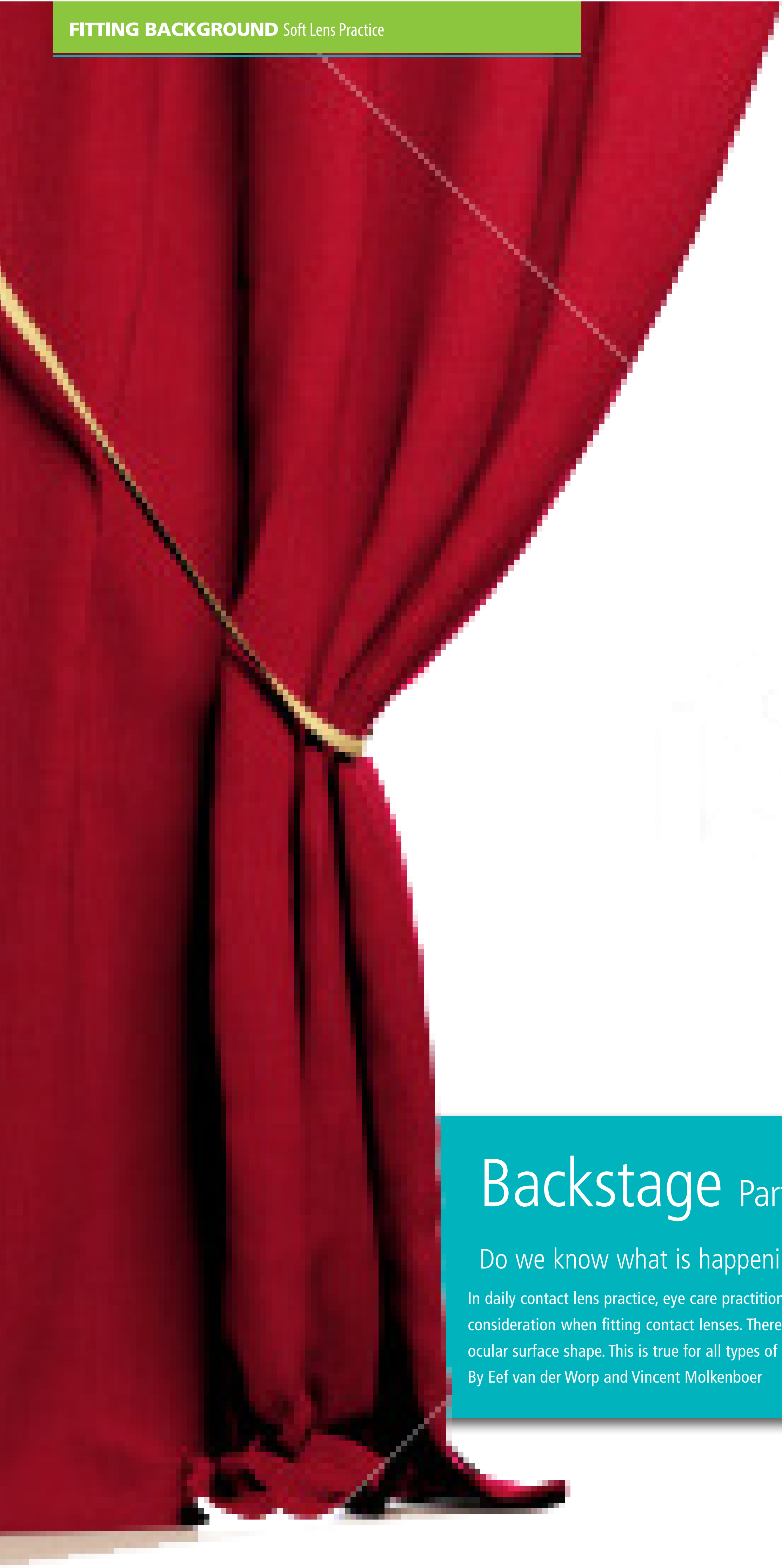

Backstage Part 2

Do we know what is happening behind a soft lens?

