%	Retinoscopy	YES using retinoscopy findings
256	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor
257	1 - 25%	Both about equally	YES using both retinoscopy and autorefractor

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258	76 - 100%	Retinoscopy	YES using retinoscopy findings
259	26 - 50%	Both about equally	YES using retinoscopy findings
260	76 - 100%	Retinoscopy	YES using retinoscopy findings
261	1 - 25%	Autorefractor	YES using retinoscopy findings
262	1 - 25%	Autorefractor	YES using retinoscopy findings
263	1 - 25%	Autorefractor	YES using retinoscopy findings
264	76 - 100%	Retinoscopy	YES using retinoscopy findings
265	26 - 50%	Both about equally	NO
266	76 - 100%	Retinoscopy	YES using retinoscopy findings
267	76 - 100%	Retinoscopy	NO
268	26 - 50%	Retinoscopy	YES using retinoscopy findings
269	51 - 75%	Both about equally	YES using retinoscopy findings
270	1 - 25%	Autorefractor	YES using retinoscopy findings
271	76 - 100%	Retinoscopy	YES using retinoscopy findings
272	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
273	76 - 100%	Retinoscopy	YES using retinoscopy findings
274	26 - 50%	Both about equally	YES using retinoscopy findings
275	76 - 100%	Retinoscopy	YES using retinoscopy findings
276	76 - 100%		YES using retinoscopy findings
277	76 - 100%	Retinoscopy	YES using retinoscopy findings
278	1 - 25%	Retinoscopy	YES using retinoscopy findings
279	76 - 100%	Autorefractor	YES using both retinoscopy and autorefractor findings
280	51 - 75%	Both about equally	YES using retinoscopy findings
281	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
282	26 - 50%	Retinoscopy	YES using retinoscopy findings
283	51 - 75%	Both about equally	YES using both retinoscopy and autorefractor findings
284	26 - 50%	Both about equally	YES using both retinoscopy and autorefractor findings
285	76 - 100%	Retinoscopy	YES using retinoscopy findings
286	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
287	51 - 75%	Retinoscopy	YES using retinoscopy findings
288	76 - 100%	Autorefractor	YES using retinoscopy findings
289	51 - 75%	Retinoscopy	YES using retinoscopy findings
290	76 - 100%	Retinoscopy	YES using retinoscopy findings
291	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings
292	76 - 100%	Retinoscopy	YES using retinoscopy findings
293	76 - 100%	Retinoscopy	YES using retinoscopy findings
294	76 - 100%	Retinoscopy	YES using retinoscopy findings
295	76 - 100%	Retinoscopy	YES using retinoscopy findings
296	76 - 100%	Retinoscopy	YES using retinoscopy findings
297	26 - 50%	Both about equally	YES using both retinoscopy and autorefractor findings
298	51 - 75%	Retinoscopy	YES using retinoscopy findings
299	1 - 25%	Autorefractor	YES using both retinoscopy and autorefractor findings

Response number	What type of retinoscope do you use?	Does your retinoscope have the facility to change from spot to streak design, or visa versa, by simply changing the bulb? (Sometimes described as Combination, Combi, dual mode or bimodal retinoscopes)	Which company manufactured your retinoscope?
1	Streak	No	Keeler
2	Streak	Yes	Keeler
3	Streak	Yes	Keeler
4	Streak	No	Keeler
5	Streak	Not sure	Keeler
6	Spot	No	Keeler
7	Streak	Not sure	Keeler
8	Streak	Yes	Keeler
9	Streak	No	Keeler
10	Streak	Not sure	Heini
11	Streak	Not sure	Keeler
12	Spot	Yes	Welch Allyn
13	Streak	Yes	Keeler
14	Streak	Yes	Keeler
15	Spot	No	Keeler
16	Streak	Yes	Keeler
17	Streak	No	Keeler
18	Streak	Not sure	Keeler
19	Streak	No	Keeler
20	Streak	Not sure	Welch Allyn
21	Streak	No	Keeler
22	Spot	Yes	Keeler
23	Spot	No	Keeler
24	Streak	Not sure	Keeler
25	Streak	Yes	Keeler
26	Streak	Yes	Keeler
27	Spot	No	Keeler
28	Streak	No	Keeler
29	Streak	Not sure	Keeler
30	Streak	Not sure	Welch Allyn
31	Streak	Not sure	Keeler
32	Streak	No	Keeler
33	Spot	No	Keeler
34	Streak	Yes	Keeler
35	Streak	No	Welch Allyn
36	Streak	No	Keeler
37	Streak	Yes	Keeler
38	Streak	Yes	Keeler
39	Streak	No	Keeler
40	Streak	No	Keeler
41	Streak	No	Keeler
42	Streak	Yes	Keeler
43	Streak	No	Keeler
44	Streak	No	Keeler
45	Streak	No	Keeler
46	Streak	No	Keeler
47	Spot	Yes	Heini

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48	Streak	Yes	Keeler
49	Streak	No	Keeler
50	Streak	No	Welch Allyn
51	Streak	Not sure	Keeler
52	Streak	No	Keeler
53	Spot	No	Keeler
54	Spot	No	Keeler
55	Streak	No	Keeler
56	Streak	Yes	Keeler
57	Streak	Not sure	Keeler
58	Spot	Yes	Keeler
59	Streak	No	Keeler
60	Streak	Not sure	Keeler
61	Streak	No	Keeler
62	Streak	No	Keeler
63	Streak	Yes	Heini
64	Streak	Yes	Welch Allyn
65	Streak	No	Keeler
66	Spot	No	Keeler
67	Streak	Yes	Keeler
68		No	Keeler
69	Streak	Yes	Keeler
70	Spot	Yes	Keeler
71	Spot	No	Keeler
72	Streak	No	Keeler
73	Spot	No	Keeler
74	Spot	Yes	Welch Allyn
75	Streak	Yes	Keeler
76	Streak	No	Keeler
77	Streak	Yes	Keeler
78	Streak	No	Keeler
79	Streak	No	Keeler
80	Streak	Not sure	Keeler
81	Streak	Yes	Welch Allyn
82	Streak	Not sure	Keeler
83	Streak	Yes	Keeler
84	Streak	No	Keeler
85	Streak	Not sure	Keeler
86	Streak	Not sure	Keeler
87	Streak	No	Keeler
88	Streak	No	Keeler
89	Streak	Yes	Keeler
90	Streak	Not sure	Heini
91	Streak	Yes	Heini
92	Streak	Yes	Keeler
93	Streak	Yes	Welch Allyn
94	Streak	No	Keeler
95	Streak	Yes	Keeler
96	Streak	No	Keeler
97	Streak	No	Keeler
98	Spot	No	Keeler
99	Streak	Not sure	Keeler
100	Streak	No	Welch Allyn
101	Spot	Not sure	Keeler

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102	Streak	Yes	Keeler
103	Streak	Yes	Keeler
104	Streak	Not sure	Keeler
105	Streak	No	Keeler
106	Streak	No	Keeler
107	Streak	Yes	Keeler
108	Streak	No	Keeler
109	Streak	No	Keeler
110	Spot	No	Keeler
111	Streak	Not sure	Keeler
112	Streak	No	Keeler
113	Spot	No	Keeler
114	Spot	No	Welch Allyn
115	Streak	No	Keeler
116	Spot	No	Keeler
117	Streak	Yes	Welch Allyn
118	Streak	Not sure	Keeler
119	Streak	Yes	Keeler
120	Streak	Yes	Keeler
121	Streak	No	Keeler
122	Streak	No	Keeler
123	Streak	Not sure	Keeler
124	Spot	No	Keeler
125	Streak	Yes	Welch Allyn
126	Streak	No	Keeler
127	Spot	Yes	Welch Allyn
128	Streak	Yes	Keeler
129	Streak	Yes	Keeler
130	Spot	No	Heini
131	Streak	Yes	Keeler
132	Spot	No	Keeler
133	Streak	Not sure	Keeler
134	Spot	No	Keeler
135	Streak	No	Welch Allyn
136	Streak	No	Keeler
137	Streak	No	Keeler
138	Spot	No	Keeler
139	Streak	No	Keeler
140	Streak	No	Keeler
141	Streak	Yes	Keeler
142	Spot	No	Welch Allyn
143	Streak	Yes	Keeler
144	Streak	Yes	Keeler
145	Streak	Yes	Keeler
146	Spot	No	None of these
147	Spot	No	Keeler
148	Streak	Not sure	Keeler
149	Streak	Not sure	Welch Allyn
150	Streak	Yes	Welch Allyn
151	Streak	No	Keeler
152	Streak	Yes	Keeler
153	Spot	Yes	Keeler
154	Streak	No	Keeler

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155	Streak	Yes	Keeler
156	Streak	Yes	Welch Allyn
157	Streak	No	Welch Allyn
158	Streak	No	Keeler
159	Spot	Yes	Keeler
160	Streak	No	Keeler
161	Streak	No	Welch Allyn
162	Spot	Yes	Heini
163	Streak	No	Keeler
164	Streak	No	Keeler
165	Streak	Yes	Keeler
166	Streak	Yes	Keeler
167	Streak	No	Welch Allyn
168	Spot	No	Keeler
169	Streak	No	Welch Allyn
170	Streak	Yes	Keeler
171	Streak	Yes	Keeler
172	Streak	Not sure	Keeler
173	Streak	Yes	Welch Allyn
174	Streak	No	Keeler
175	Streak	No	Keeler
176	Spot	No	Keeler
177	Streak	Yes	Keeler
178	Streak	Yes	Keeler
179	Streak	Yes	Keeler
180	Streak	Yes	Keeler
181	Streak	No	Heini
182	Spot	Yes	Keeler
183	Streak	Yes	None of these
184	Streak	Not sure	Keeler
185	Streak	No	Keeler
186	Streak	Not sure	Keeler
187	Streak	No	Keeler
188	Streak	Not sure	Keeler
189	Streak	Yes	Keeler
190	Spot	No	Keeler
191	Spot	Yes	Keeler
192	Streak	Not sure	Keeler
193	Streak	No	Heini
194	Spot	No	Keeler
195	Streak	No	Keeler
196	Streak	Yes	Welch Allyn
197	Streak	No	Heini
198	Streak	Yes	Keeler
199	Spot	Yes	Keeler
200	Streak	Yes	Keeler
201	Spot	No	Keeler
202	Spot	No	Keeler
203	Streak	No	Keeler
204	Streak	Yes	Welch Allyn
205	Streak	No	Keeler
206	Streak	No	Welch Allyn
207	Streak	Not sure	Welch Allyn
208	Streak	Not sure	Keeler

