What (about) the Sag

The value of sagittal height in soft contact lens fitting

This article will focus on soft contact lens ‘fitting’. Or maybe we should rather say ‘soft lens selection’, as Helmer Schweizer recently put it so eloquently, because we haven’t been ‘fitting’ soft lenses for a while now. To the surprise of some and the discontent of others, central keratometry values are not very useful in fitting soft lenses. In other words: there is a very weak correlation between the central K-readings and the soft lens fit. So what, then, about the base curve values printed on the lens boxes? What does the number ‘8.3’ or ‘8.6’ mean?

By Eef van der Worp
BASE CURVE RADIUS

The indicated base curve (usually expressed in numbers with or without mm) is by many considered to be the lens’s back surface radius. However, it may rather be viewed as a sort of indicator, more of a stock sorting helper and a symbolic value. Why? It is more often than not questionable as to whether the lens actually has an ‘8.3’ or 8.6’ mm spherical curvature on its back surface. But even if that is (centrally) the case, there are several peripheral curves potentially involved and/or in aspheric designs an eccentricity to mark a flattening toward the periphery, topped off by an edge lift – that all together form the total sagittal height across the total diameter of the lens. So the lens fit is certainly not defined by that single number on the lens box. The total sagittal height and diameter combination of the lens is of much more importance, and this should relate to the sagittal height of the anterior ocular surface and the shape of its limbus - i.e., the transition from the cornea into the conjunctiva/anterior sclera.

The total sagittal height of the ocular surface can be calculated over a certain diameter, called a ‘chord.’ The distance from a baseline (chord, base of the sagittal) to the top of the sagittal is the sagittal height. For a normal eye, the total sagittal height of the anterior ocular surface is roughly 3700 microns (a micron is 1/1000 of an mm) for a 15 mm chord. The variation, defined as standard deviation, is fairly limited: roughly 200 microns. To put things in perspective: in scleral lens fitting, a 200-micron difference would typically be ‘one step’ up or down in a scleral lens trial set. As another reference: in keratoconus, the total sagittal height is estimated to be about 200 microns higher, or 3900 microns, over a 15 mm chord because of the ectasia - but with a slightly higher variation, as one may expect: in the 400 micron range. New instruments like optical coherence tomography (OCT) and ‘fringe topography’ like that generated with the new eye surface profiler (Eaglet-Eye) can help even more as these instruments are capable of imaging the total sagittal height of the ocular surface over any given chord.

LENS SAG HEIGHT

The goal is to ‘fit’ (or select) a soft lens with a sagittal height that correlates with that of the anterior ocular surface. But there is more to it than that. For any cornea or lens of choice, many variables together form the total sagittal height of that cornea or lens; radius of central curvature is just one of them. The numeric eccentricity of the approximated elliptical shape of the cornea is another one - but also the shape of the limbus and the anterior sclera/conjunctiva adds to this.

Research by Graeme Young et al shows that for aspheric lenses, the eccentricity has a larger impact on total sagittal height than central radius has. For example: a 0.12 change in eccentricity is believed to be the equivalent of a 0.2 mm base curve radius change. In addition, diameter seems to play an even larger role. For instance, an increase in lens diameter of 14.0 to 15.0 mm change. In addition, diameter seems to play an even larger role.

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If we think in terms of changing a lens fit - because the lens is too tight, for instance – then we should think about changing the diameter first rather than changing the base curve radius if we want to have a serious impact. In defense of using the radius, eyes with flatter central K-values more often also have larger corneal diameters. In that sense, there may be some – indirect – relationship between curvature and lens fit. But it is kind of “bending the curve” – as it would be better, of course, to look at the source, the stronger driver - the diameter of the cornea - directly.

Thus, if a cornea is larger than average, and if the central K-readings are steep and/or the eccentricity is low – this combination has a huge impact on the total sagittal height of that cornea and consequently on the soft lens of choice. Vice versa is true too, of course: smaller corneal diameters combined with flat curves and high eccentricities result in clinically significant lower sag values, for which the lens sag should be selected accordingly to get an optimal or
acceptable lens fit. Having said that, measuring corneal diameter is an art in itself. Typically there is a difference between the horizontal and the vertical corneal diameters (the vertical being smaller than the horizontal) to begin with. Additionally, the vertical diameter is difficult to measure, as the eyelids can be a physical barrier. Using the oblique meridian as some sort of ‘average value’ is common practice. Measuring ‘white-to-white’ in 45 degrees with a corneal topographer may be a good way of doing this, rather than using a ruler.
Fig. 3: Height topography map of an advanced keratoconus with the eye surface profiler (ESP - Eaglet Eye):
3a - relative height map with severe irregularities and a decentered top of the cone (scale in microns compared to a best-fit-ellipse)
3b - absolute height map, with a sagittal profile (sagittal values more than 200 microns higher than in the normal eye - fig 1b)

HOW BENT ARE CURVES?

