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Refractive outcome of single running suture adjustment in penetrating keratoplasty

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PURPOSE. *To evaluate the effectiveness of single running suture adjustment in reducing postoperative astigmatism and improving visual acuity in patients who have undergone penetrating keratoplasty.*

METHODS. *Eighteen eyes of 18 patients who underwent penetrating keratoplasty at the Department of Ophthalmology, Başkent University between May 1997 and December 2000 and who had an astigmatism over 2 diopters (D) at the fourth postoperative week were included. All eyes underwent suture adjustment at the fourth week and eight eyes with residual astigmatism above 3 D underwent a second adjustment at the eighth week. Final astigmatism and visual acuity findings were evaluated 28 weeks postoperatively.*

RESULTS. *The mean postoperative keratometric and refractive astigmatism were 5.76±0.88 D (range=4.50-7.76) and 5.22±0.78 D (range=4.0-7.0) at the fourth week, which were decreased to 2.82±0.99 D (range=1.25-4.62, p=0.0001) and 2.61±1.01 D (range=1.0-4.5, p=0.0001) after suture adjustment, respectively. In eight eyes at the eighth week, a second suture adjustment reduced the average keratometric and refractive astigmatism from 3.86±0.65 D (range=2.75-4.62) and 3.81±0.44 D (range=3.25-4.50) to 2.33±0.91 D (range=0.87-3.50, p=0.012) and 2.06±0.68 D (range=1.0-2.75, p=0.011), respectively. At the 28th week, the average keratometric and refractive astigmatism levels for the entire cohort, which were 2.39±1.06 D (range=1.0-3.50) and 2.25±0.96 D (range=1.0-3.25), respectively, showed a statistically significant decrease when compared with the levels before the first suture adjustment (p=0.0001 for both data). The mean best-corrected visual acuity was 20/25 on the Snellen chart at the 28th week.*

CONCLUSIONS. *Postoperative adjustment of single running suture is a safe and effective way of reducing postkeratoplasty astigmatism. (Eur J Ophthalmol 2004; 14: 94-9)*

KEY WORDS. *Penetrating keratoplasty, Postoperative astigmatism, Single running suture, Suture adjustment*

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INTRODUCTION

Recent advancements in microsurgical techniques, eye banking, and the ability to detect and treat early graft rejection have led to excellent success in achieving and maintaining optical clarity in corneal grafts. However, visual acuity, binocular visual function, and patient satisfaction may be severely limited by postoperative astigmatism and anisometropia. Even with modern surgical techniques the control of astigmatism remains a major factor in poor subjective and objective surgical outcome. Suture adjustment has evolved from the recognition that, in the presence of a clear graft, astigmatism plays a major role in our ability to

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achieve the expected level of visual recovery.

Preexisting corneal thinning, vascularization, and especially the changes that accompany keratoconus have been associated with a high frequency of astigmatism after penetrating keratoplasty. The type of trephine, the configuration and centration of the corneal trephine opening, alignment of donor with the recipient bed, graft-host disparity, and the tension, length, depth, and configuration of corneal sutures have all been implicated as causal factors. Each of the steps in penetrating keratoplasty, from trephination of the tissues to the suturing technique, may affect final astigmatic result.

It is well known that sutures can distort the graft and play an important role in postoperative astigmatism. Recent improvements in corneal trephines, intraoperative keratoscopy, corneal topography, selective suture removal, and suture adjustment have led surgeons to concentrate more on the manipulation of astigmatism. The technique of suturing the graft with a single continuous suture allows the surgeon to adjust the suture postoperatively during routine follow-up at the slit lamp. Indeed, postoperative adjustment of keratoplasty sutures to control astigmatism has become an integral part of the modern management of corneal grafts (1-3).

The purpose of this prospective study was to evaluate the effectiveness of postoperative adjustment of single running sutures in reducing postoperative astigmatism and improving visual acuity in patients who have undergone penetrating keratoplasty.

PATIENTS AND METHODS

In this prospective study, we examined 18 eyes of 18 patients who underwent penetrating keratoplasty at the Department of Ophthalmology, Başkent University between May 1997 and December 2000. The study group consisted of patients with consecutive penetrating keratoplasties with a residual refractive astigmatism of 2 diopters (D) or higher at the fourth postoperative week. Based on these criteria, we studied 18 eyes of 18 patients with a mean age of 41 years (range = 23-79). None of the patients had neovascularization due to inflammatory or infectious pathologies. The various indications for penetrating keratoplasty are listed in Table I.

