

## **SURGICAL CORRECTION OF ASTIGMATISM CURRENT APPROACHES**

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Astigmatism of a vision compromising degree is almost always a surgical problem. With the advent of cosmetic refractive surgery even small degrees of astigmatism, corrected readily by spectacles or contact lenses, are being subjected to surgical correction to achieve the ideal of "sight without glasses". Astigmatism of greater than 6 diopters occurs in 10 to 20% of otherwise successful penetrating keratoplasty. The average residual astigmatism, considered a successful result by most corneal surgeons, is between 3 and 4 diopters, an amount entirely unacceptable to cataract surgeons.

It is probable that less than 100,000 penetrating keratoplasties are done yearly worldwide, approximately 40,000 in the United States. Thus as many as 20,000 cases need secondary astigmatism surgery to obtain full vision potential following an otherwise successful graft. It is doubtful that there are this many excessive residual astigmatism following the millions of cataract surgeries done annually. In this age of instant gratification and patient expectation of a perfect result, our mean is often no longer acceptable. Today, almost every keratoplasty patient is a potential candidate for astigmatism surgery. With improved Eye Bank preservation techniques and increasingly successful tectonic and physiologic results, we can anticipate a quantum increase in keratoplasty. This is fueled further by corneal complications of other anterior segment procedures especially those related to intraocular implants.

Surgically induced astigmatism is not a new problem.

It is only a new interest of ophthalmologists. A few of us, in particular, José Barraquer and myself, have been concerned with its mechanisms and surgical

resolution for more than three decades. My initial interest was in the prevention of astigmatism in cataract surgery, a significant problem 30 years ago. Because of the more limited parameters of its causation it was solved, for practical purposes, by my introduction and use of microsurgery and monofilament suture techniques. In spite of my most careful efforts, although I was able to significantly reduce the mean and range of residual error, I am still unable to predictably eliminate cases of excessive postoperative astigmatism. This frustration led me to devise a procedure, the Troutman corneal wedge resection, the first effective one for secondary correction of postkeratoplasty astigmatism. I presented this original work for the first time to this forum in 1971. It was appropriate that this initial presentation be made in the cradle of refractive keratoplasty since astigmatism is important among the broader refractive surgery interests of José Barraquer. He had indeed theorized and employed similar concepts and techniques for correction of congenital astigmatism. At that time neither his nor my work had received general recognition so it was to him primarily that I looked for approbation. His immediate positive response encouraged me to continue my work despite the skepticism of my colleagues who “never had significant astigmatism following penetrating keratoplasty”, “never found astigmatism to be a problem”, “it can always be corrected by contact lenses”, “the operation doesn’t work”. This latter objection was erased by Krachmer and Fenzel in 1980 when they published their results confirming the efficacy of wedge resection and of its companion procedure the Troutman relaxing incisions technique first proposed by me in 1976.

In 1981, I modified the technique of both wedge resection and relaxing incisions by the addition of compression sutures, orthogonal to the excisional or incisional zones respectively. In the case of wedge resection these sutures are placed to compensate temporarily the overcorrection considered to be essential to a good result. The better acuity obtained has made the patients more tolerant of the prolonged corneal healing period. Six months or more may be required to achieve sufficient wound stability to allow some or all sutures to be removed and the final uncompensated result achieved. On the contrary, with relaxing incisions compression sutures are used to induce a temporary over-correction, delay healing and enhance correction.

For many radial keratotomy surgeons, their familiarity with Fyodorov’s corneal weakening or relaxing procedures for myopia has made my relaxing incisions technique preferable to a corneal strengthening or wedge resection technique. Nevertheless, from both etiologic and structural standpoints, in my opinion, a corneal strengthening technique, not to be confused with a temporary suture compression correction, is to be preferred to the somewhat more