In daily contact lens practice, eye care practitioners (ECPs) take the eye's shape into consideration when fitting contact lenses. Therefore, we should respect the anterior ocular surface shape. This is true for all types of lenses and for every individual.

By Eef van der Worp and Vincent Molkenboer

Similar to gas permeable (GP) lenses, soft lenses can have an impact on the cornea and on corneal shape if fitted incorrectly. Corneal deformations as a result of suboptimal soft lens fittings are not as uncommon as many may think. If practitioners would remove soft lenses at every follow-up visit and perform corneal topography, they would be surprised by the amount of unwanted changes that can take place beneath a soft lens (figure 1) [Schornack et al, Contact Lens & Anterior Eye (2003)].

In the first part of this series in the last edition of GlobalCONTACT, several cases of corneal deformations under soft lenses were shown. It was concluded that according to our observations, corneal topographical changes do occur in silicone hydrogel soft lens wear – and our suggestion is that it occurs in most contact lens wearers of this kind to some extent. It seems that this is independent of lens power, replacement frequency, lens manufacturer and lens design used, as from our small experiment we observed the changes in plus, minus, toric, monthly, 2-week and even daily disposable lenses of different manufacturers.

But differences in magnitude may be present among those variables. All of the lenses used were silicone hydrogels, and it can be argued that silicone hydrogel lenses have a general greater impact on the sensitive corneal epithelium as the modulus is generally higher (stiffer) compared to conventional soft lenses.

From orthokeratology we know how malleable the corneal epithelium is: even within minutes of lens wear, optical changes can be seen on the cornea (figure 2).

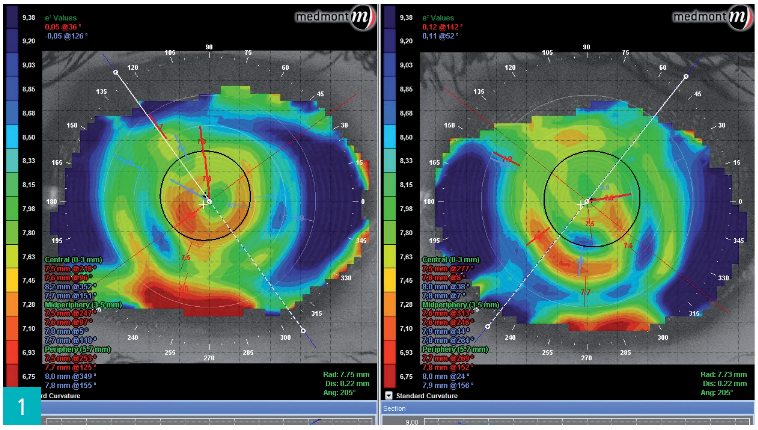

Fig. 1: Corneal changes after soft contact lens wear

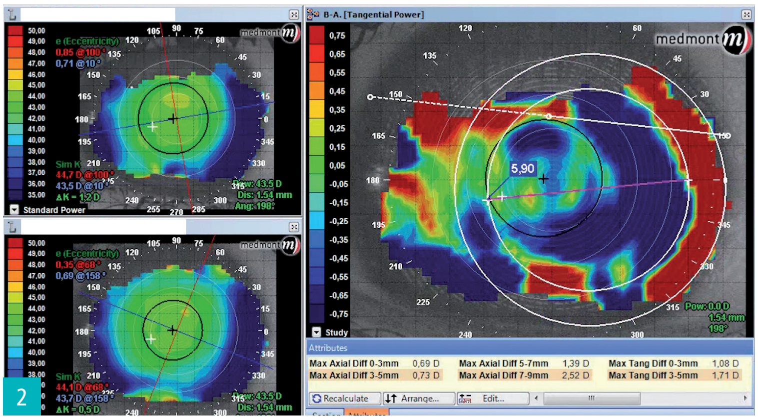

Fig. 2: Malleability of the corneal epithelium in soft lens wear

IN PERSPECTIVE

One should keep in mind that for the purpose of our study, the intervals of the map displays shown have been set to very small (sensitive) steps. 0.1D increments were used to best visualize the potential pattern in the tangential power maps used in this experiment (whereas 0.25D would be the typical map increments selected).