TABLE I - THE PATIENTS' PREOPERATIVE DIAGNOSES

Diagnosis	Number of eyes
Keratoconus	9
Macular dystrophy	3
Granular dystrophy	1
Pseudophakic bullous keratopathy	3
Trachoma sequela	1
Bacterial keratitis	1
Total	18

Surgical technique

Penetrating keratoplasty was performed in all patients by the same surgeon (Y.A.A.) using the same technique. All donor corneas were trephined in a similar fashion from the endothelial side up using a Hessburg-Baron punch (Jedmed, St. Louis, MO). Each graft was oversized by 0.25 mm in all cases. All host trephinations were 7.5 or 7.75 mm. The anterior chamber was then entered and a viscoelastic agent was injected. The host button was removed using corneal scissors to the left and to the right. After the placement of four initial cardinal 10/0 nylon sutures, a single 24 bite continuous 10/0 nylon suture was placed. The first four interrupted sutures were placed such that an equal sided "square" was barely visible on the donor tissue, with each suture bite at approximately the same tightness, and placed two fifths within the donor and three fifths within the recipient. The running suture was tied temporarily, the four cardinal sutures were removed, and the anterior chamber was reformed with balanced salt solution. The 10/0 nylon suture was then symmetrically tightened and tied permanently. The suture was manipulated intraoperatively according to the appearance of the corneal reflection in a hand-held Maloney keratoscope (JEDMED) after adjustment of the intraocular pressure to approximately normal tension.

Suture adjustment

Postoperative suture adjustment was done based on keratometry, refraction, and computerized corneal topography findings. In all cases, the first suture ad-

justment was done 4 weeks after the surgery. The tension in the running suture was redistributed at the slit lamp under topical anesthesia using a 30-gauge Rycroft cannula. The epithelial integrity had to be mildly disturbed before inserting the tip of the cannula under the suture. The process of suture adjustment was facilitated by monitoring with corneal topography, trying to redistribute the tension starting from the steepest meridian if associated with a resultant astigmatism of 3 D or more. After the initial adjustment, computerized corneal topography was repeated and further adjustments were done as required. Topical antibiotic (tobramycin) and steroid (prednisolone acetate) treatment was given for 3 days after all adjustments were completed. At 8 weeks after surgery, all eyes were rechecked and those with residual astigmatism higher than 3 D had the second suture adjustment using the above described technique. Final astigmatism and visual acuity findings were evaluated at the end of the 28th week.

Statistical analyses

Data were analyzed using nonparametric Wilcoxon signed rank test, and a p value of < 0.05 was considered to indicate statistical significance.

Data parameters

All astigmatic (refractive and keratometric) and visual acuity data were analyzed before suture adjustment at 4, 8, and 28 weeks consecutively.

RESULTS

The most common preoperative diagnoses in the study group were keratoconus, pseudophakic bullous keratopathy, and macular dystrophy (Tab. I). The mean best-corrected visual acuity of all patients before surgery was 20/400 by the Snellen chart. Before suture adjustment, the study group had an average keratometric and refractive astigmatism of 5.76 D (standard deviation [SD] = 0.88, range = 4.50-7.76) and 5.22 D (SD = 0.78, range = 4.0-7.0) at the fourth week, respectively. After the first suture adjustment in all eyes, the average keratometric and refractive astigmatism decreased to 2.82 D (SD = 0.99, range = 1.25-4.62) and 2.61 D (SD = 1.01, range = 1.0-4.5), respectively (Fig. 1). The differences in average astigmatism before and after suture adjustment were significant ($p = 0.0001$ for both keratometric and refractive data).

Eight eyes showed residual astigmatism higher than 3 D at 8 weeks. The average keratometric and refractive astigmatism were 3.86 D (SD = 0.65, range = 2.75-4.62) and 3.81 D (SD = 0.44, range = 3.25-4.50), respectively. After second suture adjustment, the average keratometric and refractive astigmatism data showed a statistically significant decrease to 2.33 D (SD = 0.91, range = 0.87-3.50, $p = 0.012$) and 2.06 D (SD = 0.68, range = 1.0-2.75, $p = 0.011$), respectively (Fig. 2).

At 28 weeks, the levels of keratometric and refractive astigmatism in the entire cohort were 2.39 D (SD = 1.06, range = 1.0-3.50) and 2.25 D (SD = 0.96, range = 1.0-3.25), respectively. There was a significant decrease in the average astigmatism after 28 weeks when compared with the average astigmatism before the first suture adjustment ($p = 0.0001$ for both keratometric and refractive data).

The mean best-corrected visual acuity increased from 20/40 before first suture adjustment to 20/25 at the 28th week postoperatively (Fig. 3). All grafts remained clear during and after suture manipulation, and none of the sutures was broken or had to be removed during adjustment.

