SUTURING TECHNIQUE FOR CONTROL OF POSTKERATOPLASTY ASTIGMATISM AND MYOPIA

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ABSTRACT

Purpose: We previously demonstrated that selective suture removal reduces keratoplasty astigmatism; however, a myopic shift was induced with increasing number of interrupted sutures removed. This study is an attempt to determine the effects of a modified surgical technique on postkeratoplasty myopia, astigmatism, and anisometropia.

Methods: Optical penetrating keratoplasties were performed on 92 eyes of 84 patients. The study group consisted of 92 consecutive penetrating keratoplasties performed using 12 interrupted 10-0 nylon sutures and a tight 12-bite continuous suture, and use of an average keratometry (K) reading of 46.00 diopters for eyes undergoing combined and intraocular lens (IOL) exchange procedures. All patients had refraction, keratometry, and videokeratoscopy postoperatively, starting at 6 weeks and at the completion of selective suture removal.

Results: Prior to suture removal, the average spherical equivalent was -0.160 ± 3.59 diopters. It was -1.58 ± 3.66 diopters at the completion of suture removal at 1 year and -1.44 ± 3.72 at the last follow-up visit, averaging 20.7 months. Final residual refractive, keratometric, and videokeratoscopic astigmatism was 2.81 ± 1.82, 4.19 ± 2.94, and 3.58 ± 2.03 diopters, respectively. Anisometropia, using the spherical equivalent of the operated and fellow eyes, was 2.49 ± 2.25 diopters at completion of the study. A best corrected visual acuity of 20/50 or better was achieved in 50 patients (59%).

Conclusions: Low myopic spherical equivalent refraction and anisometropia with moderate residual astigmatism were achieved by using tighter continuous sutures, an average K reading of 46 diopters for calculation of IOL power, and selective removal of fewer sutures.

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INTRODUCTION

Postoperative astigmatism, residual myopia, and anisometropia often determine the functional visual outcome in an otherwise successful penetrating keratoplasty. Visually successful surgery requires the reduction of astigmatism and unexpected resultant anisometropia.

The suture techniques of single or double continuous and of combined interrupted and continuous have been examined in regard to early visual rehabilitation and measurement of astigmatism, as well as final all-suture-out residual astigmatism. Reports to date differ somewhat as to which technique results in the least astigmatism and induced myopia and the earliest rehabilitation, but each usually requires either adjustment of the continuous sutures or selective removal of interrupted sutures.[1-20]

Laser in situ keratomileusis has become increasingly popular in the attempt to correct postoperative myopia and astigmatism.[21-25] However, surgical techniques and postoperative suture manipulation have not been successful in reliably reducing astigmatism and myopia. Studies to evaluate operative and postoperative techniques to minimize visually compromising anisometropia have not been addressed to date.

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We previously demonstrated that removal of selective interrupted sutures reduces keratoplasty astigmatism; however, a myopic shift was induced with increasing number of interrupted sutures removed.[26] The outcomes of two selective suture removal techniques were compared. In one group, removal of six alternate interrupted sutures at 6 weeks, and subsequent selective removal based on refraction, keratometry, and videokeratoscopy, was performed. In the other group, selective removal of interrupted sutures at the steepest meridian at 6 weeks, with repeated removal at subsequent postoperative visits, was performed. The data demonstrated that selective removal by either technique reduces keratoplasty astigmatism to 2.7 diopters or less at 1 year, with residual interrupted and continuous sutures in place. The myopic shift induced with increasing number of interrupted sutures removed resulted in an average keratometry (K) reading of 47.4 diopters in the group with more sutures removed and 46.0 diopters in the group with fewer selective sutures removed.

These results lead to the hypothesis that more interrupted sutures could be left in place, the continuous suture could be tighter, and the average predicted K reading could be increased for eyes undergoing intraocular lens (IOL) placement or exchange to better reduce postkeratoplasty myopia and yet control astigmatism. The present study is an attempt to determine the effects of such a modified technique on postkeratoplasty myopia, astigmatism, and anisometropia.

MATERIALS AND METHODS

Optical penetrating keratoplasties were performed on 92 eyes of 84 patients. The study group consisted of consecutive penetrating keratoplasties performed using 12 interrupted 10-0 nylon sutures and a tight 12-bite, 10-0 nylon continuous suture, and use of an average K reading of 46.00 diopters for eyes undergoing combined and IOL exchange procedures. All patients had refraction, keratometry, and videokeratoscopy measurements postoperatively, starting at 6 weeks and at the completion of suture removal. Six weeks postoperatively, patients underwent selective suture removal only at the steepest meridian, if associated with greater than 3 diopters of astigmatism in that meridian. This investigation was approved by the institutional review board at the University of Miami School of Medicine.