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209	Streak	Not sure	Keeler
210	Spot	No	Keeler
211	Spot	No	Keeler
212	Streak	Not sure	Keeler
213	Spot	Yes	Heini
214	Retinoscope not used	No	Heini
215	Streak	Yes	Welch Allyn
216	Streak	No	None of these
217	Streak	No	Keeler
218	Streak	Yes	Keeler
219	Streak	Not sure	Keeler
220	Streak	No	Keeler
221	Streak	Not sure	Keeler
222	Streak	Not sure	Keeler
223	Streak	Not sure	Keeler
224	Streak	Yes	Welch Allyn
225	Streak	Not sure	Keeler
226	Streak	Yes	Keeler
227	Streak	Yes	Welch Allyn
228	Streak	No	Keeler
229	Spot	Yes	Keeler
230	Streak	Not sure	Keeler
231	Streak	Yes	Welch Allyn
232	Streak	No	Keeler
233	Spot	Yes	Keeler
234	Streak	Yes	Welch Allyn
235			
236	Streak	No	Welch Allyn
237			
238	Spot	Yes	Welch Allyn
239	Streak	Not sure	Welch Allyn
240	Streak	Yes	Keeler
241	Streak	Yes	Keeler
242	Streak	Yes	Keeler
243	Spot	Yes	Keeler
244	Spot	Yes	Keeler
245	Streak	Yes	Keeler
246	Streak	No	Keeler
247	Streak	No	Welch Allyn
248	Streak	Yes	Keeler
249	Spot	No	Keeler
250	Streak	Not sure	Keeler
251	Streak	No	Keeler
252	Streak	Yes	Keeler
253	Streak	Yes	Keeler
254	Streak	Yes	Keeler
255	Streak	Not sure	Welch Allyn
256	Streak	Not sure	Keeler
257	Streak	Yes	Keeler
258	Spot	No	Keeler
259	Streak	No	Keeler
260	Streak	No	Welch Allyn
261	Streak	No	Welch Allyn
262	Streak	Not sure	Keeler

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263	Streak	No	Keeler
264	Streak	Yes	Keeler
265	Streak	Yes	Welch Allyn
266	Streak	Not sure	Keeler
267	Streak	No	Keeler
268	Streak	Not sure	Keeler
269	Streak	Yes	Keeler
270	Streak	No	Keeler
271	Streak	Not sure	Keeler
272	Streak	Not sure	Keeler
273	Spot	No	Keeler
274	Streak	No	Welch Allyn
275	Streak	No	Keeler
276	Streak	Not sure	Keeler
277	Streak	Not sure	Keeler
278	Streak	No	Keeler
279	Streak	No	Keeler
280	Streak	Not sure	Keeler
281	Streak	Yes	Keeler
282	Streak	No	Keeler
283	Streak	Not sure	Welch Allyn
284	Streak	Not sure	Keeler
285	Spot	No	Keeler
286	Streak	No	Keeler
287	Spot	Yes	Keeler
288	Streak	No	Welch Allyn
289	Spot	Yes	Welch Allyn
290	Streak	No	Heini
291	Streak	Yes	Keeler
292	Streak	Yes	Keeler
293	Streak	Yes	Keeler
294	Streak	Yes	Welch Allyn
295	Streak	Yes	Keeler
296	Streak	No	Keeler
297	Spot	Yes	Keeler
298	Streak	Yes	Keeler
299	Spot	No	Keeler

Response number	How old is your retinoscope?	How satisfied are you with the performance of your own retinoscope?	Combination retinoscopes (that have the facility to change from spot to streak design, or visa versa, by simply changing the bulb) are not as accurate as the older/designated models. Do you:
1	10 years or older	very satisfied	no opinion
2	6-9 years	very satisfied	no opinion
3	0-5 years	satisfied	no opinion
4	10 years or older	satisfied	no opinion
5	0-5 years	satisfied	no opinion
6	10 years or older	satisfied	no opinion
7	6-9 years	satisfied	no opinion
8	6-9 years	very satisfied	no opinion

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9	0-5 years	dissatisfied	no opinion
10	6-9 years	very dissatisfied	no opinion
11	6-9 years	very dissatisfied	no opinion
12	0-5 years	satisfied	no opinion
13	0-5 years	very satisfied	no opinion
14	0-5 years	satisfied	no opinion
15	10 years or older	satisfied	no opinion
16	6-9 years	very satisfied	no opinion
17	0-5 years	satisfied	no opinion
18	6-9 years	satisfied	no opinion
19	10 years or older	satisfied	no opinion
20	6-9 years	very satisfied	no opinion
21	6-9 years	satisfied	no opinion
22	0-5 years	satisfied	no opinion
23	6-9 years	very satisfied	no opinion
24	0-5 years	satisfied	no opinion
25	0-5 years	very satisfied	no opinion
26	10 years or older	satisfied	no opinion
27	10 years or older	satisfied	no opinion
28	10 years or older	satisfied	no opinion
29	10 years or older	very satisfied	no opinion
30	10 years or older	satisfied	no opinion
31	6-9 years	satisfied	no opinion
32	10 years or older	very satisfied	no opinion
33	10 years or older	satisfied	no opinion
34	0-5 years	very satisfied	no opinion
35	0-5 years	very satisfied	no opinion
36	6-9 years	satisfied	no opinion
37	0-5 years	very satisfied	disagree
38	6-9 years	very satisfied	no opinion
39	10 years or older	very satisfied	no opinion
40	0-5 years	very satisfied	no opinion
41	10 years or older	dissatisfied	no opinion
42	0-5 years	satisfied	no opinion
43	0-5 years	very satisfied	no opinion
44	6-9 years	satisfied	no opinion
45	0-5 years	very satisfied	no opinion
46	0-5 years	satisfied	no opinion
47	0-5 years	very satisfied	no opinion
48	0-5 years	satisfied	no opinion
49	10 years or older	satisfied	no opinion
50	0-5 years	dissatisfied	disagree
51	0-5 years	very satisfied	no opinion
52	6-9 years	satisfied	no opinion
53	10 years or older	very satisfied	no opinion
54	10 years or older	very satisfied	no opinion
55	6-9 years	satisfied	no opinion
56	6-9 years	very satisfied	disagree
57	6-9 years	very satisfied	no opinion
58	6-9 years	satisfied	no opinion
59	0-5 years	very dissatisfied	no opinion
60	0-5 years	very satisfied	no opinion
61	0-5 years	satisfied	no opinion
62	10 years or older	satisfied	no opinion

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63	0-5 years	very satisfied	strongly disagree
64	0-5 years	satisfied	disagree
65	10 years or older	satisfied	no opinion
66	10 years or older	very satisfied	no opinion
67	0-5 years	very satisfied	no opinion
68	0-5 years	very satisfied	disagree
69	0-5 years	very satisfied	no opinion
70	10 years or older	satisfied	agree
71	10 years or older	satisfied	no opinion
72	0-5 years	very satisfied	no opinion
73	10 years or older	satisfied	agree
74	10 years or older	very satisfied	strongly disagree
75	6-9 years	satisfied	disagree
76	6-9 years	satisfied	disagree
77	6-9 years	very satisfied	no opinion
78	10 years or older	very satisfied	no opinion
79	0-5 years	satisfied	no opinion
80	6-9 years	very satisfied	no opinion
81	0-5 years	very satisfied	no opinion
82	0-5 years	satisfied	no opinion
83	0-5 years	very satisfied	disagree
84	10 years or older	very satisfied	no opinion
85	6-9 years	very satisfied	no opinion
86	10 years or older	satisfied	no opinion
87	0-5 years	satisfied	no opinion
88	6-9 years	satisfied	no opinion
89	0-5 years	very satisfied	no opinion
90	0-5 years	very satisfied	no opinion
91	0-5 years	very satisfied	no opinion
92	6-9 years	very satisfied	disagree
93	6-9 years	satisfied	no opinion
94	0-5 years	satisfied	no opinion
95	0-5 years	satisfied	no opinion
96	10 years or older	satisfied	no opinion
97	0-5 years	very dissatisfied	no opinion
98	6-9 years	satisfied	no opinion
99	6-9 years	satisfied	no opinion
100	6-9 years	satisfied	no opinion
101	0-5 years	satisfied	no opinion
102	6-9 years	very satisfied	no opinion
103	0-5 years	satisfied	disagree
104	6-9 years	satisfied	no opinion
105	6-9 years	very satisfied	no opinion
106	0-5 years	satisfied	no opinion
107	0-5 years	very satisfied	no opinion
108	0-5 years	satisfied	no opinion
109	10 years or older	very satisfied	no opinion
110	10 years or older	very satisfied	no opinion
111	6-9 years	satisfied	no opinion
112	10 years or older	satisfied	no opinion
113	10 years or older	satisfied	no opinion
114	10 years or older	very dissatisfied	agree
115	6-9 years	satisfied	no opinion
116	6-9 years	very dissatisfied	no opinion

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117	6-9 years	very satisfied	disagree
118	0-5 years	very satisfied	no opinion
119	6-9 years	very satisfied	no opinion
120	0-5 years	very satisfied	strongly disagree
121	0-5 years	satisfied	no opinion
122	10 years or older	satisfied	no opinion
123	0-5 years	very satisfied	no opinion
124	10 years or older	satisfied	no opinion
125	6-9 years	satisfied	agree
126	6-9 years	satisfied	no opinion
127	6-9 years	very satisfied	strongly disagree
128	6-9 years	very satisfied	strongly disagree
129	0-5 years	satisfied	no opinion
130	6-9 years	satisfied	no opinion
131	0-5 years	very satisfied	no opinion
132	10 years or older	satisfied	no opinion
133	0-5 years	satisfied	no opinion
134	10 years or older	satisfied	no opinion
135	6-9 years	very satisfied	agree
136	10 years or older	very satisfied	no opinion
137	10 years or older	satisfied	no opinion
138	10 years or older	satisfied	no opinion
139	10 years or older	very satisfied	no opinion
140	6-9 years	very satisfied	no opinion
141	6-9 years	very satisfied	no opinion
142	6-9 years	very satisfied	no opinion
143	0-5 years	satisfied	no opinion
144	0-5 years	very satisfied	disagree
145	6-9 years	satisfied	disagree
146	10 years or older	very satisfied	no opinion
147	6-9 years	satisfied	no opinion
148	10 years or older	satisfied	no opinion
149	10 years or older	very satisfied	no opinion
150	0-5 years	very satisfied	disagree
151	10 years or older	satisfied	no opinion
152	6-9 years	satisfied	disagree
153	0-5 years	satisfied	no opinion
154	10 years or older	satisfied	no opinion
155	0-5 years	very satisfied	no opinion
156	10 years or older	satisfied	no opinion
157	0-5 years	very satisfied	no opinion
158	10 years or older	satisfied	no opinion
159	6-9 years	satisfied	no opinion
160	0-5 years	satisfied	no opinion
161	0-5 years	very satisfied	no opinion
162	0-5 years	satisfied	no opinion
163	10 years or older	satisfied	
164	10 years or older	satisfied	no opinion
165	0-5 years	very satisfied	no opinion
166	10 years or older	very satisfied	disagree
167	6-9 years	dissatisfied	no opinion
168	10 years or older	satisfied	no opinion
169	10 years or older	very satisfied	no opinion