## SURGICAL CORRECTION OF ASTIGMATISM

expedient incisional techniques. This is especially the case in higher degrees of astigmatism, in excess of 8 diopters, where the cause of the meridional flattening is often a thinned, even ectatic sector of the wound. Such corneas respond exceptionally poorly to multiple, more than 2, relaxing incision techniques, as the trapezoidal keratotomy of Ruiz, because such techniques tend to accentuate wound pathology rather than to correct it. More accurate results are obtained with my modified relaxing incisions technique incorporating compression sutures at 90 degrees to the incisional axis. These have been shown to enhance the correction by stabilizing the cornea at the desired curvature until healing occurs. It is my opinion that compression suture modified relaxing techniques are of use, in particular, in lower degrees of astigmatism, under 6 diopters, that have heretofore gone untreated, and to "touch up" the residual of a Troutman wedge resection over or undercorrections. Indeed it is in this area that greatest interest is being shown. I will not attempt to choose from among the myriad new procedures proposed for correction of lower refractive astigmatic errors but merely state that since all are based on weakening in the meridian of steepest curvature, all are probably capable of achieving correction of astigmatism. I prefer incisions approximating the circular shape of the cornea and adjacent to the graft scar rather than linear and tangent to its curvature with a necessarily smaller optical zone. The former is far less likely to induce irregular astigmatism. The fewer incisions used the less new pathology is introduced and the greater the accuracy and long term stability. As with radial keratotomy, incisional techniques should not be used to correct large errors. Errors in excess of 6 diopters, in my opinion, should be corrected first by a strengthening procedure. When the pathological area of the cornea which originally induced the astigmatism is stabilized then any residual astigmatism can be corrected by one of the incisional techniques.

José Barraquer was the first to observe the ovoid shape of the astigmatic cornea characteristic of keratoconus. Here the axis of the flatter meridian corresponds to the longer radius. With this in mind, we have attempted to form an ovoid recipient by wedge resection in the flatter meridian at primary keratoplasty or to use an ovoid shaped donor button in an attempt to prevent the inevitable postkeratoplasty astigmatism without significant success using mechanical instrumentation. We are working experimentally with laser cutting devices which permit us not only to vary precisely the shape, but also the depth, angulation, and width of cut. When perfected it should permit refinement of our primary surgical technique and reduce significantly the number of secondary interventions. More precise wound closure may be achieved through the use of lasers when combined with conventional closure techniques and healing may be accelerated with genetically engineered biological materials. Today, as with the

Barraquer procedures and with radial keratotomy, accuracy is the greatest barrier to achieving optimal correction. In keratoplasty this is magnified still further by the irregularly healed corneal scar, unknown optical characteristics of the homograft as well as optical variations induced by the original pathology.

It was Krachmer who first discovered the work of Lans, and obscure Dutch ophthalmologist, who in 1897 presented a thesis for his medical degree entitled "Experimental Studies of the Treatment of Astigmatism with Nonperforating Corneal Incisions". His interest had been stimulated by an article by the American, Bates, the "sight without glasses" expert of his day, published in 1894 which suggested that incisions made in cornea at right angles to the more convex steeper meridian might correct astigmatism. His approach was attempted in one case by Faber in 1895 who made a 6 mm long full thickness corneal incision parallel to the corneal limbus across the steeper axis resulting in a slight over correction of a 1.5 diopter astigmatism. Lans also referred to the work of Lucciola who in 1896 reported 10 cases of nonperforating corneal incisions made to flatten a steeper meridian. Since direct suturing of corneal incisions did not begin for almost four decades only wound closure by first intention was considered. Thus in Lans' thesis his conception of the effect of a healed corneal excision on corneal curvature is inverse to the effects as we now know them. His radially placed partial thickness/lamellar corneal excisions to either side of a steep meridian are theoretically correct and appear surprisingly similar to the Binder keratotomy procedure (1985). Unfortunately, though he became an ophthalmologist, Lans did not continue his work. the astigmatism induced by cataract and keratoplasty continued untreated for another 75 years.

It has, therefore, been most gratifying to me to see the interest that my techniques to correct this often debilitating problem have generated. I am pleased that this Forum witnessed its beginning in 1971. I owe to José Barraquer and to his brother, Joaquín, my introduction to refractive surgery and to microsurgical incision and closure techniques which formed the basis for my concepts. The problem has been identified, the causes enumerated and the principles of optical correction established. Corrective procedures based on these principles have been demonstrated to be routinely effective. It is the accuracy of these results, as with all refractive surgical procedures, which remains unacceptably high.

As I stated in 1971 "success in penetrating keratoplasty is no longer just a clear graft".