Based on this, sagittal height may become the new standard in soft lens fitting, as it seems to be a much more relevant parameter compared to other variables. Radius and curvature may become obsolete in the future. Lathes that manufacture lenses and that also make molds for cast-molded soft lens production exclusively ‘think’ in height – not in curves. With up to a micron of accuracy (or even fractions of that – nanos, which are 1/1000 of a micron), the height can be mimicked as long as there is an x, y, z coordinate. This is true in general in this new age of 3-D printing. But what do we do as contact lens practitioners? We still live in the last century, relying on trial sets with huge parameter steps and on lenses of which we have no clue what design or shape they have.
Is the base curve radius that is printed on the soft lens box completely useless, then? As said: we should perhaps view the base curve radius of a soft lens more as a symbolic value. Does an ‘8.3’ result in a ‘steeper fit’ appearance than an ‘8.7’? For the exact same lens (design, type and brand), that is likely so. In other words: Within the same lens, if the 8.3 lens is too tight, an 8.7 lens with a lower sagittal height should provide relief. In this regard, it might be better to speak of an ‘A’ lens and a ‘B’ lens rather than the – somewhat misleading – base curve radius values on the lens box. But: do not compare an 8.3 of one manufacturer to an 8.3 of another manufacturer. Significant differences may even occur between different lens designs (brands) of one manufacturer that have the same base curve printed on the pack, because we don’t know how much sag height difference there is between them. Ideally, we would want to have the absolute sag value printed on each lens pack.

Soft lenses in-vivo dehydrate, almost by definition. This is especially true with conventional materials. During the course of the day, they tend to ‘tighten up.’ For this reason, manufacturers have to produce conventional lenses flatter, around 0.7mm flatter – to compensate for this tightening up during the day. Silicone hydrogel and some biocompatible materials have this too, but to a lesser degree. So these are made 0.4mm flatter for instance, instead of 0.7mm. In theory, this also means that these lenses can be fit somewhat steeper. But interestingly enough, although there is an exception to that rule, typically the base curve on the lens packages of silicone hydrogel lenses show the same or very similar values as compared to conventional hydrogel lenses – while they could be fitted steeper.

Recently, there has been a bit of a revival regarding soft lenses that are tailor-made. Some companies even specialize in this, solely offering lenses outside the standard range and/or custom-made lenses (as discussed in the last edition of GlobalCONTACT, these are two different categories). A big change in recent days is that all of these can now be manufactured in silicone hydrogel material. But apart from these outside-of-standard and custom-made soft lenses, it may be a good idea to revisit the fitting of soft lenses altogether. In an average contact lens practice, time and energy are invested in gaining new lens wearers. But at the same time, how much do we invest in our current lens wearers to give them the best lenses available today? Can we turn around the trend that has led to soft lens fitting being a lost art? Using sagittal heights and having those available on lens packages and trial lenses would be a big step forward to start. As contact lens practitioners, even if we are willing to strive for the best lens available for a patient, we are limited in what we can do. We need better tools. To evaluate soft lens fits better, we also need better tools. This will be the subject of an upcoming issue of GlobalCONTACT.

And the topic of the ‘Lost art of soft lens fitting’ as such will be the subject of discussion from the podium by Helmer Schweizer and the author of this article at the upcoming EFCLIN meeting in Vilamoura (Portugal) May 9-11 2013. Hope to see you there. And hopefully we can ‘elevate’ soft lens fitting to a higher level in the future again - quite literally.

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Eef van der Worp is an educator and researcher. He received his optometry degree from the Hogeschool van Utrecht in the Netherlands (NL) and has served as a head of the contact lens department at the school for over eight years. He received his PhD from the University of Maastricht (NL) in 2008. He is a fellow of the AAO, IACLE, BCLA and the SLS. He is currently affiliated with the University of Maastricht as an associate researcher, a visiting scientist at Manchester University (Manchester UK) and adjunct Professor at the University of Montreal University College of Optometry (CA) and adjunct assistant Professor at Pacific University College of Optometry (Oregon, USA). He is lecturing extensively worldwide and is a guest lecturer at a number of Universities in the US and Europe.