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RESIDUAL ASTIGMATISM WITH CONTACT LENSES

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During the past ten years, corneal contact lenses have enjoyed a constantly accelerating rate of application and it seems probable that this popularity will not soon diminish. Comfort and wearing time with contact lenses have been aided by improved lens design and improved techniques for producing smoother and better surfaces and adges. However, even though their optical performance has been improved through the production of better surfaces, the majority of contact lens wearers do not see as well as they formerly did with spectacles because cylindrical corrections rarely are incorporated in the new corneal lenses.

Textbooks 1, 2, 3, 4, tell us that the astigmatism which can be demostrated in the eye wearing a corneal lens seldom is of sufficient amount to interfere with the acceptance of the new visual device. This statement is, of course, quite true; if it were not, few contact lenses would be prescribed today. However, the concern formerly expressed by refractionists for the effects of small degrees of uncorrected astigmatism upon visual comfort and efficiency probably have had some basis in fact. It seems hardly reasonable to assume that uncorrected astigmatinsm which exists while a contact lens is worn is visually less important than the uncorrected astigmatism of the person who wears no optical correction at all. In addition, it is not uncommon to find that a contact lens wearer is unable to tolerate his lenses for various tasks because of this problem[5].

Contact lens practitioners often insist that their patients see better with contact lenses than with spectacles but measurements of visual acuity do not bear out this claim except in a relatively small proportion of the contact lens population. Most contact lens wearers will express a decided preference visually (but not cosmetically) for the addition of a cylindrical correction over their contact lenses. However, because of corneal changes produced by the contact lenses ("spectacle blur"), these same patients will tell their doctor that they see better with their contact lenses on than with their spectacles.

Residual astigmatism, i.e., that astigmatism which remains uncorrected while a contact lens is being worn, most commonly approaches one-half a diopter and rarely exceeds one diopter, although a few cases of one and half to three diopters have been seen by the author. In our office, all contact wearers are refracted a number of times while their lenses are being worn and it has been found that at least seventy-five per cent of eyes have residual astigmatism of one-half diopter or more. Characteristically, this uncorrected error of refraction takes the form of a minus cylinder axis at, or rather near, ninety degrees.

Though residual astigmatism in scleral type contact lenses often can be traced to the fitting characteristics of the lens, it is unlikely that such is the case with corneal lenses. The author has attempted to alter the uncorrected astigmatism by varying the lens size from eight and one-half millimeters to twelve millimeters and by varying the "fit" of the lens from apical clearance to as much as five diopters flat. A markedly thin lens will sometimes produce a variable astigmatic error due to a vertical bending of the lens but its effect is unpredictable and the extremely thin lens often cannot be worn with physical comfort. It seems probable, then, that residual astigmatism in corneal lenses is rarely the result of a poorly fitted lens.

Three anatomical sites which might contribute to this residual error can be considered: 1) the cornea, 2) the crystalline lens, and 3) the retina.

When corneal contact lenses are fitted, it is generally assumed[2] that the corneal astigmatism as measured with the ophthalmometer is completely neutralized by the lacrimal lens which is found beween the front surface of the cornea and the back surface of the contact lens. However, this assumption is based upon a generalization which may not be true. The ophthalmometer is calibrated for an index of 1.3375 while the cornea has a somewhat higher index for about 1.376. Hence, the ophthalmometer really is measuring only .3375/.376 or about nine-tenths of the corneal astigmatism.

If the cornea is a "plano" sheet of tissue and hence acts as a "bi-toricens" of plano power, it is probable that the remaining ten percent of the corneal astigmatism is removed by the back surface of the cornea. However, if the cornea is not a "plano" sheet but instead has plus or minus power which differs in its two principal meridians, the astigmatism indicated by the ophthalmometer will not be fully corrected by the lacrimal lens.

In addition, since the bundle of rays from the point of fixation passes through the cornea along a path which makes an oblique angle[6] with the optic axis of the eye, the cornea would tend to introduce more plus power along its horizontal than its vertical meridian.

The cystalline lens of the eye also may provide an astigmatic component via two sources: 1) the crystalline lens may not be a spherical lens but instead may have the form of a sphero-cylinder; 2) the lens may be oriented so that the chief ray of light passes through the lens at an oblique angle to the optic axis of the lens. In either event, the crystalline lens would have an astigmatic focus.

A third, bus somewhat improbable, source of astigmatism would exist if an irregularity in the macular area of the retina were such as to require an astigmatic image for clearest vision.

Of the three potential sources of residual astigmatism, the cornea probably exerts the greatest influence. If it is assumed that the incident light makes an angle of about five degrees with the optic axis of the eye, one might predict that about one-half to three-quarters of a diopter of astigmatism should be presented with a spherical corneal whose radius of curvature were approximately eight millimeters. The correcting cylinder would have its minus cylinder axis at, or very near, the vertical meridian.