Appendix 14 continued

170	0-5 years	very satisfied	disagree
171	0-5 years	satisfied	no opinion
172	6-9 years	satisfied	no opinion
173	6-9 years	satisfied	disagree
174	10 years or older	very satisfied	no opinion
175	6-9 years	satisfied	no opinion
176	10 years or older	satisfied	agree
177	10 years or older	very dissatisfied	no opinion
178	10 years or older	satisfied	no opinion
179	0-5 years	satisfied	no opinion
180	6-9 years	dissatisfied	strongly agree
181	10 years or older	very satisfied	no opinion
182	6-9 years	very satisfied	no opinion
183	6-9 years	very satisfied	disagree
184	0-5 years	very satisfied	no opinion
185	10 years or older	satisfied	no opinion
186	10 years or older	very satisfied	no opinion
187	10 years or older	satisfied	no opinion
188	0-5 years	satisfied	disagree
189	6-9 years	very satisfied	no opinion
190	10 years or older	very satisfied	no opinion
191	0-5 years	very satisfied	disagree
192	10 years or older	very dissatisfied	no opinion
193	0-5 years	very satisfied	no opinion
194	0-5 years	very satisfied	no opinion
195	0-5 years	very satisfied	no opinion
196	10 years or older	very satisfied	strongly disagree
197	10 years or older	very dissatisfied	no opinion
198	0-5 years	satisfied	no opinion
199	0-5 years	very satisfied	disagree
200	10 years or older	satisfied	no opinion
201	0-5 years	very satisfied	no opinion
202	10 years or older	satisfied	no opinion
203	0-5 years	satisfied	no opinion
204	6-9 years	very satisfied	no opinion
205	0-5 years	very satisfied	no opinion
206	10 years or older	very dissatisfied	no opinion
207	6-9 years	very satisfied	no opinion
208	10 years or older	very satisfied	no opinion
209	0-5 years	very satisfied	no opinion
210	0-5 years	very satisfied	no opinion
211	10 years or older	very satisfied	no opinion
212	6-9 years	no opinion	no opinion
213	10 years or older	very satisfied	strongly disagree
214	10 years or older	very satisfied	no opinion
215	10 years or older	satisfied	no opinion
216	10 years or older	satisfied	no opinion
217	0-5 years	very satisfied	no opinion
218	0-5 years	satisfied	no opinion
219	0-5 years	very satisfied	no opinion
220	0-5 years	very satisfied	no opinion
221	0-5 years	satisfied	no opinion
222	6-9 years	satisfied	no opinion
223	6-9 years	satisfied	no opinion

Appendix 14 continued

224	0-5 years	very satisfied	no opinion
225	6-9 years	satisfied	no opinion
226	0-5 years	satisfied	no opinion
227	6-9 years	very satisfied	no opinion
228	10 years or older	very satisfied	no opinion
229	0-5 years	very satisfied	disagree
230	10 years or older	satisfied	no opinion
231	10 years or older	satisfied	no opinion
232	6-9 years	very satisfied	no opinion
233	0-5 years	very satisfied	disagree
234	6-9 years	very satisfied	no opinion
235			
236	0-5 years	very satisfied	agree
237			
238	10 years or older	very satisfied	no opinion
239	0-5 years	very satisfied	no opinion
240	6-9 years	satisfied	no opinion
241	6-9 years	satisfied	no opinion
242	0-5 years	satisfied	no opinion
243	6-9 years	very satisfied	disagree
244	0-5 years	satisfied	agree
245	0-5 years	very dissatisfied	disagree
246	0-5 years	satisfied	disagree
247	6-9 years	satisfied	no opinion
248	0-5 years	very satisfied	no opinion
249	10 years or older	dissatisfied	no opinion
250	10 years or older	satisfied	no opinion
251	10 years or older	satisfied	no opinion
252	0-5 years	satisfied	no opinion
253	6-9 years	very satisfied	no opinion
254	0-5 years	satisfied	agree
255	0-5 years	very satisfied	disagree
256	6-9 years	dissatisfied	no opinion
257	0-5 years	satisfied	no opinion
258	0-5 years	very satisfied	no opinion
259	10 years or older	satisfied	no opinion
260	10 years or older	very satisfied	no opinion
261	10 years or older	very satisfied	no opinion
262	6-9 years	satisfied	no opinion
263	10 years or older	very satisfied	no opinion
264	0-5 years	very satisfied	disagree
265	6-9 years	very satisfied	no opinion
266	6-9 years	very satisfied	no opinion
267	6-9 years	very satisfied	no opinion
268	10 years or older	very satisfied	no opinion
269	0-5 years	very satisfied	no opinion
270	6-9 years	dissatisfied	no opinion
271	6-9 years	very satisfied	no opinion
272	6-9 years	satisfied	agree
273	6-9 years	very satisfied	no opinion
274	0-5 years	very satisfied	no opinion
275	0-5 years	very satisfied	no opinion
276	6-9 years	satisfied	no opinion
277	6-9 years	very satisfied	no opinion

Appendix 14 continued

278	10 years or older	satisfied	no opinion
279	0-5 years	satisfied	agree
280	0-5 years	very satisfied	no opinion
281	0-5 years	very satisfied	no opinion
282	10 years or older	satisfied	no opinion
283	10 years or older	very satisfied	no opinion
284	10 years or older	very dissatisfied	no opinion
285	10 years or older	very satisfied	no opinion
286	6-9 years	dissatisfied	no opinion
287	10 years or older	very satisfied	no opinion
288	10 years or older	very satisfied	no opinion
289	6-9 years	satisfied	no opinion
290	0-5 years	very satisfied	no opinion
291	0-5 years	very satisfied	no opinion
292	0-5 years	very satisfied	agree
293	6-9 years	satisfied	no opinion
294	0-5 years	very satisfied	disagree
295	0-5 years	very satisfied	strongly disagree
296	6-9 years	dissatisfied	strongly agree
297	0-5 years	satisfied	no opinion
298	0-5 years	very satisfied	disagree
299	10 years or older	satisfied	no opinion

Response number	Retinoscopy is NOT an important aspect of an Optometric examination. Do you:	Retinoscopy is useful for detecting keratoconus. Do you:	Ignore the use of a working distance allowance lens in this question. When initiating retinoscopy, I prefer to use starting point lenses in the trial frame (i.e. the previous prescription or autorefractor result). Do you:
1	strongly disagree	strongly agree	strongly disagree
2	disagree	agree	strongly disagree
3	disagree	agree	strongly agree
4	strongly disagree	strongly agree	agree
5	strongly disagree	strongly agree	disagree
6	strongly disagree	agree	strongly disagree
7	strongly disagree	strongly agree	disagree
8	strongly disagree	agree	agree
9	disagree	strongly agree	disagree
10	strongly disagree	agree	disagree
11	disagree	agree	agree
12	strongly disagree	agree	agree
13	strongly disagree	agree	disagree
14	disagree	disagree	strongly disagree
15	strongly disagree	agree	agree
16	strongly disagree	agree	strongly disagree
17	strongly disagree	strongly agree	strongly disagree
18	strongly disagree	strongly agree	strongly disagree
19	disagree	agree	disagree
20	strongly disagree	strongly agree	strongly agree
21	disagree	strongly agree	strongly disagree
22	disagree	strongly agree	strongly agree

Appendix 14 continued

23	strongly disagree	strongly agree	strongly disagree
24	strongly disagree	agree	disagree
25	strongly disagree	agree	disagree
26	disagree	strongly agree	strongly disagree
27	disagree	agree	disagree
28	agree	agree	disagree
29	strongly disagree	strongly agree	disagree
30	strongly disagree	strongly agree	agree
31	disagree	strongly agree	agree
32	strongly disagree	agree	agree
33	disagree	agree	disagree
34	disagree	strongly agree	disagree
35	agree	agree	disagree
36	disagree	agree	disagree
37	strongly disagree	strongly agree	strongly agree
38	strongly disagree	strongly agree	disagree
39	strongly disagree	agree	disagree
40	strongly disagree	strongly agree	strongly agree
41	strongly disagree	agree	no opinion
42	disagree	agree	strongly disagree
43	strongly disagree	strongly agree	strongly disagree
44	strongly disagree	agree	agree
45	strongly disagree	strongly agree	agree
46	disagree	agree	disagree
47	strongly disagree	strongly agree	strongly agree
48	disagree	agree	strongly agree
49	disagree	strongly agree	agree
50	disagree	agree	disagree
51	disagree	agree	strongly disagree
52	disagree	agree	disagree
53	strongly disagree	strongly agree	strongly disagree
54	strongly disagree	agree	agree
55	strongly disagree	strongly agree	agree
56	disagree	agree	disagree
57	disagree	agree	disagree
58	strongly disagree	agree	agree
59	disagree	strongly agree	strongly disagree
60	disagree	agree	strongly disagree
61	disagree	no opinion	disagree
62	disagree	agree	no opinion
63	disagree	agree	agree
64	disagree	agree	agree
65	disagree	strongly agree	disagree
66	disagree	agree	no opinion
67	disagree	agree	disagree
68	strongly disagree	strongly agree	strongly agree
69	strongly disagree	strongly agree	disagree
70	strongly disagree	agree	agree
71	strongly disagree	strongly disagree	strongly disagree
72	strongly disagree	agree	disagree
73	disagree	agree	disagree
74	strongly disagree	strongly agree	strongly disagree
75	strongly disagree	agree	disagree
76	disagree	agree	disagree

Appendix 14 continued

77	strongly disagree	strongly agree	disagree
78	strongly disagree	strongly agree	strongly disagree
79	strongly disagree	agree	disagree
80	agree	strongly agree	strongly disagree
81	disagree	agree	agree
82	disagree	agree	disagree
83	strongly disagree	agree	no opinion
84	disagree	agree	agree
85	disagree	agree	disagree
86	strongly disagree	agree	agree
87	disagree	disagree	disagree
88	disagree	strongly agree	disagree
89	strongly disagree	strongly agree	strongly disagree
90	disagree	agree	agree
91	strongly disagree	agree	strongly disagree
92	disagree	agree	agree
93	strongly disagree	agree	agree
94	disagree	agree	disagree
95	disagree	agree	disagree
96	strongly disagree	agree	strongly disagree
97	strongly disagree	strongly agree	disagree
98	strongly disagree	agree	disagree
99	strongly disagree	strongly agree	strongly disagree
100	strongly disagree	strongly disagree	disagree
101	disagree	disagree	disagree
102	strongly disagree	agree	strongly disagree
103	strongly disagree	strongly agree	strongly agree
104	agree	strongly agree	strongly disagree
105	strongly disagree	strongly agree	strongly disagree
106	agree	agree	disagree
107	strongly disagree	agree	strongly disagree
108	strongly disagree	strongly agree	disagree
109	strongly disagree	strongly agree	disagree
110	disagree	agree	disagree
111	strongly disagree	strongly agree	strongly agree
112	disagree	strongly agree	no opinion
113	disagree	agree	disagree
114	strongly agree	strongly agree	disagree
115	disagree	agree	disagree
116	strongly disagree	strongly agree	disagree
117	strongly disagree	agree	disagree
118	strongly disagree	strongly agree	no opinion
119	strongly disagree	strongly agree	agree
120	strongly disagree	strongly agree	agree
121	disagree	agree	disagree
122	strongly disagree	agree	disagree
123	strongly disagree	strongly agree	strongly disagree
124	disagree	agree	disagree
125	agree	agree	agree
126	disagree	agree	no opinion
127	strongly disagree	strongly agree	strongly disagree
128	strongly disagree	strongly agree	strongly disagree
129	disagree	agree	disagree

