CLINICAL RESEARCH NOTE

Vision with disposable toric contact lenses and daily-wear toric contact lenses

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Summary
The study compared the vision, the use and evaluation criteria in a group of students with corrective daily-wear toric contact lenses and disposable toric contact lenses, in order to ascertain which of the two optical systems is more advantageous. We fitted 114 subjects with daily-wear and disposable lenses to be worn for 12 months, one type of lens in one eye and the other type in the fellow eye. The results reveal no significant differences between the two systems in terms of visual acuity attained; both lenses centred well and were comfortable. Nevertheless, the deposits were significantly greater in the daily-wear lenses. The ocular reactions were less with the disposable toric lenses. In conclusion, the disposable lenses led to fewer deposits and less ocular reactions, but are limited in parameters. However, both optical systems were appropriate for correcting for astigmatism, and provided good visual acuity. © 1998 The College of Optometrists. Published by Elsevier Science Ltd

Introduction
Early studies by Holden (1975) revealed that about 45% of the population seeking contact lenses have an astigmatic correction of 0.75 D or more, and Duke-Elder (1970) estimated that 35% of the general population require 1.00 D cylinder or more. If the criterion for significant astigmatism is taken at the 0.75 D level, then approximately 40% of the spectacle-wearing population are potential candidates for astigmatism-correcting hydrogel lenses. Thus, there is a considerable need for contact lenses that correct astigmatism, especially when a hydrogel lens is preferred.

Toric hydrogel lenses developed slowly during the 1970s, principally in Europe and Australia, but advanced rapidly in the United States during the 1980s, as all major (as well as several smaller), contact lens manufacturers devoted increasingly more effort to the advanced design and fabrication technology of specialized lenses (Ott, 1978; Remba, 1981). Finally, the generation of disposable toric contact lenses arose.

In the present work, we seek to determine the vision as well as criteria for fitting and evaluating lenses in a group of subjects with compensatory toric disposable contact lenses in one eye and daily-wear contact lenses in the other eye, in order to determine the relative adequacy of the two optical systems.

Materials and methods
We chose 114 healthy subjects who had never worn contact lenses and who suffered from spherical ametropia as well as astigmatism, fitting them with compensatory disposable contact lenses in the left eye and daily-use contact lenses in the right eye. Routine eye examinations were performed to eliminate any subjects with ocular or visual complications that would contraindicate the use of contact lenses as well as to prescribe the appropriate correction of the toric contact lenses. We studied palpebral height, corneal diameter, palpebral tension and the tear ducts. An SL-550 Photo Slit Lamp was used to examine the structure of the an-
terior pole of the eye, before lens use and after 12 months of wearing the lenses (Velasco, 1994). Afterwards, we measured the aqueous layer of the tear film, using the Schirmer test, and the mucin layer using tear break-up time (BUT). Keratometry was performed with a Javal Schiotz Keratometer.

The daily-wear hydrogel toric contact lenses used in correcting astigmatism were made of 2-hydroxyethyl metacrylate (2-HEMA), a hydration of 55% and an optic zone of 12 mm in diameter. The refraction index was 1.43 and the total diameter was 14 mm. The radius of the contact lens was fitted to each subject according to the data obtained by keratometry. The power of the contact lens corresponded to the refractive error, and the power of the astigmatism in each lens was made so that the axes would vary by increments of 5°. The total diameter of the contact lenses was determined according to the corneal diameter of each subject (Velasco et al., 1992). The stabilization of the axis of the astigmatism was achieved by a prism ballasting of 1 D. For observing the stabilization, a mark was made in the base of the prism. The lens had back surface torics (Jurkus and Tomlinson, 1979; Gasson, 1979).

The disposable toric contact lenses were made of 2-hydroxyethyl metacrylate and USP povidone, with an aqueous content of 55%. The refraction index was 1.415. The diameter of the lens was constant, at 14.5 mm, while the base curve was 8.9 and 9.20 mm. The spherical power ranged from +4.00 to −6.00 D, the cylindrical powers were −1.00 DC and −1.75 DC, and the axes varied by increments of 10°. These lenses were stabilized by a 1 D prism ballasting of the lower base. For observation of the stabilization, three marks are situated at 90°, 180° and 270°; the lens had back surface torics (Jurkus et al., 1979; Malin and Kohler, 1981).