It is instructive in this connection to point out that, in an analysis of seven aphakic eyes wearing spherical corneal contact lenses, five eyes showed residual astigmatism between one-half and three-quarters of a diopter, and two eyes had between one-quarter and one-half diopter. In all seven cases, the correcting minus cylinder axis was within ten degrees of the vertical meridian.

Since the vast majority of non-aphakic patients also require about this same amount and type of astigmatic correction over their contact lenses, it seems probable that the "obliquity factor" at the cornea is the most common and most important site of responsabitity for residual astigmatism when spherical contact lenses are worn. However, whether or not agreement can be reached as to the cause or causes of residual astigmatism, a reasonable solution to the problem of astigmatic corrections in corneal lenses must be sought.

It is possible to produce a corrective cylinder effect by grinding cilynder power on either the back surface or the front surface of a contact lenses or, indeed, the lens might be made bitoric but of spherical power as read in the lensometer. Let us examine each of these possible solutions in turn.

Nissel[5] has pointed out the mechanical and optical advantages and disadvantages of the inside surface cylinder. He points out that: 1) the machinery necessary to grind inside cylinders is simpler than for outside cylinders, and 2) a much larger margin of error is permissable since the lacrimal fluid will reduce the apparent error. However, as he also states, a cylinder of nearly three times the desired correcting effect is required because of this same lacrimal fluid neutralizing effect.

An otuside surface cylinder, since its full effect as read in the lensometer would be apparent must, be made far more accurately, hence difficulties would be greater. However, since only the residual error of refraction need be incorporated, the cylinder required would be markedly less.

The bi-toric lens would present extreme difficulties in its fabrication if the lens were to be ground. However, if it were made by "warping or bending a spherical corneal lens, it might provide a very useful temporary correction, at least. Its cylindrical effect upon the contact lens-eye system would be impressed upon the lacrimal lens, hence its correcting effect could be read with reasonable precision on the ophthalmometer or radiuscope. Naturally, its power as read with the lensometer would be spherical for all clinical purposes.

If one of the above lenses can be produced, our next problem would involve a technique whereby the rotation of the lens could be stopped or at least minimized to a resonable degree. The author and a number of others [5, 6, 7, 8, 9, 10] have found methods which will reduce rotation of a corneal contact lens so that an astigmatic correction might be feasible.

Perhaps the simplest and most generally applicable technique would be that of an unbalanced or "weighted" lens. This technique makes use of a prism in the lens of about one degree apical angle or approximately one prism diopter of power. Such a procedure would demand that an equal amout of prism be incorporated in each lens in a binocular case unless a vertical phoria correction were desired. A second type of weighting involves the implanting of a small metallic disc [7] near one margin of the lens. The base of the prism and the metallic disc both tend to orient themselves at the lowest point of the corneal lens.

One manufacturer [8] has stopped or minimized lens rotation by the use of a toric peripheral or secondary curve on the lens. The curvature difference between the principal meridians of the secondary curve can be varied to fit the needs of the individual cornea.

A second manufacturer [9] has used a toric inside curve plus small facets to eliminate rotation of this corneal lens but it should be noted that this solution demands that the astigmatic correction desired and the minimum degree of toricity required to stop rotation mus be in good agreement unless the facets alone are used.

Corneal lenses which are made oval [10] in shape (rather than round) tend to assume a position with the major axis of the lens along the horizontal meridial of the eye. Hence, this design also might be used to reduce or remove rotational effects.

It is probable that each manufacturer and each practitioner will find reasons to argue for one of the above techniques but a weighted lens has the major advantage that it would require no particular change in our present techniques of contact lens fitting. Adjustments on such a lens could be carried out just about as they are at present.

The manufacturing costs of astigmatic contact lenses would appear at first glance to be rather high but if it is remembered that the residual astigmatism is of consequence only when it is from about one-half to one diopter in amount, and further, that its minus cylinder axis nearly always is at or very near the vertical meridian, it would seem possible to make such lenses on a stock basis just as are spherical lenses. Special lenses would be needed only when a rather extra-ordinary problem occurred.

If it might be assumed, for example, that the prismatic technique for stopping rotation were to be used and that the cylinder were to be ground on the front surface, lenses, then would be made with a plus cylinder of about one-half diopter ground with its axis at right angles to the base apex line of the prism. Only in a few special cases would spherical lenses be required and in still fewer cases would cylinders greater than one-half diopter be ordered.

Residual astigmatism is a problem which today is recognized by relatively few practitioners in the eye care field. It is however, one of the very real and, I believe, rather serious problems remaining in the contact lens field. When it is solved, we shall have made a real stride in the direction of making the contact lens a really complete visual aid.

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