

THE PATHOPHYSIOLOGY OF CORNEAL ASTIGMATISM AFTER CATARACT SURGERY

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Although the ophthalmic surgeon has concerned himself with postoperative corneal astigmatism, since it is an integral part of the postoperative refractive error in aphakia, there has been much confusion in explaining the pathophysiology of postoperative changes in corneal curvature.

Since the turn of the century, it has been observed that astigmatism after cataract extraction is generally of the against-the-rule variety. This is caused by some degree of flattening of the corneal meridian perpendicular to the direction of the incision. This observation was valid in the days of unstured incisions and remained so after popularization of corneoscleral sutures. A radical change has occurred during the past 10 years. A variety of new suture materials have been introduced and innovative suture techniques have been described. A characteristic change in corneal curvature is associated with each of these techniques. The purpose of this presentation is to explain these changes on the basis of carefully controlled observations.

SLIDE: For orientation, this illustrates that the vertical corneal meridian is more steeply curved than the horizontal in astigmatism with-the-rule. The opposite is true in astigmatism against-the-rule. In an eye whose cornea requires a plus correcting cylinder at 45° , the 45° meridian is more steeply curved than the 135° meridian.

In order to evaluate the change in corneal curvature induced by a particular technique, it is mandatory to perform pre and postoperative keratometry and to quantitate the difference between these 2 measurements. If you are unconvinced of the importance of making both measurements, consider this **SLIDE** which shows relatively large amounts of postoperative

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corneal astigmatism (center column) with a variety of suture techniques, but when the difference between pre-and postoperative keratometry is mathematically calculated, we find that the amount of corneal astigmatism induced by the surgery (last column) is much less. Conversely, on this SLIDE, the postoperative Readings are much less than the actual changes in corneal curvature induced by the surgery.

This is not the appropriate forum for describing trigonometry but that is what was used in making all the calculations in my series of cases. SLIDE.

The series on which I based my conclusions consisted of 1,557 cataract extractions utilizing a variety of suture materials and techniques of incision and closure.

SLIDE: The following suture techniques were employed. Four types of continuous sutures. SLIDE: The Troutman suture commences at the horizontal termination of the incision and continues in non-locking fashion to 12 o'clock where the 2 halves are tied to each other. The Willard suture commences with a horizontal bite at 12 o'clock with one arm continuing to the right and one to the left. SLIDE: The over and over suture commences on the nasal side and terminates temporally in each eye. SLIDE: There were also a variety of interrupted suture techniques. There were 2 types of interrupted 10-0 nylon and 9-0 silk series, one with a relatively posterior incision and sutures inserted to about half the depth of the wound and another with a more anterior incision and more deeply inserted sutures. There were also series using 7-0 silk, 7-0 chromic catgut, and 7-0 chromic collagen. A fornix-based conjunctival flap was used in all series except for 7-0 collagen which was covered by a limbus-based flap.

SLIDE: In each series, the calculated induced surgical change was classified as with-or against-the-rule. This summary slide reveals that there was a characteristic with-or against-the-rule astigmatism induced by a particular technique. The Troutman suture induces with-the-rule change in a ratio of 6:1 while the Willard suture induces against-the-rule change in a ratio of 2:1. How do we explain this with 2 seemingly similar sutures? Most surgeons tend to pull up and tighten a continuous suture greatest near its termination. For the Troutman suture, this is 12 o'clock. Therefore, the greatest wound compression occurs here. The Willard suture is terminated at the horizontal extremities of the wound; therefore the greatest wound compression occurs horizontally. What does wound compression have to do with corneal curvature? Wound compression tends to shorten the circumference of the globe in that meridian, thus steepening the curvature.

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There is also a compensatory flattening of the opposite meridian, but to a lesser degree. Therefore, it is not surprising that the Troutman suture induces with-and the Willard suture against-the-rule astigmatism. If this thesis is correct, we should be able to apply it to the over and over series. SLIDE: Since this suture is always terminated on the temporal side of the incision, we should expect the steepest corneal meridian to be temporal to 90° in most cases. SLIDE: This proved to be the case in 16 of 20 right eyes and 28 of 32 left eyes.

How do we explain the tendency of large sutures such as 7-0 silk and 7-0 catgut to cause against-the-rule astigmatism? 7-0 silk is usually removed in 3-4 weeks thus permitting some wound gape. 7-0 catgut, especially when covered only by a fornix-based flap tends to disintegrate early allowing some wound gape. What does wound gape do? SLIDE: This lengthens the circumference of the globe in the meridian of the suture, thus decreasing curvature in this meridian. There is a compensatory steepening of the opposite meridian, but to a lesser degree.