The vertex distance (12 mm) was used to calculate the power of the lens with respect to the refraction error of the subjects.

We evaluated the centring of the lens after 90 min by using a SL-550 Photo Slit lamp with the subjects looking straight ahead, to the right, to the left, upwards and downwards, so that the edge of the lens did not reach the cornea in these eye positions (Velasco, 1994; Velasco et al., 1992a).

Afterwards, we evaluated lens stability, determining the position of the hash marking with respect to the six-o’clock position. If the marking rotated clockwise, we added the degrees of the rotation angle to the axis of the cylinder, and if rotation was anti-clockwise, the degrees of rotation were subtracted (LARS).

The subjects were instructed to blink completely and at a normal frequency, a necessary habit for deriving good use from these contact lenses.

The maintenance system of both types of toric contact lenses was polyamine propylbiguanide. In addition, instructions were given for the use of enzyme tablets weekly in cleaning the daily-wear lenses (but not the disposable lenses). Both types of lenses were used 12 h daily.

Finally, we studied the deposits produced on the surface of the daily-wear lens, and disposable lenses using Carl Zeiss DSM 950 Scanning Electron Microscope (SEM) by energy dispersive X-ray Analysis (EDAX) (Maltzman, 1988). An ANOVA test was used to evaluate the statistical significance.

Results

Of the 114 subjects studied, 80 were females and 34 males. The average age of the females was 27-years-old, ranging from 15 to 33 years of age; the males averaged 24 years, ranging from 19 to 29 years of age.

The palpebral height was between 9 and 12 mm, the most frequent value being 10 mm, with 70% for the right eye and 70.6% for the left. The statistical analysis revealed no significant differences between the two eyes (Figure 1).

The corneal diameter was between 11 and 12 mm, diameters of 12 mm being more frequent, with 50%
for the right eye and 50.88% for the left. Differences between the two eyes did not prove significant with regard to this parameter (Figure 2).

The most frequent pupil diameter was 5 mm, with 61.4% for the right eye and 64.04% for the left. The greatest and least pupil diameter was 4 and 6.5 mm, respectively. This latter diameter was consistently smaller than the diameter of the optic zone of the contact lens. This diameter was consistently greater than the pupil diameter because the glare from light rays hitting the peripheral band was eliminated. There was no statistical significance between the two eyes for this parameter (Figure 3).

The palpebral tension and the tear ducts were normal in all the subjects studied.

In the right eye, the measurement of the aqueous layer before lens wearing, using the Schirmer test, was between 11 and 40 mm, with a mean of 18.33 mm. For the left eye, this measurement was between 10 and 50 mm, with a mean of 18.57 both in females and males. After the compensation of the toric contact lenses, we found a non-significant decrease ($P > 0.05$) in the aqueous layer of the tear film (0.20 mm in the right eye and 0.32 mm in the left). Furthermore, there were no significant differences ($P > 0.05$) between the two eyes in terms of the aqueous layer before or after lens use.

The mean mucin layer in the right eye was 13.54 sec in both sexes before lens wearing. In the left eye, it was 13.29 sec. After fitting for daily use in the mucin

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layer was 13.44 sec in the right eye and 13.11 in the left. The differences between the two eyes wearing contact lenses were not significant. The reactions observed in the aqueous and mucin layers depended on the hydration and on the thickness of the lens (Guillon and Guillon, 1988).

The horizontal corneal radii were between 7.75 and 8.20 mm, and the vertical radii between 7.60 and 8.05 mm (Table 1).

