Scleral gel contact lenses in treatment of dry eyes

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In the past 15 years various types of scleral contact lenses have been developed for the treatment of pathological conditions of the cornea and conjunctiva. Our previous investigations found the hydrophilic corneo-scleral lens very effective in the treatment of various inflammatory and degenerative corneal changes (Krejčí, 1970, 1971).

In our present study the Czech hydrophilic corneo-scleral contact lens (Spofa lens) has been employed in the treatment of dry eye caused by various conditions such as keratoconjunctivitis sicca, filamentous keratitis, keratitis pemphigoides, Stevens-Johnson syndrome, xerosis, and keratosis corneae, and also in the therapy of dry corneal spots caused by chemical burns.

Material and methods

The lens is composed of a hydrophilic polymer of hydroxyethyl methacrylate cross-linked with ethylene glycol dimethacrylate. The thickness of the lens varies between 0.3 and 1.3 mm. and the overall diameter between 14.0 and 16.8 mm. The lens has a corneal and scleral curvature and the variable sagittal depth permits correct fitting according to the irregularities and pathological changes in the cornea and conjunctiva. These lenses differ from the conventional scleral lens in concept and design. It is not necessary to manufacture a mould of the anterior segment of the eye and then to form the lens over the mould as with the "hard" methylmethacrylate contact lens.

The first and most essential part of the fitting technique is the ophthalmic and medical evaluation. A keratometer reading should be taken, a careful slit-lamp examination performed, and the diameter of the cornea measured. In all cases it is necessary to evaluate the microbiological condition of the cul-de-sac and to ensure that there is adequate space to fit the lens. The passage through the lacrimal sac has to be examined and the interpalpebral fissure and total size of the eye must be measured. Neither the apical clearance method, nor the usual alignment method is used. The lens is fitted to allow a 1.0 to 1.5 mm. distance between the apex of the cornea and the posterior surface of the lens. The average "hard" scleral lens has a minimum corneal clearance. The cornea-to-lens clearance is manufactured at 0.2 to 0.3 mm., evolving into a 0.1–0.15 mm. clearance when the lens is fitted. The gel lens relies on a corneal clearance of ten times this amount and produces a large pool of precorneal fluid.

The slit-lamp examination is repeated to check the movement and centering of the gel lens as well as the thickness of the precorneal film. Fluorescein must only be used for any corneal disturbances with the lens off, otherwise the dye will be absorbed by the gel. The adaptation period based on the lens-cornea relationship is shorter than that required for the hard contact lens. It is possible to wear the gel lens for 8 to 12 hours daily from the first day and for 24 hours during the first week.

The patients were shown how to insert and remove the lens and were instructed to boil the lens every 24 to 36 hours for 15 minutes in physiological saline. Actively growing pathogens were found not to survive a daily 15-minute exposure to 100°C.

Results

Our patients are wearing the gel lens continuously for 24 to 36 hours and sometimes even longer without any problems. Using the method of daily boiling there has been no case of infection. A large pool of precorneal fluid is maintained evenly over the entire cornea, permitting easier regeneration of the corneal epithelium. Moreover, the lens protects the cornea from the action of the overlying cicatricial lid and from trichiasis.

The epithelization of dry corneal spots caused by chemical burns (4 eyes) and at the sites of filaments in patients with keratitis sicca and filamentous keratitis (8 eyes) was completed in a period of 2 to 6 weeks. The slow and continuous debridement of the corneal and conjunctival "leathery" layers in cases of Stevenson-Johnson syndrome (4 eyes) and in cases of xerosis and keratosis of different aetiology (5 eyes) was followed by regrowth of normal epithelium in 6 to 10 weeks, and in the most severe cases in 6 months. The lens provided complete relief of pain, photophobia, and blepharospasm, and preserved the moisture of the cornea and conjunctiva, inhibiting further scarring. The visual acuity improved from 20/200 to 20/40-30 and from finger counting to 20/200 in all nine xerotic and keratotic eyes (Figs 1 and 2).