Also, the choice for using tangential power maps is a discussion in itself: is this the best map to visualize difference in shape? If you wanted to know the effect of corneal topography changes on optics and vision, then analyzing refractive power change within the pupil (e.g. sphere / cylinder / and Zernike polynomials) would probably be best. If you want to relate the changes to how the lens fits, then height changes or axial map changes are probably more relevant – although the changes may be so small that they are hardly detectible.

But if you want to know where the changes occur and visualize them – then the tangential maps most likely would be your best tool (Michael Collins, Queensland University of Technology, Brisbane Australia – personal communication). And power maps (in diopters of change) most probably would best represent the change, rather than millimeters and radii of curvature. So to the best of our knowledge, we used the tangential power map (in diopters) to visualize the soft lens-induced changes to the ocular surface.

Something else to consider is that, with the absence of spectacle blur, the topographical changes seen in these examples may not truly be "topographical changes" to the cornea. Perhaps subtle mucine layer compression or redistribution could also cause the changes we see, as suggested by Patrick Caroline (Pacific University, Portland USA). In other words – we don't know the real clinical relevance of this yet. On the other hand, if these were truly tear film and / or mucine layer disturbances, then it would make sense that the corneal topographies would return back to normal in no time. Clinically, that is not the case. It can take days or even weeks for the cornea to return to "normal".

LORD OF THE RINGS

What does all this mean? The results show that corneal topography changes do occur under soft lenses. Often, the changes that occurred in this experiment truly showed an irregular pattern, which many times "made no sense at all". In daily practice, leaving the lenses out for a while, like 10-15 minutes, would make a world of difference, as many tear film disturbances that may interfere in the analysis would have dissipated by then.

On the other hand, in selected subjects in this observation a pattern could be detected – although sometimes arbitrary and

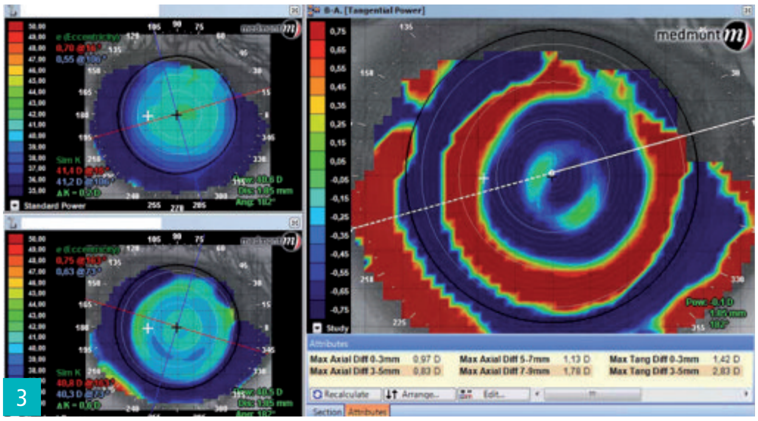

Fig. 3: Lord of the rings

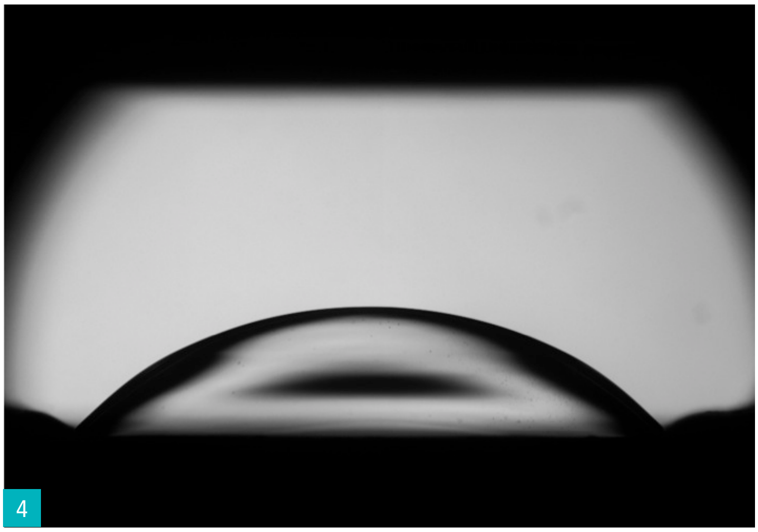

Fig. 4: Overall sagittal height of a soft contact lens (courtesy Optocraft, Germany)