All subjects had spherical refraction and astigmatism. The spherical powers of the right eye, with compensation by daily-wear toric contact lenses, were between +4.00 and −8.00 D, the most frequent powers (Figure 4) being −4.75 (10.53%), −5.75 (9.66%) and −2.00 D (8.77%). The astigmatisms of the right eyes of the subjects were from −0.75 and −3.25 D, the most frequent values (Figure 5) being −1.00 D (25.44%), −0.75 D (17.54%) and −1.25 D (14.04%). The axes of the astigmatisms were between 180 ± 30 and 90 ± 40°.

The spherical powers of the left eye, after compensation with disposable toric contact lenses, were between +4.25 and −6.50 D, the most frequent spherical powers (Figure 6) being −5.75 D (9.65%), followed by −5.50 D (7.89%), and less common, +4.25 D (0.89%). The astigmatisms of the left eye corresponded to the cylindrical power of −1.00, −1.25, −1.75, −2.00
and −2.25 D, with −1.00 D (33.33%) being the most frequent, while −1.25 D (8.77%) was less common (Figure 7). For the left eye, the degrees of astigmatism were 180 ± 30° and 90 ± 25°.

Direct astigmatism predominated over reverse, 98 subjects (85.96%) having direct stigmatism, and 16 (14.04%) reverse.

The visual acuity attained by all the subjects, with the daily-wear contact lenses, was 20/20. This acuity also was reached with the disposable toric contact lenses. With both types of lenses, we achieved good vision in all directions of gaze.

In the extended-use lenses, we found organic deposits in five lenses (4.39%), inorganic deposits in three lenses (2.63%), iron being the most abundant component; in addition, we found calcium and sodium. The microbial deposits were detected in six lenses (5.26%), principally *Staphylococcus epidermidis* and *Staphylococcus aureus* in one contact lens (0.88%).

Finally, one lens was scratched (0.88%). In daily-wear lenses after one month, we found organic deposits on three lenses (2.63%); we also found inorganic deposits on four lenses (3.5%), the main component being iron on lenses (2.63%), and sodium, potassium and calcium also being present. The microbial deposits appeared on three lenses (2.63%), revealing the presence of *S. epidermidis*, *S. aureus* and *Bacillus subtilis*. In two lenses, we found scratches (1.75%) (Figure 8). The statistical analysis indicated no significant differences ($P > 0.05$) in the deposits between the two types of lenses after a month of use.

After 12 months of use, the daily-wear toric contact lenses showed deposits in greater proportions, organic deposits appearing in 30 lenses (26.32%), inorganic deposits in 18 lenses (15.79%), where the components were (in order of frequency): sodium, iron, potassium, calcium and magnesium, and, in small proportions, aluminium, mercury and phosphorus. Microbial depos-
its were found on 22 lenses (19.30%), containing *S. epidermidis*, *S. aureus*, *Streptococcus viridans*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Enterobacter aerogenes* and *Pseudomonas fluorescens*. Finally, we found nine lenses with scratches (7.89%) (Figure 9). The statistical analysis showed significant differences ($P < 0.05$) in the deposits on the daily-wear lenses between one and 12 months.

The analysis of the organic deposits indicated that proteins, (fundamentally lysozyme) constituted the principal component coming from the tear film. The lenses have highly reactive surfaces and the same groups which capture water can also gather proteins and inorganic ions. The proteins already accumulated favour the rapid deposit of new proteins, microbial and inorganic compounds during lens wearing.

The analysis of the anterior pole of the eye demonstrated that no ocular reactions in the subjects were found that would have contraindicated the use of contact lens wearing. At 12 months, the eyes wearing disposable monthly-use contact lenses showed dilatation of the perilimbic vein network in two eyes (1.75%) in the lower zone and corneal edema in one eye (0.88%). In eyes with the daily-wear lenses, these reactions were greater. We found dilatation of the perilimbic vein network in six eyes (5.26%) in the lower zone and corneal
edema in eyes (2.62%). We also found small papillae (less than 1 mm) in the upper tarsal conjunctive, in the zone near the edge of the eyelid in one eye (0.88%) (Figure 10).

