Keratometry – a technique that should be relegated to the clinical dark ages?

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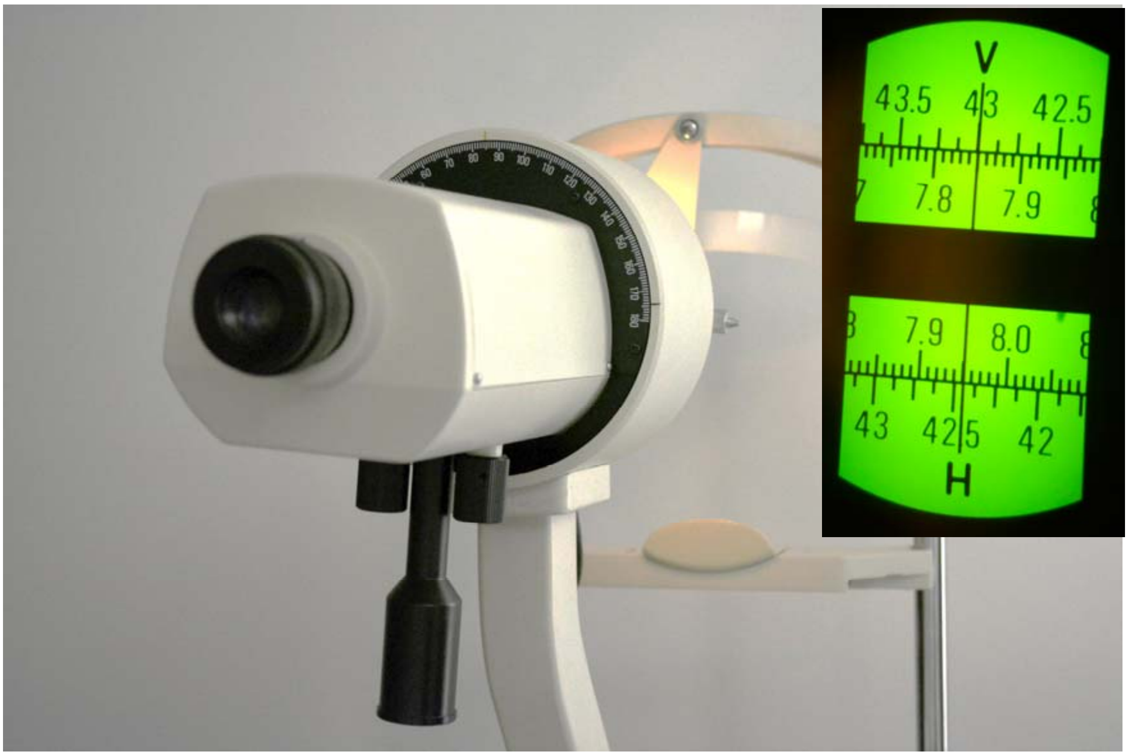
The selection of initial base curve has traditionally been based on central corneal curvature, as measured by keratometry. The underlying assumption behind this approach is that flatter corneas have less sagittal height and therefore require a lens of less sagittal depth in the form of a flatter base curve to optimally fit the cornea and vice versa [1]. Ocular sagittal height, though, is governed not just by central corneal curvature, but also by corneal diameter, corneal shape factor and the peripheral corneo-scleral profile [1,2]. This explains why changing from a 8.4 to a 8.7mm lens does not always solve a poor fitting issue in the same material [3], or why a 8.4 in one material/design may not perform the same as a 8.4 in a different product [4], due to different peripheral curves and edge lift amounts. It has been advocated that contact lens manufacturers start recording sagittal height on the specification data, in addition to base curve and diameter [5]; manufacturers providing lenses with different sagittal heights may increase the fitting potential of their soft lenses, rather than just different base curves [5].

Soft contact lenses typically have a diameter ranging from 13.8 to 14.2mm and hence they drape over the limbus onto the sclera by about 1mm all round. Consequently, keratometry can be considered an over-simplistic predictor of soft lens fit and previous studies have shown that there is no strong correlation between keratometry readings [6,7] or even computerised video keratoscopy (which captures many thousands of data points across the corneal surface compared to that of only four in conventional keratometry) [8] and the best fitting soft contact lens. Modelling [9-11] and clinical research [8] shows the corneo-scleral junction, which varies with patient demographics such as ethnicity [12], has the most influence on soft lens fit since this is where lenses are required to make the greatest flexural changes in order to align to the ocular surface. It is the diameter and total sagittal height combination that is most meaningful. As there is no evidence with current soft lenses that knowledge of central corneal shape helps to choose the appropriate soft lens in terms of lens centration, mobility or comfort, the concept of taking the average keratometry reading and adding 0.6 to 1.0mm to identify the optimal base curve is incorrect.

