Contact lens wear and its complications
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CHAPTER V

IMPROVEMENT OF VISUAL ACUITY AND CORNEAL PHYSIOLOGY IN KERATOCONUS BY FITTING ASPHERICAL, HIGH OXYGEN-PERMEABLE CONTACT LENSES

Courtesy of International Ophthalmology
ABSTRACT

Keratoconus is a condition in which the cornea assumes a complex irregular curvature caused by central corneal thinning. The abnormal topography of the cornea in combination with central corneal scarring results in an impaired visual acuity. Even in mild cases spectacles do not correct vision adequately. The use of hard contact lenses with a spherical geometry in the past has already given a marked therapeutic improvement. The use of these lenses however, is complicated by hypoxia and mechanical trauma of the cornea. These complications could theoretically be avoided by fitting elliptical lenses with a high oxygen transmission. To investigate this hypothesis we compared low oxygen-permeable spherical lenses with high oxygen-permeable elliptical contact lenses in a group of twenty patients with mild keratoconus. Our results showed both a marked subjective and objective visual improvement after fitting elliptical lenses with a low incidence of complications.

INTRODUCTION

The treatment of keratoconus includes correction with spectacles, contact lenses and, in severe cases, penetrating keratoplasty (1-3). Epikeratoplasty is recommended for those patients who are contact lens intolerant, but who can obtain at least 20/40 visual acuity with a contact lens and have minimal or absent apical scarring (4). Until now most keratoconus patients were fitted with hard (PMMA) or rigid gas-permeable (RGP) hard contact lenses with a spherical geometry (5). Several studies have shown this type of design to be quite successful for long-term comfort and increased wearing time when used with a RGP lens material (6). Trauma from mechanical stress and hypoxia from PMMA material may result in scarring at the apex of the cornea (7). Rigid gas-permeable lenses are the lens of choice for fitting keratoconus patients. These lens materials have the advantage of increased oxygen transmission, thereby minimizing corneal edema and related complications observed with PMMA lenses (5). Recent advances in the measurement of corneal topography now provide accurate indices of corneal curvature under normal and pathological conditions (8). The normal cornea is estimated to have an elliptical shape factor, or numerical eccentricity (E) of 0.5. A keratoconus eye has a rapid rate of peripheral flattening compared to the normal eye. The central curvature of the cornea increases from mild to severe keratoconus, while the mid-peripheral curvature remains constant. The shape factor of a
keratoconus eye can increase accordingly as much as three-fold (8). For this reason a severe keratoconus requires a contact lens with a high eccentricity, while a mild keratoconus may be fitted with lower eccentricity lenses. The spherical contact lenses used until now have no numeric eccentricity and therefore have pronounced pressure zones at the apex and at 12 o’clock. The fitting shape of the spherical contact lens therefore has pronounced pressure zones at the apex and at 12 o’clock (6). This is evidenced by staining of the cornea, seen upon fluorescein examination (6). An aspherical lens design becomes progressively flatter from the centre to the periphery, this allows the contact lens to align better with the cornea, so that the mechanical stress on the cornea is reduced and the tear exchange is improved. Furthermore, super high Dk lens material may lead to a better oxygenation of the cornea.

MATERIAL AND METHODS

Twenty-five eyes from twenty patients (five female, fifteen male; mean age 29.4, s.d. 13.3) were examined: twenty eyes were refits and five eyes were first fits. All patients belonged to the grade 1 group of the Amsler Classification modified by Muckenhirn (8). In other words, the flattest central keratometry reading of this group of eyes was greater than 7.30 and/or the eccentricity of the cornea was less than 0.8. Patients had horizontal keratometer readings of 7.58 mm (s.d. = 0.43) and vertical readings of 7.46 mm (s.d. = 0.39). The mean astigmatism was 0.32 mm (s.d. = 0.21). The aspherical contact lens used in this study had a spherical optic zone of 14°, changing into an aspherical peripheral part up to 30° with an eccentricity of 0.6. The lens diameter was 9.6 mm with a base curve radius between 7.2 and 8.3 mm. The lenses were made of Quantum material (Bausch and Lomb) consisting of a fluoro-silicone-copolymer with high oxygen transmissibility (Dk = 92 x 10⁻¹¹ (35°)). Durability of the lens material was examined by the slit-lamp. Fitting of the lenses was evaluated by examining the fluorescein pattern under the lens. The lens should exhibit slight conical and peripheral bearing, thereby eliminating excessive bearing areas, commonly seen with a spherical lens design fitting. Ten contact lenses were fitted by trial-and-error, on the basis of two central keratometry readings. Fifteen contact lenses were fitted with the assistance of two central keratometer values and four peripheral readings (horizontal and vertical 30° apart from the visual axis). The six keratometer readings
were given as input data to a computer (Tandy PC-4 with software obtained from Microlens Contact Lens Manufacturers, Arnhem, The Netherlands) to calculate corneal eccentricity (E), using Wilms' formula (9), which is

\[ E = \sqrt{\left( r_s^2 - r_o^2 \right) \cdot \left( r_s \times \sin \alpha \right)} \]

whereby \( r_s \) = sagittal radius; \( r_o \) = central radius; \( \alpha \) = angle between these two radii.