Discussion

The stability of the daily-wear and disposable lens was excellent, allowing the hydrogel lens to resist rotational forces and thereby providing good vision. One theory proposed that the prism stabilizes by lowering the centre of gravity of the lens (Ott, 1978). However, prism stability has been explained more accurately by the watermelon seed principle (Knoll, 1976) that is lid pressure squeezes the lens in the base-down direction. Because of the insignificance of gravity in contrast to the lens-cornea adherence and lid forces, toric hydrogel lenses usually do not rotate on patient eyes. Stable vision was minimally affected by lid actions. In sustained vision minimal effects from dehydration or base curve change that may affect meridional orientation. Despite that high cylindrical corrections are more sensitive to axis rotation or mislocation, effective present-day custom toric lenses are available. In addition the back cylinder may aid stability, especially on eyes with a corneal toricity greater than 3.00 D.

In all the eyes, we confirmed that the contact lenses were comfortable from the beginning, although the lower zone was thicker in both types of lens.

Furthermore, the centring of the edge of the lens was good, given that the edges of the lenses did not touch the limbus in any of the different eye positions tested.

We found no deposits on either type of lens before use. However, after one month of use, we found organic, inorganic and microbial deposits as well as scratches on both types of lenses. The disposable lenses revealed a greater proportion of organic and microbial
deposits, while the inorganic deposits and scratches were found in a lower proportion than in the daily-wear lenses. This protein accumulation may indicate a failure to use the enzyme tablet to clean the disposable lenses, and over this layer of protein, microorganisms can grow more easily (Fowler et al., 1994).

The results indicate that the reactions produced were related to the deposits of the contact lenses, given that these reactions were greater in the eyes using lenses with more deposits. This was true of the daily-wear lenses, although the differences were not significant ($P > 0.05$). The dilatation of the vein network, as well as the corneal hypoxia, may be due to mechanical causes, since the contact lenses were thicker in the lower zone due to the prism ballasting. This possibility is supported by Westin and Benjamin (1988), who demonstrated neovascularization in toric contact lenses under prolonged use. Therefore, the vascular irritation of the cornea can be avoided by using contact lenses of smaller diameters, lesser thicknesses and greater oxygen transmission.

The corneal epithelial edema is due to the increased thickness of the toric contact lens. In our study, this problem was greater in the disposable lenses, which are thicker than the daily-wear lenses. Nevertheless, the corneal edema observed in our subjects is slightly less than that found by Hanks et al. (1987), who reported 2.6% to 4.9%, after hydrogel toric contact lenses were worn for 3 hr.

With both optical systems, we achieved good visual acuity in the subjects, although we could appreciate a slight reduction of parameters in the disposable toric contact lens, representing a limitation in certain types of astigmatism.

Conclusions

Our results indicate that the disposable toric contact lenses, as well as daily-wear toric contact lenses, offer good centring and movement, without touching the limbus. The good vision reached with the two types of lenses was optimal, confirming that the stability was excellent with regard to the rotation of the lens with back torics and prism ballasting, in compensating for the astigmatism. Both lenses were comfortable from the outset. Neither lens varied the physiological factors...
Figure 10. Ocular reactions at 12 months of contact-lens use. Dilatation the perlimbic vein network (DPVN) to a degree that could be considered abnormal. The disposable lenses gathered few deposits and produced few ocular reactions; nevertheless, there was a limitation in the number of parameters, and thus not all the subjects with astigmatism could wear the disposable lenses. The daily-wear lenses presented slightly greater (non-significant at $P > 0.05$) ocular reactions than did the disposable lenses. However, the deposits on the daily-wear lenses after 12 months were significant ($P < 0.05$) with respect to the disposable lenses. On the other hand, vascularization and corneal edema were greater in the disposable lenses because of a greater lens thickness than that of the daily-wear lenses.

The daily-use contact lenses were more prone to deposits than were the disposable lens after 12 months.

In conclusion, the comparison of these two types of lenses shows that the disposable contact lens offers good stability against rotation and good visual acuity, and, above all, promotes ocular health.

References