even with the need of a little imagination – of a series of concentric rings on the cornea (figure 3). The finding of an arbitrary flat central zone (with typically some small central islands, possibly confluent) of roughly 4-6mm, followed by a (usually partial) red ring, in some selected subjects is an interesting one.

Inverted silicone hydrogel lenses, especially if in a high minus prescription, have been described in the literature as potentially resulting in an "orthokeratology-like" pattern. It could be that this is the case, too, in some of our subjects. However, it seems unlikely that the frequency of inverted lenses would that high in this group of long-term, successful soft lens wearers.

As these are all silicone hydrogel lens wearers, hypoxia is not the first thing that comes to mind, either. Apart from the high Dk/t of these lenses, topographical changes of this magnitude are not likely to come from edema, as epithelial edema does not lead to an increase in thickness (only stromal edema does). The question that arises here is: could the corneal disturbances seen be a reflection of lens design?

PERIPHERAL LENS STRAIN

From theoretical models, we can learn that for a soft lens to fit well to the eye, according to our standards, the lens has to fit slightly tighter in the periphery. Graeme Young (UK) developed a mathematical model of soft lens fits. The model calculates the lens edge strain as a predictor of lens tightness. If a lens' overall sagittal height exactly matches the sagittal height of the ocular surface, that lens most probably would be too "loose" on the eye as tear film forces – gravity, but especially eyelid forces – will cause excessive movement on the eye and lead to decentration of the lens. Such a lens would easily have its edge cross the limbal zone on the eye and cause significant discomfort. In other words: a lens' sagittal height has to be higher than the ocular sagittal height to fit well, causing by default some tightness in the periphery (figure 5). This tightness or tension will cause the lens to center well and move slightly. Studies at Pacific University (USA) and at Maastricht University (the Netherlands) independently showed that well accepted soft lenses most probably should be at least 200-400 microns higher on a small selection of custom-made lenses than the ocular sagittal height. Could it be that the peripheral tightness that is thus created is responsible, at least partially, for the topographical changes observed?

Typically, the optical zone of a soft contact lens is larger than the 8mm zone that we observe in the topography. So if the changes we see are mechanical and from the lens design, then these most probably would come from the optical zone area. Is the central "blue" area caused by a flat central portion of the lens (with some central islands, as the soft lens is not as optically

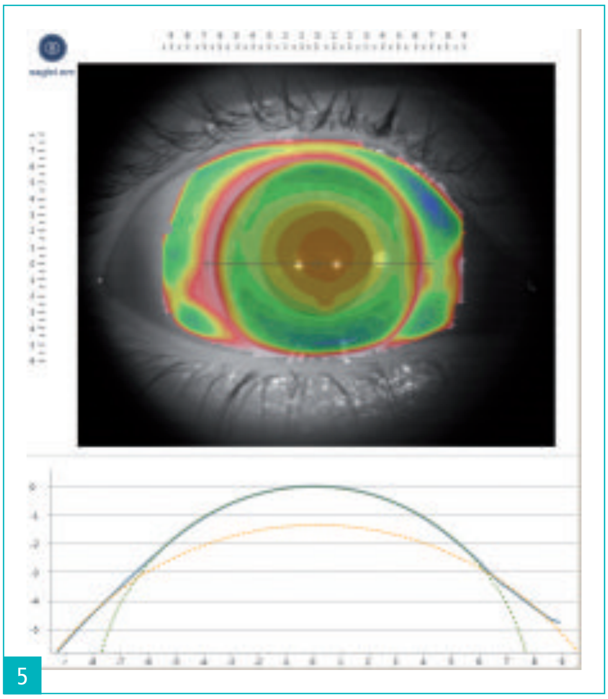

Fig. 5: ESP image showing the corneal, limbal and anterior scleral profile – which all may have an impact on how a soft lens fits on the eye (Eaglet Eye)