FIG. 1 Dry cornea of a keratotic eye with Stevens-Johnson syndrome before treatment with corneo-scleral gel contact lens

The patients were able to wear the lenses day and night without any symptoms of insufficient oxygen supply and with complete comfort as well. Even after one week's permanent wear no complications were observed. The gel lens minimizes the possibility of repeated corneal infiltration and ulceration at the sites of permanent mechanical irritation (*i.e.* in cases of trichiasis).

With the exception of two cases of keratitis sicca, no substance other than physiological saline was instilled during the gel lens treatment. In these two cases intermittent therapy

FIG. 2 The same cornea after treatment with corneo-scleral gel contact lens for 4 months

was given: one week with the lens on, and the next week with the lens off and methylcellulose drops instilled four to six times a day.

No reactivation of vascularization has been observed when the gel lenses were placed on previously scarred and vascularized corneae.

The follow-up period of all our patients was at least 10 months.

Discussion

Methylmethacrylate corneo-scleral lenses have several drawbacks. If the cornea is closed off by a hard contact lens, oxygen can reach the corneal surface only when dissolved in the tear fluid, which exchanges with the trapped volume of fluid. The investigations of Hill and Fatt (1964), Ko, Maurice, and Ruben (1970), Fatt and Bieber (1968), and Fatt, Bieber, and Pye (1969) showed that there was insufficient fluid exchange under the hard scleral lenses, so that the respiratory requirements of the cornea cannot be met. A contributory cause of corneal distress may be the development of a negative pressure under the lens (Bergman, Maurice, and Ruben, 1970). The reports of Takahashi, Goldstick, and Fatt (1966) and Hill (1967) have shown that hydrophilic gel contact lenses like those made of methylmethacrylate let through less oxygen than is necessary for normal corneal respiration. It has been found in ophthalmological practice, however, that there has to be enough movement of the hydrophilic lens on the eye to effect good circulation of oxygen as with the conventional hard contact lens (Krejčí, 1970; Gruber 1970; Lerman and Sapp, 1971). The level of lactic acid in the cornea is a very sensitive indicator of the physiological state. Kopecek, Lím, Sprincl, Praus, and Brettschneider (1969) found that the concentration of lactic acid in the cornea increased considerably under the influence of the "hard" contact lenses, and the values attained were found to be

four times higher than those observed after the application of the hydrophilic gel lens. The methylmethacrylate "hard" lens also had an unfavourable effect on the formation of the basic substance of the cornea, as was indicated by a large decrease in the incorporation of radioactive sulphate into acid mucopolysaccharides in animal trials (Praus and Brettschneider, 1970).

The gel lens has several other advantages over the hard lens in the treatment of dry eyes. The high water absorption due to their hydrophilic properties is 30 to 91.5 mg. H₂O, i.e. 37 to 40.4 per cent. according to the thickness of the lens (Krejčí, Brettschneider, and Praus, 1971) and this allows better diffusion of electrolytes, CO₂, and oxygen through gel lens.

The refractive index is 1.43, which is lower than the 1.49 to 1.55 for conventional hard contact lens material (Gruber, 1970).

The elasticity of the gel lens and the pumping effect of the lens and eyelids cause a periodical circulation of tear fluid under the lens, as well as regular fluid exchange, which increases the access of oxygen (dissolved in the tear fluid) to the cornea and prevents the accumulation of mucus and debris between the lens and the cornea (Krejčí, 1970, 1971).

The gel lens produces a large pool of precorneal fluid over the corneal surface which encourages regeneration (Krejčí, 1971; Lerman and Sapp, 1971).

The cornea is splinted and protected from trichiasis and other forms of mechanical irritation.

Summary

21 dry eyes of various aetiology were treated with hydrophilic corneo-scleral gel contact lenses. These lenses, which can be worn for from 24 to 36 hours, maintain a large pool of precorneal fluid over the entire cornea, protecting it and permitting easier regeneration of corneal tissue. The slow and continuous debridement of the filaments at the sites of dry spots caused by chemical burns as well as of the "leathery" corneal layers seen in cases of xerosis and keratosis was followed by the regrowth of normal epithelium. The follow-up period was 10 to 20 months.

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