Rigid contact lenses fit within the cornea and therefore keratometry can be useful, although the added benefit of computerised video keratoscopy, especially in more complex situations such as orthokeratology or fitting a keratoconic eye, has been well documented [13,14]. Sclerals and semi-sclerals vault the cornea for central curvature is of little importance to corneal clearance based on the sagittal depth of the eye. Keratometry's use to detect lens flexure is also limited by its small area of assessment. Keratometry has also been used to assess tear film stability (although subjectively only over a very limited area of the ocular surface which differs slightly on each measurement) [15] and much better techniques are available [16]. The other argument for keratometry is to diagnose corneal shape abnormalities such as keratoconus. However, the evidence basis for the best techniques to diagnose keratoconus suggests that elevation based topography along with other newer techniques such as corneal biomechanics can detect the disease earlier than curvature based topography [17]. Even if these techniques such as Optical Coherence Tomography are not available in practice, the split reflex seen in retinopathy is reasonably sensitive for detecting keratoconus [18].

The relationship between a spectacle or contact lens prescription axis and the corneal radii measure with a manual keratometer can cause confusion and unfortunately this is poorly reported in text books. A Bausch + Lomb type manual keratometer (note the type refers to the company that originally produced the instrument, while many companies have since copied the original mire formats) is a single position instrument, presenting both horizontal and vertical mire for radii alignment following axis orientation alignment simultaneously. The axis nearest the horizontal meridian is recorded with the radius of curvature from the dial labelled 'horizontal' and the axis nearest the vertical meridian is recorded with the radius of curvature from the dial labelled 'vertical' (in the example figure inset 7.85@85; 7.95@175). Of course the instrument head should not be rotated more than 90 degrees clockwise or anti-clockwise for this to be the case. Note also in Europe the measurement is generally recorded as a radius as keratometry is an anatomical assessment, whereas in North America an assumption is made regarding the refractive index of the cornea and the measurement is recorded in dioptres of power.



Bennett and Rabbetts [19] state "To prevent misunderstanding, the meridian along which the radius is measured should not be recorded as an 'axis'" Various different notations have been used such as 'along', '@', 'mer' or 'm'.

In the example above (7.85@85; 7.95@175), the cornea is steeper (has a shorter radius of curvature) in the horizontal meridian, termed against the rule. To correct this requires a <u>positive</u> cylindrical spectacle correction (corrected for the back vertex distance) or soft contact lens correction of approximately 1.0D (where 0.05mm of corneal radius difference equated to ~0.25D around the population average corneal topography) at the same axis (+1.00x2) or alternatively a <u>negative</u> cylindrical correction 90° displaced (-1.00x92).

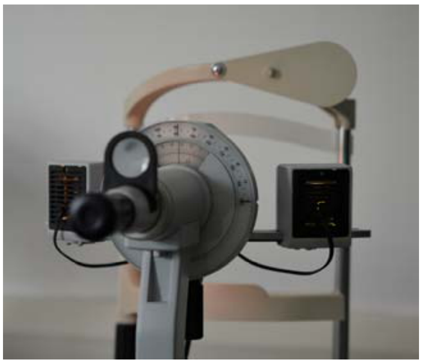
To add to the confusion, the two position keratometers which use Javal-Schiotz type mires:

- sometimes have two scales in opposite directions. Modern convention dictates that for both eyes zero is at the 3o'clock position, increasing to 90° at the 12o'clock position.

- there are two markers that point to the orientation, sometimes with the incorrect one being lit by the light source illuminating the radius dial. The keratometry radius direction (@ or along) is the same orientation as the bar joining the mires.

Historically, keratometers were designed in the 19th century, at which time cylinder axes placed the zero at the nose, with 90 degrees at the 12 o'clock position and 180 placed temporally. Keratometers were also originally designed to estimate refractive error - thus the axes markings refer to cylinder axes, not power meridians, as used for corneal shape annotation.