Appendix 14 continued

130	strongly disagree	strongly agree	strongly agree
131	strongly disagree	agree	agree
132	strongly disagree	strongly agree	disagree
133	strongly disagree	strongly agree	strongly disagree
134	strongly disagree	strongly agree	strongly disagree
135	strongly disagree	strongly agree	agree
136	strongly disagree	agree	disagree
137	strongly disagree	strongly agree	disagree
138	agree	agree	strongly disagree
139	disagree	disagree	agree
140	disagree	strongly agree	agree
141	disagree	no opinion	disagree
142	strongly disagree	strongly agree	strongly agree
143	disagree	agree	disagree
144	strongly disagree	strongly agree	agree
145	strongly disagree	strongly agree	disagree
146	strongly agree	strongly agree	strongly disagree
147	disagree	agree	agree
148	disagree	agree	agree
149	strongly disagree	strongly agree	disagree
150	disagree	strongly agree	strongly agree
151	disagree	strongly agree	agree
152	disagree	agree	agree
153	disagree	agree	agree
154	strongly disagree	strongly agree	disagree
155	strongly disagree	agree	strongly disagree
156	strongly disagree	strongly agree	strongly agree
157	strongly disagree	strongly agree	strongly disagree
158	disagree	strongly agree	no opinion
159	strongly disagree	agree	strongly agree
160	disagree	agree	disagree
161	strongly disagree	strongly agree	strongly disagree
162	disagree	agree	disagree
163	strongly disagree	strongly agree	disagree
164	disagree	strongly agree	agree
165	strongly disagree	agree	strongly disagree
166	strongly disagree	strongly agree	disagree
167	strongly disagree	agree	disagree
168	disagree	agree	strongly disagree
169	strongly disagree	strongly agree	disagree
170	disagree	agree	strongly disagree
171	strongly disagree	strongly agree	disagree
172	disagree	agree	disagree
173	disagree	agree	strongly disagree
174	strongly disagree	agree	strongly disagree
175	disagree	agree	agree
176	strongly disagree	strongly agree	strongly disagree
177	strongly disagree	strongly agree	strongly disagree
178	strongly disagree	agree	agree
179	strongly disagree	agree	agree
180	disagree	agree	disagree
181	strongly disagree	strongly agree	strongly disagree
182	strongly disagree	agree	disagree
183	strongly disagree	strongly agree	disagree

Appendix 14 continued

184	agree	agree	disagree
185	strongly disagree	agree	strongly disagree
186	strongly disagree	strongly agree	strongly disagree
187	strongly disagree	strongly agree	disagree
188	strongly disagree	strongly agree	disagree
189	strongly disagree	agree	disagree
190	strongly disagree	strongly agree	agree
191	strongly disagree	strongly agree	strongly disagree
192	strongly disagree	strongly agree	disagree
193	disagree	agree	disagree
194	strongly disagree	strongly agree	disagree
195	strongly disagree	strongly agree	strongly disagree
196	strongly disagree	strongly agree	strongly disagree
197	strongly disagree	strongly agree	disagree
198	strongly disagree	strongly agree	agree
199	agree	strongly agree	disagree
200	strongly disagree	strongly agree	strongly disagree
201	strongly disagree	agree	strongly disagree
202	strongly disagree	strongly agree	agree
203	strongly disagree	agree	agree
204	strongly disagree	strongly agree	agree
205	disagree	agree	disagree
206	strongly disagree	agree	disagree
207	strongly disagree	strongly agree	strongly disagree
208	disagree	agree	agree
209	strongly disagree	strongly agree	strongly disagree
210	strongly disagree	strongly agree	strongly disagree
211	strongly disagree	strongly agree	strongly agree
212	strongly disagree	agree	disagree
213	strongly disagree	strongly agree	strongly disagree
214	agree	disagree	no opinion
215	strongly disagree	strongly agree	agree
216	disagree	strongly agree	disagree
217	disagree	strongly agree	disagree
218	strongly disagree	agree	strongly disagree
219	disagree	agree	strongly disagree
220	strongly disagree	strongly agree	strongly agree
221	strongly disagree	agree	no opinion
222	strongly disagree	strongly agree	agree
223	strongly disagree	strongly agree	strongly disagree
224	strongly disagree	agree	disagree
225	strongly disagree	agree	strongly disagree
226	strongly disagree	no opinion	strongly disagree
227	strongly disagree	strongly disagree	strongly disagree
228	strongly disagree	strongly disagree	strongly disagree
229	disagree	agree	agree
230	disagree	agree	disagree
231	strongly disagree	strongly agree	agree
232	disagree	no opinion	disagree
233	strongly disagree	strongly agree	agree
234	strongly disagree	agree	disagree
235			
236	strongly disagree	agree	agree
237			

Appendix 14 continued

238	strongly disagree	agree	no opinion
239	disagree	agree	disagree
240	disagree	agree	disagree
241	strongly disagree	strongly agree	disagree
242	disagree	strongly agree	no opinion
243	disagree	strongly agree	strongly disagree
244	disagree	agree	disagree
245	strongly disagree	strongly agree	strongly disagree
246	strongly disagree	agree	agree
247	agree	disagree	disagree
248	disagree	strongly agree	disagree
249	strongly disagree	strongly agree	no opinion
250	strongly disagree	strongly agree	agree
251	disagree	strongly agree	strongly disagree
252	disagree	strongly agree	disagree
253	no opinion	strongly agree	disagree
254	disagree	agree	agree
255	strongly disagree	strongly agree	strongly disagree
256	disagree	agree	agree
257	disagree	agree	disagree
258	strongly disagree	strongly agree	agree
259	disagree	strongly agree	agree
260	strongly disagree	strongly agree	strongly disagree
261	strongly disagree	disagree	agree
262	disagree	agree	disagree
263	strongly disagree	agree	strongly agree
264	strongly disagree	strongly agree	strongly disagree
265	strongly disagree	strongly agree	disagree
266	strongly disagree	agree	strongly disagree
267	strongly disagree	strongly agree	strongly disagree
268	strongly disagree	strongly agree	disagree
269	strongly disagree	agree	disagree
270	disagree	agree	strongly disagree
271	strongly disagree	agree	agree
272	agree	agree	strongly agree
273	strongly disagree	strongly agree	no opinion
274	strongly disagree	strongly agree	disagree
275	strongly disagree	agree	strongly disagree
276	strongly disagree	strongly agree	disagree
277	strongly disagree	agree	disagree
278	disagree	agree	strongly disagree
279	disagree	agree	no opinion
280	strongly disagree	agree	agree
281	disagree	strongly agree	strongly disagree
282	disagree	agree	strongly agree
283	disagree	agree	agree
284	disagree	agree	no opinion
285	strongly disagree	strongly agree	agree
286	disagree	strongly agree	disagree
287	strongly disagree	agree	disagree
288	disagree	strongly agree	no opinion
289	strongly disagree	agree	agree
290	strongly disagree	strongly agree	strongly disagree
291	disagree	no opinion	no opinion

Appendix 14 continued

292	strongly disagree	strongly agree	strongly disagree
293	disagree	agree	disagree
294	strongly disagree	agree	agree
295	no opinion	agree	disagree
296	strongly disagree	agree	agree
297	agree	agree	agree
298	strongly disagree	agree	strongly disagree
299	disagree	agree	strongly disagree

Response number	Retinoscopy is NOT useful for detecting crystalline lens changes or opacities. Do you:	Dynamic retinoscopy (i.e. use of a retinoscope to give information regarding accommodation) is used:	Do you own a more recently purchased retinoscope which you do not use, as you prefer an older model?	If you have answered Yes to this question, who is your newer, unused, retinoscope manufactured by?
1	strongly disagree	Frequently	No	
2	disagree	Never	No	
3	disagree	Occasionally	No	
4	strongly disagree	Occasionally	No	
5	disagree	Occasionally	No	
6	no opinion	Occasionally	No	
7	disagree	Occasionally	No	
8	strongly disagree	Never	No	
9	agree	Occasionally	No	
10	disagree	Never	No	
11	disagree	Never	No	
12	disagree	Never	No	
13	disagree	Never	No	
14	agree	Never	No	
15	strongly disagree	Occasionally	Yes	Keeler
16	strongly disagree	Never	Yes	
17	disagree	Occasionally	Yes	Keeler
18	disagree	Never	No	
19	disagree	Occasionally	No	
20	strongly disagree	Occasionally	No	
21	strongly disagree	Occasionally	No	
22	disagree	Never	No	
23	disagree	Occasionally	No	
24	strongly disagree	Occasionally	No	
25	strongly disagree	Occasionally	No	
26	strongly disagree	Never	No	
27	agree	Never	No	
28	agree	Never	No	
29	strongly disagree	Occasionally	No	
30	strongly disagree	Occasionally	No	
31	disagree	Never	No	
32	disagree	Occasionally	No	
33	disagree	Never	No	
34	disagree	Never	No	
35	disagree	Occasionally	No	
36	strongly disagree	Never	No	

Appendix 14 continued

37	disagree	Occasionally	No	
38	no opinion	Frequently	No	
39	strongly disagree	Frequently	No	
40	disagree	Never	No	
41	strongly disagree	Occasionally	No	
42	strongly disagree	Never	No	
43	strongly disagree	Occasionally	No	
44	disagree	Occasionally	No	
45	strongly disagree	Never	No	
46	disagree	Never	No	
47	strongly disagree	Occasionally	No	
48	disagree	Never	No	
49	disagree	Never	No	
50	disagree	Never	No	
51	agree	Never	No	
52	disagree	Never	No	
53	strongly disagree	Occasionally	No	
54	disagree	Never	Yes	Heini
55	strongly disagree	Never	No	
56	disagree	Occasionally	No	
57	strongly disagree	Never	No	
58	strongly disagree	Never	No	
59	strongly disagree	Occasionally	No	
60	disagree	Never	No	
61	no opinion	Never	No	
62	disagree	Occasionally	No	
63	strongly disagree	Never	No	
64	strongly disagree	Never	No	
65	no opinion	Never	No	
66	no opinion	Occasionally	No	
67	agree	Never	No	
68	strongly disagree	Never	No	None of these
69	strongly disagree	Never	No	
70	strongly disagree	Never	No	
71	strongly disagree	Frequently	No	
72	strongly disagree	Occasionally	No	
73	disagree	Occasionally	No	
74	strongly disagree	Occasionally	No	
75	strongly disagree	Occasionally	No	
76	disagree	Occasionally	No	Keeler
77	strongly disagree	Never	No	
78	strongly disagree	Occasionally	Yes	Keeler
79	strongly disagree	Occasionally	No	
80	strongly disagree	Never	No	
81	disagree	Never	No	
82	disagree	Never	No	
83	disagree	Never	No	
84	disagree	Never	No	
85	disagree	Never	No	
86	disagree	Never	No	
87	disagree	Occasionally	No	None of these
88	disagree	Never	No	
89	strongly disagree	Never	No	
90	disagree	Occasionally	No	