With these data a base curve radius of each contact lens was determined using a fixed eccentricity of 0.6. The lenses were checked for good fit according to the same criteria mentioned above.

The mean follow-up was 10.0 months, with a standard deviation of 6.1 months. The contact lenses were examined by slit-lamp biomicroscopy for protein binding, scratching, crazing, cracking and breakage. The base curve radius was checked by a radiuscope.

Statistical analysis of data was performed using Wilcoxon Signed-ranks matched pairs test.

**RESULTS**

Fitting of the elliptical contact lenses was initially performed on a trial-and-error basis (10 eyes). For keratoconus eyes this is a tedious time-consuming procedure, which is largely dependent on the experience of the contact lens fitter. To obtain a more efficient lens fitting we measured the topography of the cornea from the next fifteen eyes at six sites and the lens base curve radius was calculated with a computer.

The base curve radius of the final lens turned out to be very close to the calculated radius (Fig. 1).

To evaluate the therapeutical effect of elliptical lenses in keratoconus the following study was performed. Clinical data were obtained from twenty eyes wearing low oxygen-permeable spherical contact lenses. Subsequently these eyes were refit with elliptical high oxygen-permeable lenses. Furthermore, data were obtained from five eyes who were previously corrected by spectacles and now were fitted with these elliptical lenses for the first time. Forty percent of the refit eyes obtained better visual acuity (p< 0.01). Sixty percent maintained their initial visual acuity (Fig. 2).

Of the five patients fit for the first time with aspherical contact lenses two eyes achieved better vision, while three eyes maintained their initial vision. Comparison of the incidence of complications before and after fitting of the new contact lenses shows a marked reduction of the side effects (Table 1).

Before fitting, thirteen eyes gave rise to visual acuity complaints, which
diminished with the new lens. The patients wearing the new lenses were examined for a mean period of ten months whereby special attention was paid to the durability of the lens material. No obvious protein binding, scratching, crazing, cracking or warpage was noted using slit-lamp and radiuscope examination. One contact lens was broken during the follow-up period.

Figure 1. Correlation between the base curve radius of the final lens selected by trial-and-error and that calculated by the computer ($n = 15$ eyes). The correlation coefficient is 0.953.

Figure 2. Visual acuity before and after fitting the aspherical lens in keratoconus.
DISCUSSION

The data presented in this report show that fitting elliptical super high gas-permeable contact lenses in mild keratoconus leads to a marked improvement of visual acuity with minimal side effects such as corneal epithelial damage. In this study an elliptical lens design of 0.6 eccentricity was fitted to align the corneal topography in mild keratoconus. The use of elliptical lenses with a higher eccentricity in mild keratoconus has a slight negative influence on the visual acuity (10). This may be related to poor lens centration, which is the result of excessive peripheral flattening. However such lenses perform well in advanced keratoconus. Visual acuity was tested objectively by Snellen chart and subjectively by recording visual acuity complaints. Both parameters improved with the aspherical lenses. Despite the fact that the image quality of the spherio-elliptical lens design is inferior to that of spherical lenses, visual acuity results are good. Only the spherical central part of the lens contributes to the good visual acuity, which indicates that centration is of utmost importance when wearing these lenses. The fact that such good effects on vision were experienced by the patients indicates that no problems occurred with centration.

It is possible that the alignment of the aspherical peripheral part of the lenses with the cornea tends to stabilize centration of the lens on a keratoconus eye. This might be due to a large surface contact between the lens and the conical profile of the cornea in these patients. Different new keratoconus lens designs like the Soper lens (11), the Mc Guire lens (12) and the Ni-cone lens (13), try to vault or slightly touch the central cornea, and to align the cornea in the periphery. The same effect is realized by the aspherical lens design. Thus side effects that are mostly related to mechanical factors, like staining, erosion and corneal impression are subsided. Since there is no abrupt change in curvature between the central and peripheral curvatures, but rather a

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Table 1 Complications prior to fitting the Ascon Quantum 92 lens (caused by spherical contact lenses or spectacles) were compared with those after fitting this lens.

<table>
<thead>
<tr>
<th>Complication</th>
<th>Pre-existing</th>
<th>After fitting Ascon quantum 92</th>
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<tbody>
<tr>
<td>Staining</td>
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<td>Lens loss</td>
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<td>Visual acuity complaints</td>
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<td>No side effects</td>
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- refit, n=20 eyes
- first fit, n=5 eyes

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gradual and progressive flattening; and since there is little pinching effect of the lens on the central, mid-peripheral and peripheral cornea, the tear exchange under the lens may be improved. In combination with the high oxygen transmissibility of the lens material, the oxygenation of the cornea will be enhanced. This may result in a reduced corneal edema response and improved visual acuity. Whether the high Dk material or the lens design is more important for the good results has to be investigated in a future study. None of the Quantum lenses needed any modification after lens wear had begun. The accuracy afforded by the computer-assisted calculations, even with deviant corneal topography, makes this a very attractive method of making an initial lens selection, thereby saving much time as compared to a traditional trial-and-error fitting.
REFERENCES


5. Henry VA, Bennett ES. Contact lenses for the difficult to fit patient. Contact Lens Form 1989; 14: 49-68.