@90



@180

Hence manual keratometry should be taught as a historical perspective and also to demonstrate the principals of reflective (specular reflection) corneal curvature assessment. The insistence on the availability and/or use of keratometers in guidance from professional bodies and regulators should be removed and replaced with access to, and the ability to use and interpret, corneal topography. If a practitioner is just fitting soft contact lenses keratometers can be safely mothballed and if they are fitting more complex gas permeable lenses, they should invest in better technology to assess the shape of the ocular surface.

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References

1. A.C. Snyder, Cosmetic extended-wear lenses: considering sagittal differences between the lens and eye,. Int. Contact Lens Clinic 11 (1984) 613-624.

2. L. Garner L, Sagittal height of the anterior eye and contact lens fitting, Ophthalmic Physiol. Opt. 59 (1982) 301-305.

3. G. Young, C. Schnider, C Hunt, S Efron, Corneal topography and soft contact lens fit, Optom. Vis. Sci. 87 (2010) 358-366.

4. J.S. Wolffsohn, O.A. Hunt, A.K. Basra, Simplified recording of soft contact lens fit. Contact Lens Ant. Eye, 32 (2009) 37-42.

5. J.S. Wolffsohn, L. Hall, S. Mroczkowska, O.A. Hunt, P. Bilkhu, D. Drew, S.A. Sheppard, The influence of end of day silicone hydrogel daily disposable contact lens fit on ocular comfort, physiology and lens wettability. Contact Lens Ant. Eye, 38 (2015) 339-344.

6. E. van der Worp. What (about) the sag; the value of sagittal height in soft contact lens fitting, GlobalContact 1-13 (2013) 16-20.

7. R. Gundal, H. Cohen, D. DiVergillio, Peripheral keratometry and soft contact lens fitting, Int. Eyecare 2 (1986) 611-613.

8. L. Hall, G. Young, J.S. Wolffsohn, C. Riley, The influence of corneo-scleral topography on soft contact lens fit, Invest. Ophthalmol. Vis. Sci..52 (2011) 6801-6806.

9. M. Bibby, A model for lens flexure – validation and predictions, Int. Contact Lens Clinic 7 (1979) 124-138.

10. G. Young, L. Hall, A. Sulley, K. Osborn-Lorenz, J.S. Wolffsohn, Inter-relationship of soft contact lens diameter, base curve radius, and fit, Optom. Vis. Sci. (2017) *In press*

11. A. Sulley, K. Osborn-Lorenz, J.S. Wolffsohn, G. Young, Theoretical fitting characteristics of typical soft contact lens designs, Contact Lens Ant. Eye (2017) *In press.*

12. L. Hall, C. Hunt, G. Young, J.S. Wolffsohn, Factors affecting corneoscleral topography, Invest. Ophthalmol. Vis. Sci. 54 (2013) 3691-3701.

13. D. Hansen, Evaluating the eye with corneal topography, *Cont. Lens Spectrum* August (2003) 27-32.

14. Caroline PJ, André MP, Norman CW. Corneal topography and computerised lens-fitting modules. *Int Contact Lens Clinic* 1994; 21: 185-195.

15. A: Asharlous, E. Jafarzadehpur, A. Mirzajani, M. Khabazkhoob, Comparing tear film stability prolongation evaluated by Javal-Schiotz keratometer and slitlamp, Eye Contact Lens, 41 (2015) 101-106.

16. Wolffsohn JS, Arita R, Chalmers R, Djalilian A, Dogru M, Dumbleton K, Gupta P, Karpecki P, Lazreg S, Pult H, Sullivan BD, Tomlinson A, Tong L, Villani E, Yoon K-C, Jones L, Craig JP. (2017) TFOS DEWS II Diagnostic Methodology Report. Ocular Surface. In press

17. Y. Shi, Strategies for improving the early diagnosis of keratoconus, Clin. Optom. 8 (2016) 13-21.

18. S. Goebels, B. Kasmann-Kellner, T. Eppig, B. Seitz, A. Langenbucher, Can retinoscopy keep up in keratoconus diagnosis? Contact Lens Ant. Eye 38 (2015) 234-239.

19. A.G. Bennett, R.B. Rabbetts, ‘Clinical Visual Optics’ 4th Edition, 2007.