Appendix 14 continued

91	agree	Occasionally	No	
92	strongly agree	Never	No	
93	strongly disagree	Frequently	No	
94	strongly disagree	Never	No	
95	strongly disagree	Never	No	
96	strongly disagree	Occasionally	No	
97	strongly disagree	Occasionally	No	
98	strongly disagree	Occasionally	No	
99	strongly disagree	Occasionally	No	
100	strongly disagree	Never	No	
101	disagree	Never	No	
102	strongly disagree	Occasionally	No	
103	strongly disagree	Never	No	
104	disagree	Never	No	Keeler
105	disagree	Never	No	
106	disagree	Occasionally	No	
107	strongly disagree	Never	No	
108	strongly disagree	Frequently	No	
109	strongly disagree	Never	No	
110	strongly disagree	Occasionally	No	
111	strongly disagree	Never	No	
112	strongly disagree	Never	No	
113	strongly disagree	Occasionally	No	
114	strongly agree	Never	No	
115	strongly disagree	Occasionally	No	
116	strongly disagree	Never	No	
117	disagree	Occasionally	No	
118	strongly disagree	Never	No	
119	strongly disagree	Never	No	
120	strongly disagree	Occasionally	Yes	Keeler
121	disagree	Occasionally	No	
122	disagree	Occasionally	No	
123	no opinion	Occasionally	No	
124	strongly disagree	Occasionally	No	
125	disagree	Never	No	
126	disagree	Occasionally	No	
127	strongly disagree	Occasionally	No	
128	strongly disagree	Never	No	
129	disagree	Never	No	
130	strongly disagree	Never	Yes	Heini
131	disagree	Occasionally	No	
132	strongly disagree	Occasionally	Yes	Keeler
133	strongly disagree	Occasionally	No	
134	disagree	Occasionally	No	
135	strongly disagree	Occasionally	No	
136	disagree	Never	No	
137	strongly disagree	Never	No	
138	no opinion	Occasionally	No	
139	strongly disagree	Never	No	
140	strongly disagree	Never	No	
141	disagree	Never	No	
142	strongly disagree	Occasionally	No	
143	strongly disagree	Never	No	

Appendix 14 continued

144	strongly disagree	Occasionally	No	
145	strongly disagree	Occasionally	No	
146	strongly disagree	Never	No	
147	disagree	Never	Yes	Keeler
148	disagree	Never	No	
149	strongly disagree	Occasionally	No	
150	disagree	Occasionally	No	
151	strongly disagree	Occasionally	No	
152	agree	Occasionally	No	
153	disagree	Never	No	
154	disagree	Never	No	
155	strongly disagree	Occasionally	No	
156	strongly disagree	Never	No	
157	strongly disagree	Occasionally	No	
158	no opinion	Never	No	
159	strongly disagree	Never	No	
160	disagree	Occasionally	No	
161	strongly disagree	Never	No	
162	disagree	Never	No	
163	disagree	Occasionally	No	
164	disagree	Occasionally	No	
165	strongly disagree	Occasionally	No	
166	strongly disagree	Occasionally	No	
167	strongly disagree	Never	No	
168	no opinion	Never	Yes	None of these
169	strongly disagree	Occasionally	No	
170	disagree	Never	No	
171	disagree	Occasionally	No	
172	disagree	Never	No	
173	strongly disagree	Occasionally	No	
174	disagree	Never	No	
175	disagree	Never	No	
176	strongly disagree	Occasionally	No	
177	strongly disagree	Occasionally	No	
178	strongly disagree	Occasionally	No	
179	strongly disagree	Never	No	
180	disagree	Never	No	
181	strongly disagree	Frequently	No	
182	strongly disagree	Never	No	
183	strongly disagree	Occasionally	No	
184	disagree	Never	No	
185	strongly disagree	Never	No	
186	strongly disagree	Occasionally	No	None of these
187	strongly disagree	Occasionally	No	
188	agree	Never	No	
189	disagree	Occasionally	Yes	Welch Allyn
190	strongly disagree	Occasionally	No	
191	disagree	Never	No	
192	strongly disagree	Never	No	
193	disagree	Occasionally	No	
194	strongly disagree	Occasionally	No	
195	strongly disagree	Frequently	No	
196	strongly disagree	Occasionally	No	
197	disagree	Occasionally	No	

Appendix 14 continued

198	disagree	Occasionally	No	
199	disagree	Never	No	
200	strongly disagree	Occasionally	No	
201	strongly disagree	Occasionally	No	
202	disagree	Occasionally	No	
203	strongly disagree	Never	No	
204	strongly disagree	Occasionally	No	
205	disagree	Never	No	
206	strongly disagree	Occasionally	No	
207	strongly disagree	Occasionally	No	
208	agree	Occasionally	Yes	Keeler
209	strongly disagree	Occasionally	No	
210	disagree	Occasionally	No	
211	strongly disagree	Never	No	Not sure
212	disagree	Occasionally	No	
213	strongly disagree	Never	No	
214	agree	Never	No	
215	strongly disagree	Occasionally	No	
216	disagree	Never	No	
217	agree	Never	No	
218	no opinion	Occasionally	No	
219	disagree	Never	No	
220	strongly disagree	Never	No	
221	strongly disagree	Never	No	
222	disagree	Never	No	
223	strongly disagree	Never	No	
224	strongly disagree	Occasionally	No	
225	strongly disagree	Frequently	No	
226	agree	Never	No	
227	strongly disagree	Occasionally	No	
228	strongly disagree	Occasionally	No	
229	agree	Occasionally	No	
230	strongly disagree	Occasionally	No	
231	strongly disagree	Occasionally	No	
232	disagree	Occasionally	No	
233	disagree	Never	No	
234	strongly disagree	Occasionally	No	
235				
236	disagree	Frequently	No	
237				
238	disagree	Frequently	No	
239	disagree	Never	No	
240	disagree	Never	No	
241	strongly disagree	Never	No	
242	strongly disagree	Never	No	
243	strongly disagree	Occasionally	No	
244	disagree	Never	No	
245	disagree	Occasionally	No	
246	disagree	Never	No	
247	disagree	Never	No	
248	agree	Never	No	
249	disagree	Never	No	
250	disagree	Never	No	
251	disagree	Occasionally	No	

Appendix 14 continued

252	disagree	Occasionally	No	
253	agree	Never	No	
254	disagree	Never	No	
255	disagree	Occasionally	No	
256	disagree	Never	No	
257	strongly agree	Never	No	
258	strongly disagree	Occasionally	No	
259	strongly disagree	Never	No	
260	strongly disagree	Never	No	
261	agree	Never	No	
262	strongly disagree	Never	No	
263	strongly disagree	Never	No	
264	strongly disagree	Occasionally	No	
265	disagree	Occasionally	No	
266	disagree	Never	No	
267	disagree	Never	No	
268	disagree	Never	No	
269	strongly disagree	Occasionally	No	
270	disagree	Never	No	
271	strongly disagree	Never	No	
272	disagree	Occasionally	No	
273	disagree	Occasionally	No	
274	disagree	Occasionally	No	
275	disagree	Occasionally	No	
276	strongly disagree	Occasionally	No	
277	disagree	Occasionally	No	
278	disagree	Never	No	
279	no opinion	Occasionally	No	
280	disagree	Never	No	
281	disagree	Never	No	
282	disagree	Never	No	
283	agree	Never	No	
284	no opinion	Occasionally	No	
285	strongly disagree	Occasionally	No	
286	strongly disagree	Never	No	
287	disagree	Never	No	
288	strongly disagree	Occasionally	No	
289	strongly agree	Occasionally	No	
290	disagree	Occasionally	No	
291	disagree	Never	No	
292	strongly disagree	Occasionally	No	
293	strongly disagree	Never	No	
294	disagree	Occasionally	No	
295	disagree	Never	No	
296	strongly disagree	Never	No	
297	disagree	Never	No	
298	disagree	Never	No	
299	disagree	Never	No	

Appendix 15. The comments received by respondents in response to the final survey item. The author has made an individual interpretation in order to categorise these comments.

Positive comments regarding retinoscopy
i think the use of a ret&having one should be a must in any optometric work place&not an option.
Qualitative information gained as well as quantitative results
1 I routinely use retinoscopy on children under the age of about 10. 2 I always use retinoscopy on patients returning for their first examination after cataract surgery. 3. Please would you email me the results of your survey-many thanks
I do use retinoscopy mainly in infants/kids and in older Px's when no previous records available.
I never spend a long time performing retinoscopy, but I would feel lost without it. The retinoscope gives such a good "overview" of the state of the eyes, right at the start of an eye examination.
I would use retinoscopy less if I had an autorefractor available, but still consider it an important part of optometric practice.
I always use it when old rx is unknown, eg. 1st ever test, post cataract op, and for children and learning difficulty px's
it is very valuable, i would feel lost without my retinoscope!
I find retinoscopy very useful in everyday practice. I hated it at Uni, and never thought I'd be any good at it, and I am still surprised at how waving a streak of light at the eye can often find a good starting point for refraction, or even a fairly accurate Rx and V good VA.
All instruments we use inform the overall clinical picture. Few are indispensible. The beauty of a ret is that it's a low cost instrument. It could be replaced by higher cost ones requiring a less skilled operator. In my view it's future will be decided by the cost/benefit decision and on quality of education.
I love my retinoscope. It has two aperture settings that is a useful feature. My final Rx differs little from the retinoscopic findings.
Retinoscopy is a very important part of the eye exam, which when done accurately can speed up the exam and allow patients to feel happier that they haven't
Retinoscopy provides important information for every refraction is clinically much more useful than autorefractors are.
Don't get rid off them!! Ensure it is part of the core competency. Although I have aa autorefractor aswell, when they breakdown, back to basics is the best!
Useful tool for objective assessment for non standard cases and cl over refraction. Otherwise autorefractor more practical.
It reduces the chance of patient accommodation and false prescription starting point. Gives an accurate point to start subjective refraction.
Retinoscopy is the most valuable tool in practise to gadge the Patients,RX. the ret gives the practitioner valuable info not available by oter objective methods
I feel it is a very important tool to accurately detect refractive error, astigmatism, keratoconus, quality of media, and is often the only tool possible with some
Retinoscopy provides more information to the clinician than an autorefractor !!!
Really helps when a Px has variable subjective results, and I feel is a major reason that I consistently have the lowest number of remakes due to Rx error in my store. Great for Kids and accommodative problems too.
I think retinoscopy is still a very important clinical skill required by an optometrist especially for detecting lens opacities and for young children or adults with learning disabilities. I use ret in all of my patients regardless whether they have an exsisting prescription or not. Especially useful for hypermetropes and I find I nearly always find more plus for hypermetropes than their current glasses. Although I must admit that my practice does noy have an auto-refractor so maybe this would be different if I did!
I would not be without my retinoscope - the quality of the reflex give so much information. For very high errors, eg after graft surgery, I consider it to be the only accurate way of determining refraction starting point.
Although I don't use the retinoscope often it is an essential tool to have available especially for test where I need to prescribe from the objective result, or get an idea of likely Rx with patients who have no obvious starting point for subjective (e.g. post-cataract Px). I much prefer retinoscopy to autorefractors & wouldn't consider buying an autorefractor as I don't feel it is as useful/accurate as my retinoscope.
Essential for all hyperopes and astigmats