DISCUSSION

Comparison of the effects of variations in keratoplasty suturing technique on postkeratoplasty astigmatism and visual rehabilitation is not conclusive. Karabatsas et al (4) have reported that postkeratoplasty astigmatism can be decreased similarly with either adjustment of a single running suture or selective removal of interrupted sutures.

It should be kept in mind that the degree of postoperative astigmatism seen after penetrating keratoplasty is related to a number of factors in addition to suturing technique. Oversizing the graft may decrease the incidence of peripheral anterior synechiae and postoperative glaucoma, and may also allow for better apposition between the graft and the host tissue. In contrast, undersizing the graft to decrease a myopic refraction in a patient with keratoconus can lead to higher degrees of astigmatism, because the increased ten-

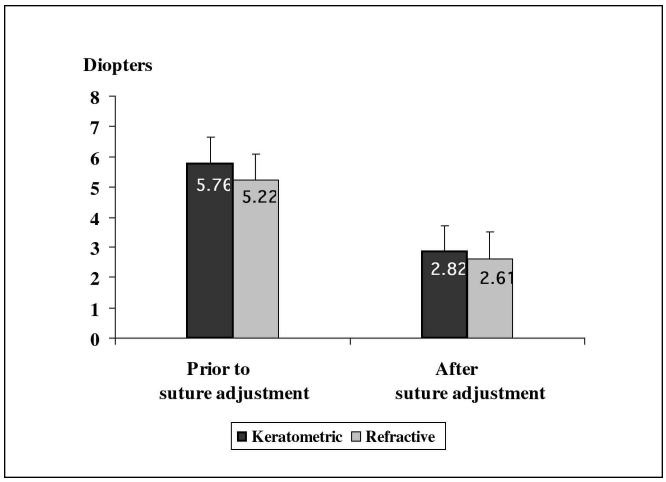

Fig. 1 - *Mean keratometric and refractive astigmatism levels 4 weeks postoperatively (18 eyes).*

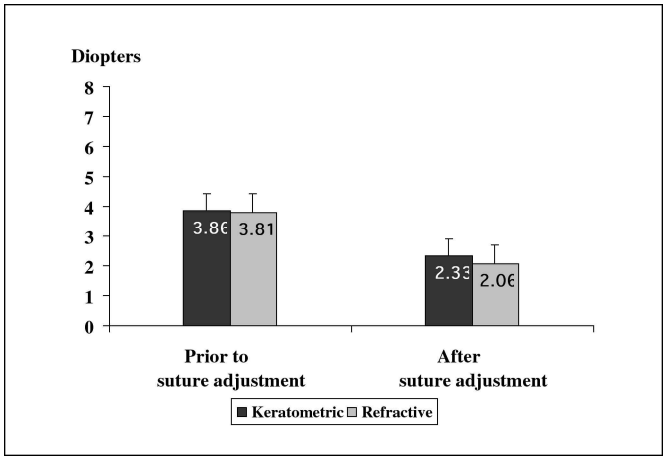

Fig. 2 - *Mean keratometric and refractive astigmatism 8 weeks postoperatively (8 eyes).*

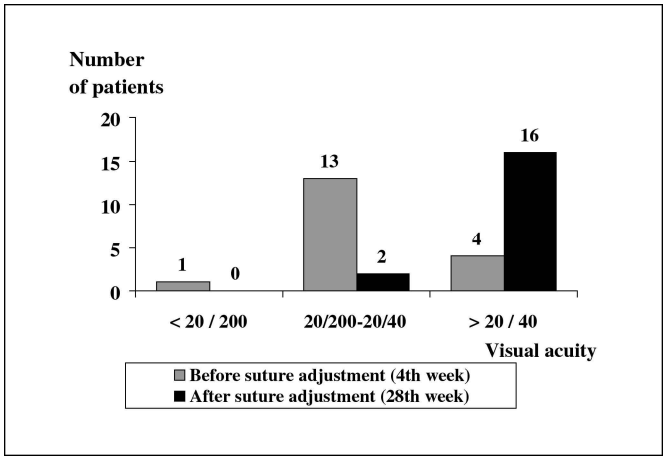

Fig. 3 - *The distribution of visual acuity before first suture adjustment at the fourth week and 28 weeks postoperatively.*

sion at closure can yield poor wound apposition in areas of peripheral thinning of the host (1). Several technical factors during surgery have been implicated in producing uneven, irregular, or oval trephination of the tissues. Small degrees of tilting of the trephine or decentration on the Teflon block will produce an oval cut. A tilt of 20 degrees results in approximately 0.5 mm of disparity between the major and minor axes (5). Suction trephine systems such as the Hanna, Hessburg-Baron, or Krumeich are preferred for trephination of host tissue because they stabilize the globe during the trephination, ensuring that the cutting surface is held perpendicular to the cornea. A dull or damaged trephine or corneal block, poor punch technique, pressure on the globe from the lid speculum, bridle suture, fixation ring, or fixation forceps can adversely affect trephination (6).