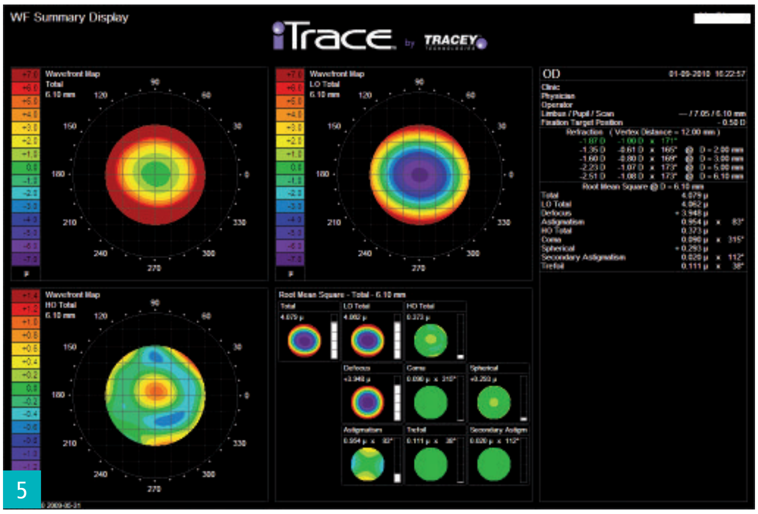

Fig. 6: Wavefront aberrometry: an additional tool to evaluate our soft lens wearers?

sound as a GP lens), followed by a mid-peripheral ring of steeping? Spherical soft contact lens designs are flatter than the central cornea. When placed on the eye, their centers should in principle "touch" the front of the cornea, and exert limited or no pressure in the mid-periphery, whereas their periphery and / or edges are pressing onto or even into the far peripheral cornea and conjunctiva, as has been suggested by Helmer Schweizer (Zurich, Switzerland).

According to John Mountford (personal communication), the characteristics of a soft lens on the eye may be the result of a combination of the effects of the lens flexure / modulus and cavitation in the post-lens tear layer. As the lens flexes with blinking, this causes cavitation in the tear layer, and the thinner the tear layer, the greater the squeeze forces – which potentially could lead to mechanical forces on the corneal epithelium and, hence, topographical changes.

Other lens-related variables that could potentially influence the topography map are lens dehydration (soft lenses are thought to dehydrate on the eye, potentially creating a tighter periphery) and the front lens optics. Through lid pressure, the thicker parts of the lens could potentially be 'pressed' into the epithelium by the eyelids, leaving a mark in the corneal epithelium.

DISCUSSION

A question that does remain is: if these corneal changes indeed do occur, why don't we see more "spectable blur" complaints in our practices? Is it because the changes are too subtle? Is it because they are mainly happening outside of the pupil zone? Or could it be that our measuring technique, the letter chart with 100% contrast, is not sensitive enough to pick up minor visual disturbances? Maybe if we would routinely perform aberrometry on all of our soft lens wearers, we would detect optical disturbances in soft lens wearers as represented by an increase in higher-order aberrations such as coma, spherical aberration and trefoil.

In this light, let's also take another look at the corneal staining debate. Sometimes the so-called "solution-induced" staining is seen in a mid-peripheral or peripheral ring-shaped pattern. Could there be a link between mechanical pressure on the (mid-) peripheral cornea by the soft lens and the staining seen (with a potential additional solution interaction component)?

FINAL REMARKS

Although it appears that this paper raises more questions that in answers, it may be an option to go back to the drawing board – to look at corneal topographical changes beneath soft lenses. Could corneal topography "pre"- and "post"- soft lens fitting be a good indicator of how well a soft lens fits, as an additional clinical tool? Especially in this silicone hydrogel era, as it has now become the number one lens prescribed worldwide, it may be more critical than with conventional soft lenses to see if we can better align soft lenses with the ocular surface. In other words: let's take the "backstage tour" to inform ourselves and to perhaps achieve better soft lens performance in the future. ■

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