Appendix 15 continued

ret is one tool for getting to an accurate rx. I don't use ret at any specific point in my refractions but may use it at any point if things 'feel' wrong - end point VA is poor - suspect px telling porkies - or large changes indicated. I always use ret on under 16s
I tend to use the retinoscope for young children, px's with learning disabiities or as a diagnostic tool for keratoconus. I do prefer the autorefractor
Having worked in a practice with autorefractors in the past I can recommend retinoscopy enthusiastically. It is an important and useful skill, particularly in less straightforward patients, and I rely on it more and more. Done properly it is swift and effective, and I strongly believe that those who don't use it are just plain lazy.
Retinoscopy is not only a vital skill but essential in optometric practice as it provides more information about the state of the eye compared to an autorefractor for example. The more you do it, the better you get at it. i have found "wet" retinoscopy especially more useful post qualifying and will continue to make it part of my routine. As a matter of fact , we do not own an autorefractor in my practice.
Retinoscopy is essential in practice. It gives vital information on the cornea, media and even fundus - i.e red reflex etc. I would not practice without one.
I believe it is still a very important test and the retinoscopy result should be recorded on record cards. With a skilled user it is more accurate than an autorefractor for children and latent hyperopia. I think the best ret wwas the old Hamlin streak ret but they are not made anymore but my Keeler works well and I dfind it very accurate.
I strongly believe retinoscopy is a valuable tool giving good quick objective information. Much better than an autorefractor as you can assess the lens, accommodation & how still the px can sit! I really hope that the profession doesn't give it up.
I use my ret more than my direct opthalmoscope but would not to be wihout either. I hope there are no plans to omit retinoscopy from optometric training. Its vital for the very young and very old-ie domiciliary exams.
It is a vital assessment as it helps with Px whoo have poor subjective responses (ie poor communication or not able to comprehend) and also for those who are hyperopic and cycloplegic refractions too
An important skill and diagnostic tool
I work as a domiciliary optometrist and retinoscopy is vital in the detection and prescribing of specs to patients with learning difficulties, brain injuries, mental illnesses and dementia related diseases. I could not be without it. Sometimes it is the only way of checking for lens opacities, keratoconus as Ophthalmoscopy cannot always be achieved.
I would definitely not be without my retinoscope. Even though I do not use it on every patient, it is invaluable when examining children, people unable to communicate well, pseudomyopes etc. Occasionally the autorefractor gives spurious results, or perhaps a patient's findings do not correlate, at these times it is reassuring to use my RET and feel confident in my objective findings. At University I bought a Keeler RET, and still have it now 14 yrs later. I have since tried the Heine BETA 200 and I think this is better, but I cannot afford to buy a new RET at this stage.
I would consider my retinoscope to be essential in most examinations, mainly because I work n a hospital setting and it is used diagnostically.
Retinoscopy is an essential piece of equipment especially if the practice doesn't have an auto-refractor. I always do ret on those patients that require it even if I have auto-refractor results as there is more degree if error and I want to be sure I have refracted the patient adequately. Sometimes the auto-refractor may need re-calibration so it's far quicker to ret a patient than to mess around with subjective refraction based on auto-refractor results.
Retinoscopy is a very useful and important aspect of an optometric eye examination.
I only use ret if I don't have an existing prescription to use or with children or those with a learning disability.
In my practice I reply on my ret as the sole method of refraction in some individuals as I have no aurorefractor. It is essential. I love the streak best. Donot find it as useful with keratoconus as the keratometer though.
Large interest in paedeatrics therefore retinoscopy invaluable
It is an essential tool especially in refraction of the young and those with challanging refractive errors. I have also dignosed subtle early lamellar cataracts which have been missed slit lamp and ophthalmoscope by experienced ophthalmologists
Can miss alot if you don't use your ret.
Can miss alot if you don't use your ret.
Surprised at the thought that OOs may not do it. Am I a dinosaur?
Retinoscopy is a very valuable technique which I feel I flounder without. Spot rets are, I feel, more useful in detecting lens opacities, abberations and also post capsule changes in pseudophakes.
A very useful tool for children, unexplained variation in vision, reduced vision and checking the media whilst refracting. But not necessary to use on ALL patients.

Appendix 15 continued

I dropped my ret on the floor one saturday before starting work. It was like losing my right hand. i really don't understand how anyone works without a ret.
Very useful technique if practised regularly.
Ret only done on new patients, old Px is subjective is suspect and kids ~ < 10years. Not done on old Px, use the old Rx as starting point. Auto-Rx done on most new adult Px although I prefer to use old Spec Rx as a starting point.
My supervisor once told me that if he could only have one instrument it would be a retinoscope, I tend to agree
Its a vital diagnostic test and a skill which every optometrist should be competent in.
I only ret selected patients. New patients, people with big refractive changes, people with reduced VA etc. It's not routine on most returning patients but it is absolutely essential part of optometry I would say.
I wouldn't be without my ret
although I do not perform retinoscopy on everybody, I certainly find there are times when it gives the best result and would not like to be without it.
I wouldn't be without my ret.
good start to an eye exam. gives an indication of clarity of media. couln't live without my retinoscope. I don't use autorefractors as there aren't any in the practices in which I locum.
Retinoscopy is useful for estimating spherical abberations / irregular corneal shapes. It also allows one to estimate accommodation activity in children. It is an essential tool for understanding fully the patient's refractive error (ie older uncorrected hyperopes as well as keratoconics, children, learning disabled, etc). I couldn't be without it!
Retinoscopy should be used on all patients as it is an important diagnostic tool in every eye exam.
I do not use on every patient but it is invaluable when examining children, alzheimers/dementia patients and those with learning difficulties. Also very useful for those new patients who are not very good at subjective refraction!
I would feel totally lost without my ret! I use it on all new px plus old px if the VA has changed significantly. It gives me so much more info than just the Rx - quality of reflex etc. I wonder if it is used enough by optometrists? Maybe not.
I feel retinoscopy is still an important part of examination work, especially in a Hospital.
retinoscopy can be more reliable than autorefractors and subjective
Retinoscopy is a useful tool in practise. I would not advocate mandatory use on all patients as it sometimes provides no further information. e.g A young person with 6/5 vision with previous correction. Do you need to do ret, or do you start your subjective exam with the previous prescription?
people that don't do retinoscopy are usually weak optometrists and their records are usually deficient in other areas.
I feel retinoscopy is a very important part of an eye examination.
Retinoscopy is a very useful tool in optometric practice as it can be used not only for refraction but also diagnostically. I prefer using spot retinoscopy as I believe the axis can be found more easily using this method. I believe retinoscopy should remain an integral part of optometric practice.
I feel retinoscopy is an important factor in examination. without my retinoscope I would be lost. I am saying this as I am a newly qualified and work in a practice with poor equiptment and the clients are all NHS of whom more than half do not speak a word of english and have never had an eye test before!! I have also diagnosed keratoconas on many occasions solely using my retinoscope. I feel it is an important tool in an eye test given the type of patient you are dealing with and the facilities you have avaliable in practice.
Do a lot of domiciliary work.Couldn't manage without my retinoscope.
As far as vision in young children is concerned Retinoscopy is the best way to determine the dynamics of accommodation as an auto refractor is simply not good enough on its own. I think many of the questions are not appropriate for the intention of this survey, so I am not quite sure as to what the point of this survey is.
Colleagues who use autorefractor and don't retinoscopy reg have struggled if autorefractor noyt working. Useful skill to have even though I think autofrefractors are going to become the norm.
On new patients and children, retinoscopy is invaluable. I will always trust ret over an autorefractor result. I view autorefraction as a time saving alternative to routine, asymptomatic patients.
no need for autorefractors if you are capable of accurate ret ret is very useful tool if px unreliable although not essential with every px
Highly important skill that GREATLY reduces testing time, a good ret result often impresses the px too!
retinoscopy is still usefull, especially for correcting large cyls and refracting children

Appendix 15 continued

I always use retinoscopy first without looking at the existing Rx so as not to be influenced by a possible erranous Rx . Once retinoscopy and subsequent subjective Rx are determined I then compare with existing spex and refine my dispensing Rx accordingly if required. If retinoscopy is not performed on every Px then skill level would not be as good and I would be unaware of latent errors which is always useful to know when determining final outcome.
retinoscopy, i find, to be very useful in everyday practice. the only down side is really the battery power in my ret- seems to only last a short time and needs to be charged all the time.
I feel retinoscopy is a fundamental aspect of an eye examination, particular for the younger generation (with accommodation). It gives the practitioner full independent control of the px's accommodation and the state of the px's actual refraction. I dont feel retinoscopy will become redundant inlight of autorefractors purely because there are many variables which are uncontrollable with autorefractors. I suppose the same can be said for opthalmoscopy inlight of fundus imaging technology.
i would be lost without my ret
Your survey didn't distinguish between practice based and domicilliary optometrists. The answers you are provided with may be different determined by the way each practices. I am a domicillary community optometrist and haven't access to an autorefractor therefore my ret is very important to me. If I work in practice it is much less significant.
Although I use a Streak retinoscope, I much prefered my old spot retinoscope to ascertain Rxs. If I am not performing a cyclo, I tend to use retinoscopy to look at the quality and appearance of the reflex wrt lens/corneal distortions and opacities etc.
Ret is a must part of the eye exam
believe it to be extremely useful and every optometrist should routinely use it
I find my ret is more accurate than an autorefractor
Still feel its avery valuable test to start with and gives you a good idea of the rx especially if the patient has poor subjective responses during the later exam.
Negative comments regarding retinoscopy
Bulb quality, brightness and lifespan seems to vary within the same instrument. Retinoscopes are a rip off for what they are. :-)
It doesn't always give a very accurate result, sometimes it is just useless to perform on some patients
Comment relating to multiple type practice
Many multiples do not give practitioners time for retinoscopy
Comment relating to retinoscope manufacturers
I own a keeler streak however I discovered that the Welch Allen streak which I use in the HES are significantly better, giving a brighter reflex and it would be my instrument of first choice.
older keeler ret from 1988 lasted for 15 yrs until ball bearings for rotating streak became stuck. Ret currently used again made by Keeler are with the rubber sleeve over the rotating part which disintergrated very quickly and has made retting slower because you now need 2 hands to rotate the streak and a more recent one which is slightly better but not as durable as any of the much older models. Ideally you should be able to rotate the streak with one finger allowing the other hand for picking up the trial lenses. Is this a ploy by the manufacturers to make less durable instruments so we keep having to buy more equipment?
Years ago I used a purvis streak ret made I think by Hamblin and I would revert to this tomorrow if they were still available. Best ret ever made!
prefer the original Hamblin streak ret
In my opinion I prefer my Keeler retinoscope which unfortunately had to be replaced. I'm disappointed with my Welch Allen but at the time, could not justify spending the money on another Keeler. Also, the model that Keeler had at that time was not as user friendly as my 1st retinoscope. Hence the decision to go with Welch Allen. I believe now, with the precision and the increase use of autorefractors, I am less accurate with the retinoscope. I think autorefractors are an excellent aid but equally,the ability to perform objective refraction is still an important skill for any optometrist.
Keeler rets are too expensive and i will definitely choose another provider based on cost alone. It's a torch and a mirror. More competition is a good thing with such products. Even the replacement batteries should be better value. The same goes for Pulsairs. I have 5 consulting rooms and i used to have 4 pulsairs. Pointless when you stop servicing older models to force us to buy new ones. You are getting a bad name in the industry.
I use a keeler in one practice & a heini in the other & get on well with both