A number of different suturing techniques have been proposed for penetrating keratoplasty, all aimed at decreasing the incidence of high astigmatism and improving visual acuity. McNeill and Kaufman (7) reported the use of double-running nylon sutures. However, in this approach, removal of one continuous suture is followed by an unpredictable shift in astigmatism. Stainer et al (8) popularized the use of a combination of eight interrupted 10/0 nylon sutures followed by an overlay continuous 11/0 nylon suture. This technique, with selective interrupted suture removal, decreases astigmatism and improves visual acuity. Later, McNeill and Wessels (9) described the use of a single continuous suture that could be adjusted in the early postoperative period to redistribute tension. Their study showed that this method significantly reduces astigmatism. Although 38% of the patients required repeated adjustments and there was significant regression in the effect of postoperative suture adjustment after 6 months, mean keratometric astigmatism after suture removal in adjusted patients remained significantly lower than the mean in nonadjusted patients. Similarly in our study, 44% of patients required second suture adjustment, but we did not observe any significant regression in the effect of suture adjustment after 28 weeks postoperatively.

Several reports have documented encouraging results with the intraoperative and postoperative adjustment of the single running suture to control astigmatism after penetrating keratoplasty. In a retrospective study, Van Meter and associates (10) reported advantages

of this method over previous results achieved with the combined running and interrupted suture technique in reducing postoperative astigmatism. Filatov et al (11, 12) suggested that the adjustable single running suture technique provides a greater control of astigmatism after penetrating keratoplasty compared with a technique using a combination of a 16-bite running suture and eight interrupted sutures. Further study by the authors showed that a single running suture results in more rapid visual rehabilitation and less early astigmatism. Works by Serdarevic et al (13, 14) showed that low astigmatism and good visual results could be obtained after suture removal in cases where a single running suture has been adjusted either intraoperatively or postoperatively. In other research, Riddle Jr et al (15) documented results that support the use of a single running suture in cases where this is indicated and possible. The authors recommended that adjustments should be made at the end of the procedure and 1 month postoperatively, based on keratoscopy and topography. In our experience, suture adjustments performed earlier than 4 weeks after surgery are generally premature because the corneal topography is usually not stable before this time. The results of this study indicate that postoperative adjustment of single running sutures may effectively reduce astigmatism, thus confirming the findings of recent retrospective studies. Others have had similar success, documenting an average of a 6 to 7 D decrease in astigmatism using this technique with an improvement in postadjustment visual acuity (16-18).

The single running suture technique requires fewer suture manipulations, which reduces the risk of postoperative wound infection and injection. Another advantage of this method is that all adjustments are reversible. Also, the changes can be made easily at the slit lamp during follow-up; thus there is no increased risk to the graft (19). Several theories have been advanced to explain the lower postoperative astigmatism seen with the adjustment of the single running suture. One proposed explanation is that this type of suturing redistributes corneal tension evenly along the entire circumference of the wound (10).

This procedure allows for immediate postoperative adjustment as there is no weakening effect on the wound integrity. Other advantages of this technique have been documented as it is titratable to the magnitude of astigmatism and is reversible should an overcorrection occur (9).

The benefits of this method are clear; however, the single running suture technique and its adjustment have potential disadvantages. Among these are suture breakage during postoperative adjustment, disruption of the corneal wound, and the need for relatively loose placement of the single running suture to effectively redistribute suture tension postoperatively (10). In our study, there were no complications related to suture adjustment intra- or postoperatively. We suggest that it is advantageous to use the Rycroft cannula for suture adjustment because the tip is blunt, which makes it almost impossible to break the suture.

Whereas various suturing configurations and suture removal or adjustment techniques have been proposed to reduce early astigmatism and promote a more rapid return of vision, it remains controversial whether these factors can influence the final astigmatism after all sutures have been removed. Several authors have reported unpredictable changes in astigmatism with late suture removal (20-23). Our study shows the effect of suture adjustment and visual acuity improvements prior to suture removal.

Penetrating keratoplasty is a common surgical treatment for eyes with severe corneal pathology. Many techniques have been used to manage postkeratoplasty astigmatism, including combinations of interrupted and continuous sutures with interrupted suture removal and refractive surgery. Our results show that adjustment of a single continuous suture can markedly reduce the postoperative astigmatism associated with this surgery. Although the single running suture technique and suture adjustment requires experience in achieving correct suture tension and should only be employed by experienced transplant surgeons, the success and the low complication rate associated with this method make the adjustment of the single running suture an excellent technique for enhancing surgical outcome after penetrating keratoplasty.

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