What about the series where fine, interrupted, permanent sutures were employed? SLIDE: Note that in each case when the incision was further away from the cornea and the sutures inserted less deeply, the type of astigmatism was evenly distributed. When the incision was moved closer to the cornea and the sutures inserted more deeply, there was a decided shift toward astigmatism with-the-rule for both 10-0 nylon and 9-0 silk.

The theory of wound compression being associated with steepening of the corneal curvature is adequately defended in my experience by the effect of cutting a suture in the steepest corneal meridian. SLIDE: Note in the first column that a Troutman suture caused 12 diopters of with-the-rule astigmatism. This was completely eliminated by cutting the suture at its termination, 12 o'clock. SLIDE: Note in the second column that interrupted 9-0 silk sutures caused 6 diopters of with-the-rule astigmatism which was more than completely eliminated by removing 3 sutures at 11, 12, and 1 o'clock. Similar dramatic changes were observed with other types of sutures in this series but I will dwell on these no further. The change in corneal curvature as a result of removing a suture is usually dramatic, especially when removing nylon sutures.

I would like to emphasize a few points. SLIDE: The closer the incision is to the cornea the greater the astigmatism, whether due to wound gape or wound compression. SLIDE: The following factors favor wound compression. 1. fine sutures such as 10-0 nylon and 9-0 silk used to close relatively

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anterior incisions 2. deeply inserted fine sutures 3. wide suture bites 4. tightly tied sutures 5. greater number of sutures 6. overlapping of the wound SLIDE: Wound compression may be minimized by repressurizing the eye with air after the lens extraction. This lessens the tendency to compress the wound margins with the sutures. SLIDE: Remember when attempting to reduce astigmatism by cutting a suture, always cut the suture in the highest plus meridian.

The clinical application of these findings point to the control of post-operative astigmatism. The study suggests that the surgeon may choose from a variety of suture techniques one which will not exaggerate a pre-existing corneal astigmatism and one which might reduce it. Troutman has certainly re-emphasized the use of a wedge resection in the flattest corneal meridian to neutralize a pre-existing corneal astigmatism.

As you can well imagine, a study such as this requires tons of paper work SLIDE: but no job is finished until all the paper work is done.

SUMMARY

Since the turn of the century it has been observed that the postcataract corneal astigmatism is of the against-the-rule type, caused by a certain degree of flattening of the corneal meridian perpendicular to the direction of the incision. This observation was valid in the days of the unsutured incision, remaining so after the popularization of corneo-scleral sutures. In the past 10 years there has been a radical change due to new techniques and new sutures which caused changes in the corneal curvature. To evaluate this change, it is mandatory to perform pre and post-operative keratomeries and to quantitate the difference between these two measurements.

For this study the author chose 1557 cataract extractions, using a variety of sutures as well as incision and closure techniques (slides).

Four types of continuous sutures were used: the Troutman suture, the Williard suture, the over and over suture, and the interrupted suture, using 10-0 nylon and 9-0 silk. There were also series using 7-0 silk, 7-0 chromic catgut, and 7-0 chromic collagen, buried under a conjunctival flap. The Troutman sutures induced with-the-rule changes in a ratio of 6:1, while the Williard sutures induced against-the-rule changes in a ratio of 2:1.

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This may be explained by the fact that there is a tendency to pull up and tighten a continuous suture near its end; in the Troutman suture this happens at 12 and in Willard's near its termination.

Large sutures using 7-0 silk and 7-0 catgut caused an against-the-rule astigmatism. This is caused by the wound gape which takes place when removing the silk suture in 3-4 weeks and by the early desintegration of the catgut.

The compression of the wound tends to shorten the corneal diameter in that meridian, thus increasing the curvature; there is also a compensating flattening of the opposite meridian. The wound opening would increase the corneal meridian, thus decreasing the curvature in this meridian; there is also a compensating deviation of the opposed meridian, but in a lesser degree.

The theory of wound compression associated to a modification of the corneal curvature was proved when a change of curvature was achieved after cutting the corneal suture in the corresponding meridian.

The clinical application of these findings make possible to control the post-operative corneal astigmatism, allowing the surgeon to choose a technique with which a pre-existing corneal astigmatism is not exaggerated, or another one with which he may actually reduce it.

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