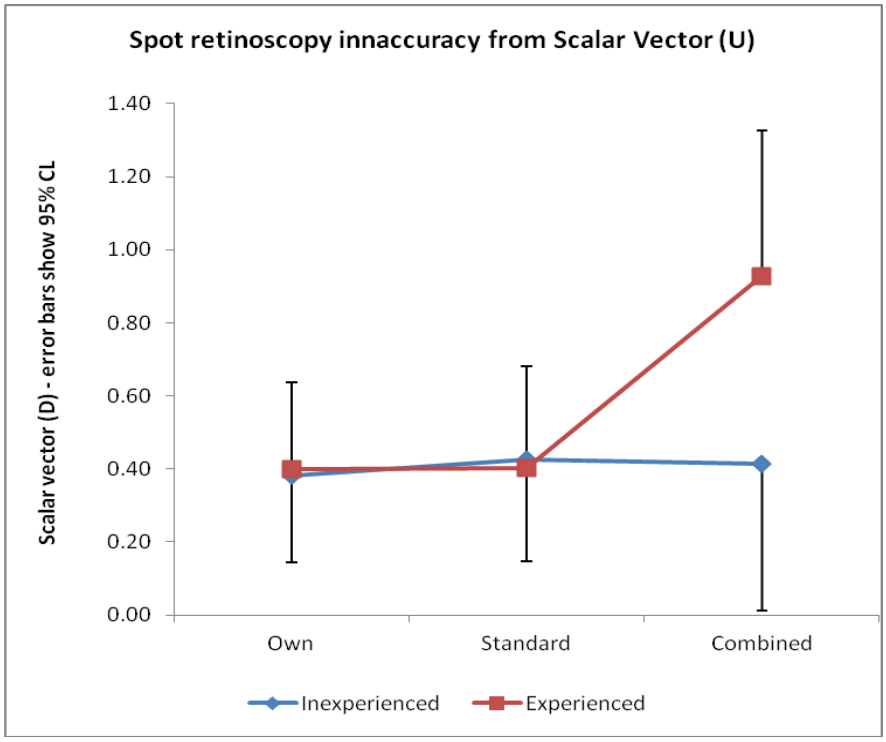
Appendix 15 continued

best retinoscope in the world HEINE!
General points
in my experience auto refractors are a waste of time. Results too random and subject to subjective errors.
autorefractor much quicker when pushed for time
I'll only use a retinoscope if I'm in a practice without an autorefractor or if I'm testing a child/non communicative patient. I routinely cyclo my patients and they all have pentacams to assess corneal topography.
it is underused by practitioner that use auto refractors
I sometimes wonder if I had learnt spot ret instead of streak whether my ret result would be more accurate.
How much is Derek going to pay me for this survey please?!
I have a combi retinoscope but only use streak retinoscopy. The fact it could change to either type was not a factor in its purchase. It is excellent as a streak retinoscope.
cannot comment on fixed retinoscopes (i.e non-combi) as i have never used one! i qualified in 2004.
I probably dont do it as much as I used to as most of my patients are longstanding rather than new patients and it is less useful then.
retinoscopy is difficult with a refractor head. therefore I tend to do more ret when using a trial frame
Sometimes its difficult using a phoropter head
no
Ret is useful but not used often enough in a busy modern practice due to the availabilty of good quality autorefractors and secondly due to the myth of the 20min eye test. A fully booked clinic at 20min intervals does not allow for accurate retinoscopy. Time restarints are the main reason why tests such as ret, fixation disparity, accommodation tests are not carried out by the majority of high street opticians in my opinion, tests which all provide valuable information to the prescribing optometrist.

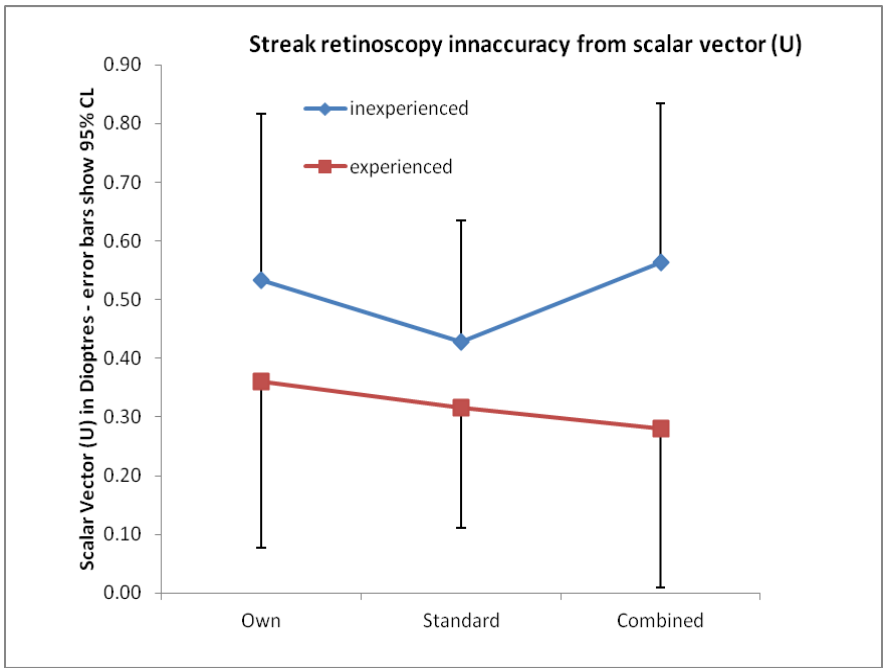
Appendix 16. Various aspects of the present study (UK and international surveys highlighted in bold) are compared with previous practitioner surveys. All Surveys are arranged in order of ascending number of items.

Authors, topic, profession, country	Number of items	Was survey piloted?	Incentives offered?	Nature of survey	Response rate (%)
Dunstone, International retinoscopy survey , optometrists and ophthalmologists, present study	**5**	**Part**	**No**	**Tick box form distributed to course delegates**	**Unknown**
Turner et al.,(112) dry eye, eye care practitioners, UK.	8	Yes	No	Internet	94
Craig & Warburton,(114) visual fields, optometrists, UK.	9	Yes	No	Internet	10
Kammer et al., (115) Low vision, Optometrists, USA.	18	Not recorded	Not recorded	Post & Internet	7
Gill et al.,(117) Contact lenses, eye care practitioners, UK	20	Yes	Not recorded	Post	45
Dunstone et al., (224) Retinoscopy survey, optometrists, UK	**23**	**Yes**	**Yes**	**Internet**	**30**
College of Optometrists, Clinical Practice Survey, (248) Optometrists, UK	24	Yes	No	Post & Internet	30
Warburton et al., (113) recall intervals, optometrists, UK	26	Yes	No	Post	65
Myint et al., (116) glaucoma tests, optometrists, UK.	27	Yes	No	Internet	28
Leece et al., (118) Internet versus mailed surveys, surgeons, Canada.	38	Yes	No	Post & Internet	51 (45% from internet and 58% from mail)
College of Optometrists, Workforce Survey (in press), Optometrists, UK	59	Yes	Yes	Post & Internet	34

Appendix 17. Spot retinoscopy inaccuracy values (U) for different types of retinoscopes. 95% confidence limits shown.



Appendix 18. Streak retinoscopy inaccuracy values (U) for different types of retinoscopes. 95% confidence limits shown.



Appendix 19. The full international survey showing questions with alternative answers. Tick box instrument design used.

Retinoscopy Survey

Please place a tick in the appropriate box for your answer to each question.

1. What is the profession to which you belong?

	Tick
Ophthalmologist – medical doctor with eye specialty.	
Optometrist or Optician – graduate in eye care who conducts eye examinations.	
Dispensing Optician, Optometric Assistant or Dispensing Assistant - eye care professional trained in spectacle or contact lenses but who does not conduct full eye examinations.	

2. When did you qualify as an eye care practitioner?

	Tick
Before 1965	
1965 - 1979	
1980 - 1994	
1995 – 2010	
This year (2011)	
No professional qualification received to date	

3. What is your primary method of objective refraction?

	Tick
Retinoscopy	
Autorefractor	
Retinoscopy and Autorefractor about equally	
Do not carry out objective refraction	

4. Dynamic retinoscopy (i.e. use of a retinoscope to give information regarding accommodation) is used:

	Tick
Never	
Occasionally	
Frequently	

5. Do you consent to your responses being used for our research and for any publications that result from this research?

	Tick
Yes	
No	

Appendix 20. The full international survey showing questions with alternative answers translated into Russian. Tick box instrument design used.

СТРАНА: Russia

Обзор по ретиноскопии
Чтобы ответить на вопрос, поставьте галочку в нужной клетке.

1. Какая у вас специальность?

	Отметить
Офтальмолог	✓
Оптометрист – специалист, который проводит осмотр глаз	
Оптик-оптометрист- специалист, подбирающий очки или контактные линзы, но не проводящий полного осмотра глаз	

2. Когда вы получили квалификацию в офтальмологии или оптометрии?

	Отметить
До 1965 г.	
1965 – 1979 гг.	
1980 – 1994 гг.	✓
1995 – 2010 гг.	
В этом году (2011)	
На настоящее время у меня нет профессиональной квалификации	

3. Какой метод оценки объективной рефракции вы в основном применяете?

	Отметить
Ретиноскопия	
Авторефрактометрия	✓
Примерно поровну – ретиноскопия и авторефрактометрия	
Я не провожу оценку объективной рефракции	

4. Я выполняю динамическую ретиноскопию (например, использую ретиноскоп для оценки аккомодации):

	Отметить
Никогда	✓
Иногда	
Часто	

5. Вы согласны, чтобы ваши ответы были использованы в нашем исследовании и связанных с ним публикациях?

	Отметить
Да	✓
Нет	

Appendix 21. The full international survey showing questions with alternative answers translated for practitioners from the Czech & Slovak Federal Republic . Tick box instrument design used.

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Česká republika / Slovenská republika | 10/2011

Průzkum v oblasti skiaskopie

Prosím, odpovězte na každou otázku zaškrtnutím příslušného políčka.

1. Jaká je vaše profese?

	Zaškrtnutí
Oftalmolog	
Optometrista	X
Oční optik/ Oční technik/ Prodejní poradce/ Laborant	

2. Kdy jste získal(a) kvalifikaci jako oční specialista provozující praxi?

	Zaškrtnutí
Před rokem 1965	
1965 - 1979	
1980 - 1994	X
1995 – 2010	
V tomto roce (2011)	
Dosud jsem nezískal(a) žádnou odbornou kvalifikaci	

3. Jaká je vaše primární metoda pro stanovení objektivní refrakce?

	Zaškrtnutí
Skiaskopie	
Autorefraktor	X
Přibližně ve stejném rozsahu skiaskopie a autorefraktor	
Nestanovuji objektivní refrakci	

4. Dynamická sklaskopie (tj. použití skiaskopie k poskytnutí informací o akomodaci) je používána:

	Zaškrtnutí
Nikdy	X
Občas	
Často	

5. Souhlasíte s tím, aby byly vaše odpovědi použity pro náš výzkum a pro jakékoli publikace vycházející z tohoto výzkumu?

	Zaškrtnutí
Ano	X
Ne	

2

Appendix 22. The full international survey showing questions with alternative answers translated for practitioners from Germany, Austria and Switzerland . Tick box instrument design used.

DACH 08 group 1 1930/11 09 26

DACH: Germany / Austria / Switzerland | 09/2011

Umfrage zu Skiaskopie

Bitte setzen Sie einen Haken in das entsprechende Feld für Ihre Antwort auf jede Frage.

1. Welche Berufsbezeichnung passt am ehesten zu Ihnen?

	Haken
Ophthalmologe/ in– Arzt/Ärztin, der/die auf Augenheilkunde spezialisiert ist	
Optometrist(in), Augenoptikermeister(in) – Absolvent(in) einer Fachschule, der / die Untersuchungen am Auge durchführt.	✓
Augenoptiker(in) oder – Augenspezialist(in), der / die in Brillengläsern oder Kontaktlinsen spezialisiert ist, jedoch keine vollständigen Untersuchungen am Auge durchführt.	

2. Wann haben Sie sich als Augenspezialist(in) qualifiziert?

	Haken
Vor 1965	
1965 – 1979	
1980 – 1994	✓
1995 – 2010	
Dieses Jahr (2011)	
Bisher noch keine Berufsqualifikation erhalten	

3. Welches ist Ihre Hauptmethode für eine objektive Refraktion?

	Haken
Skiaskopie	
Refraktometer	✓
Skiaskopie und Refraktometer	
Ich führe keine objektive Refraktion durch	

4. Dynamische Skiaskopie (d. h. Verwendung eines Skiaskops um Informationen für die Anpassung zu erhalten) wird angewendet:

	Haken
Niemals	✓
Gelegentlich	
Häufig	

5. Sind Sie damit einverstanden, dass Ihre Antworten für unsere Forschungsarbeit und für Veröffentlichungen verwendet werden, die sich aus dieser Forschungsarbeit ergeben?

	Haken
Ja	✓
Nein	

2

Appendix 23 . Distribution of potential influencing factors and professions. Sample includes all responses from the various eye care professions (n=583).

Nature of question	Alternatives responses	Answers	
		Percentage	Count
When qualified ('Age')	1965-1979	4.3	25
	1980-1994,	23.7	138
	1995-2010	59.7	348
	2011	8.9	52
	No qualifications	3.1	18
	Skipped question	0.003	2
Country or area	Germany	12.2	71
	Czech and Slovak Federal Republic	12.2	71
	Russia	30.4	177
	South East Europe(Bulgaria/ Croatia/Romania/Slovenia)	3.9	23
	Benelux (Belgium/Netherlands/Luxembourg)	2.4	14
	Kingdom of Saudi Arabia	3.1	18
	Kuwait	0.003	2
	Kingdom of Bahrain	0.003	2
	Qatar	0.002	1
	United Arab Emirates	10.5	61
	Nordic(Sweden/Norway/Finland/Denmark)	12.2	71
	UK	12.3	72
Profession	Ophthalmologist	23.8	139
	Dispensing Optician	13.9	81
	optometrist	61.9	361
	no qualification	0.002	1
	Skipped question	0.002	1

Appendix 24. Distribution of potential influencing factors for optometrists who use objective refraction (n= 338). Responses from Kuwait, Kingdom of Bahrain & Qatar were subsequently deselected; n= 334 used for analysis.

Nature of question	Alternatives responses	Answers	
		Percentage	Count
When qualified ('Age')	1965-1979	5.6	19
	1980-1994,	24.3	82
	1995-2010	63.0	213
	2011	7.1	24
	Skipped question	0	0
Country or area	Germany	10.7	36
	Czech and Slovak Federal Republic	17.2	58
	Russia,	3.3	11
	South East Europe(Bulgaria/ Croatia/Romania/Slovenia)	5.6	19
	Benelux (Belgium/Netherlands/Luxembourg)	3.3	11
	Kingdom of Saudi Arabia	3.6	12
	Kuwait	0.003	1
	Kingdom of Bahrain	0.006	2
	Qatar	0.003	1
	United Arab Emirates	16.9	57
	Nordic(Sweden/Norway/Finland/Denmark)	19.8	67
	UK	18.6	63

Appendix 25. Details of online literature search of PubMed (www.ncbi.nlm.nih.gov/pubmed) conducted in respect of repeatability of refraction, showing search terms used and studies found.

Subject	Date of online search	Search terms	Studies found
Repeatability of refraction	9 July 2013	Refraction AND repeatability NOT aberrations NOT Pachymetry NOT biometry	90; 17 relevant papers summarised in Appendix 26
Repeatability of retinoscopy	12 July 2013	Refraction AND (repeatability OR reliability) NOT aberrations NOT Pachymetry NOT biometry (for 1980 and onwards)	35; 6 relevant papers summarised in Appendix 27

Appendix 26. Previous studies that have measured repeatability of refraction, presented in chronological order. Unless stated otherwise, repeatability figures are for mean difference (MD), followed by standard deviation (SD). (Auto= autorefraction, Ret= retinoscopy, Subj= subjective, MSE= Mean sphere equivalent, CR= Coefficient of Repeatability, RE= right eyes, LoA= Limits of Agreement).

Author, Country	Methods of refraction studied	Repeatability	Number of eyes	Other points of interest
Yeow & Taylor (1989)(249), UK	Auto & subj	Auto for MSE: 0.02 +/- 0.31	110	Auto v subj: -0.01 +/- 0.51
Rosenfield & Chiu (1995)(250), USA	Auto & Subj	Subj: SD +/- 0.14, 95% LoA +/- 0.27D	12	Repeatability better with subj, compared with auto
Elliott et al (1997)(239), USA	Auto & Subj	Subj: CR 0.611 Auto: CR 0.712	30 RE	Subj more repeatable than auto refraction
Bullimore et al (1998)(205), USA	Auto & Subj	Subj: MD -0.12, 95% LoA -0.90 to +0.65D, 95% within 0.90D	172	Auto more repeatable than subj refraction
Davis et al (1998)(251), UK	Subj	-0.32 +/- 2.91 (for sphere)	129 (keratoconic)	Only 36% of repeat sphere measures within 0.50D, compared with >90% in studies with normal eyes
Chat & Edwards (2001)(252), Hong Kong	Auto	-0.01 +/- 0.35	53 RE	Reliability of auto is improved using cycloplegia
Raasch et al (2001)(253), USA	Subj	Normal eyes: MD 0.03, 95% LoA +0.51 Keratoconic eyes: MD -0.41, 95% LoA +5.51	40 RE	Repeatability of refraction is reduced with keratoconic eyes
Mallen et al (2001)(177), UK	Auto	SD for sphere: 0.14D	200 (100 subjects)	Auto valid but found slightly more plus than subj. Difference for MSE: +0.16 +/- 0.44D
Allen et al (2003)(254), UK	Auto	+0.04 +/- 0.38, 95% LoA +0.79 to -0.71	50 RE	Auto v subj: +0.30 +/- 0.50, 95% LoA +1.28 to -0.67
Davies et al (2003)(255), UK	Auto	MD for sphere 0.11D, 95% within +0.50D	198 (99 subjects)	Difference between auto and subj: 0.14 +/- 0.35D
Dave & Fukuma (2004)(256), UK	Auto	-0.06 +/- 0.19D (for MSE)	100 RE	No significance between subj auto and conventional subj refraction
Sheedy et al(2004)(257), USA	Auto & Subj	Auto: +0.05 +/- 0.37D Subj: 0.01 +/- 0.27D (for MSE)	60 subjects	Subj refraction more repeatable than autorefraction
Nissmann et al(2006)(258), USA	Auto	0.03 +/- 0.15D (for sphere)	105 (53 subjects)	Difference between auto and subj: 0.34 +/- 0.28D for sphere
Leinonen et al (2006)(240), Finland	Subj	Subj for SE: MD 0.04, CR +/- 0.74D	99 (99 subjects)	Eyes with lower visual acuity had greater variability in results
Dahlmann-Noor (2009)(191), UK	Ret & Auto	Auto for MSE: MD 0.03, 95% LoA -0.62 to 0.68D	103 children	Non-cycloplegic auto found significantly less positive prescription than cycloplegic ret
Sheppard & Davies (2010)(259), UK	Auto & subj	Auto: 90% within +/- 0.50D	150 (75 subjects)	Difference between auto and subj: -0.01 +/- 0.38D
de Juan et al (2012)(260), USA	Auto, ret & subj	Auto for MSE: SD 0.18D	124	Difference between ret and auto: 0.32 +/- 0.77D (more positive result with ret)

Appendix 27. Previous studies that have measured repeatability of retinoscopy, presented in chronological order. (MD = Mean difference, Standard Deviation =SD, Auto= autorefraction, Ret= retinoscopy, Subj= subjective, MSE= Mean sphere equivalent, RE= right eyes, LoA= Limits of Agreement, r = Correlation Coefficient).

Author, Country	Methods of refraction studied	Repeatability	Number of eyes	Other points of interest
Guillon (1986)(182), UK	Ret & Auto	Ret for MSE: MD -0.89, SD 0.89	21 aphakic (17 subjects)	Repeatability lower with aphakic eyes
Zadnik et al (1992)(179), USA	Auto, ret & subj	Ret: -0.006 +/- 0.394, 95% LoA -0.78 to 0.77D	40 RE	Auto refraction with cycloplegia is more repeatable than ret or subj refraction
Saunders & Westall (1992)(261), UK	Ret	MD -0.3, 95% Confidence limits +0.1 to –0.7	20 (for repeatability study)	Ret has poor repeatability
Hodi & Wood (1994)(238), UK	Ret & Video refraction	Interobserver: MD 0.03, SD 0.37, r = 0.96 Intraobserver: MD -0.05, SD 0.16, r = 0.91	150 infants	Ret more consistent than video refraction
Walline et al (1999)(262), USA	Auto, ret & subj	Ret: 95% LoA +/- 1.02D for astigmats	40 patients	Cycloplegic autorefraction most reliable
Chen et al (2011)(237), China	Ret	Correlation between examiners, r = 0.96	162 (81 subjects)	Chinese neonates highly hyperopic yet at high risk of becoming myopic