SURGICAL TECHNIQUE

All eyes underwent penetrating keratoplasty by the same surgeon (R.K.F), who prepared the donor tissue endothelial side up and used a gravity trephine with a Katena blade (7.75 to 8.25 mm). The recipient cornea was trephined to a depth of approximately 0.4 mm with a Storz guarded trephine with disposable blade (7.5 to 8 mm), and recipient corneal removal was completed with scissors. All donor corneal tissue was trephined 0.25 mm larger than the recipient trephination, except for patients with primary keratoconus, in which case same-size donor-host trephination was performed. The first four interrupted sutures were placed such that an equal-sided “square” was barely visible on the donor tissue, each suture bite was about the same tightness, and interrupted sutures were placed, at about three-quarters depth, two fifths within the donor and three fifths within the recipient. The 12-bite 10-0 nylon continuous suture was then placed somewhat more tightly than the interrupted sutures after adjustment of the intraocular pressure to approximately normal tension.

All eyes undergoing combined keratoplasty and cataract extraction, or IOL exchange procedures, had IOL power calculations using a predicted postkeratoplasty average K reading of 46.00 diopters (based on the results of our previous study[11]).

SELECTIVE SUTURE REMOVAL

Patients underwent selective removal of sutures at the steepest meridian, if associated with greater than 3 diopters of astigmatism starting at 6 weeks postoperatively. One of two sutures in a particular meridian was removed if the topographic analysis indicated that only one of the two appeared to be tight in the steeper meridian. Interrupted sutures were then selectively removed on follow-up visits until the resultant astigmatism and overall refractive spherical equivalent best minimized anisometropia. Follow-up visits usually occurred every 4 to 6 weeks for the first 6 months postoperatively, within 1 month following selective suture removal, and then every 3 to 4 months. With patients under topical anesthesia, sutures were removed with use of a jeweler’s forceps and razor blade. Antibiotic drops were applied with no patching or continuation of topical antibiotics, but with continuation of topical prednisolone acetate, or other steroid drops, at the same frequency as previously used, and of ocular hypertension–lowering agents as necessary. Refraction, keratometry, and videokeratoscopy measurements were performed by optometrists and/or allied health personnel.

DATA PARAMETERS

All astigmatic and visual acuity data were analyzed at 6 weeks postoperatively, prior to any suture removal, after the initial sutures were removed, at 6 months postoperatively, after final selective interrupted sutures were removed, and at the final visit.

Manifest refraction was analyzed in terms of spherical equivalent, keratometric, and videokeratoscopic parameters; simulated keratometry (Sim K); surface regularity index (SRI); and surface asymmetry index (SAI).

For comparative purposes, the 92 eyes included in this study are referred to as *Current Study*. *Prior Study* represents those eyes in the selective suture removal group from the previous study.[11]

In the *Current Study*, spherical equivalent results of those eyes in which an IOL was placed at the time of penetrating keratoplasty were compared to those of eyes without IOL placement. In addition, we compared the spherical equivalent results of eyes undergoing IOL placement in the *Prior Study*, using an average K reading of 45.00 diopters, to those in the *Current Study*, in which an average K reading of 46.00 diopters was used.

STATISTICAL METHODS

For each dependent variable (spherical equivalent and all astigmatism measures), the two-sample *t* test was used to compare values at each follow-up time.

RESULTS

DEMOGRAPHICS, DIAGNOSES, AND PROCEDURES

The study includes 92 eyes of 84 patients, and mean follow-up time is 20.7 months (range, 6-36 months). The demographics included the following: 33 males (39%) and 51 females (61%); 47 right eyes (51%) and 45 left eyes (49%); and mean age, 73 years (range, 26-95 years). The preoperative diagnoses were pseudophakic corneal edema (44%), Fuchs' endothelial dystrophy with cataract (19%), aphakic corneal edema (2%), keratoconus (5%), corneal scars (9%), reoperations for failed grafts (17%), and other diagnoses, including corneal degenerations and iridocorneoendothelial syndrome (4%).

A penetrating keratoplasty only was performed in 51 eyes (56%) and a triple procedure combining a penetrating keratoplasty with extracapsular cataract extraction and IOL implantation in 22 eyes (24%). An IOL exchange was performed in 16 eyes (17%), and a secondary IOL insertion was performed in 3 eyes (3%).

POSTOPERATIVE SPHERICAL EQUIVALENT

The spherical equivalent prior to selective suture removal was -0.16 ± 3.59 diopters. About 1 month following selective suture removal, it was -0.30 ± 3.57 diopters; at 6 months, it was -1.32 ± 3.96 diopters; and at the completion of selective suture removal, it was -1.58 ± 3.66 diopters. At the final visit the spherical equivalent was -1.44 ± 3.72 diopters (Figure 1).

Low myopic spherical equivalent refraction could be achieved after selective suture removal, and there was somewhat more control over the postoperative residual myopia compared to the *Prior Study* (*P* = .27) at 6 months and at the last follow-up visit (*P* = .19) (Table I).

THE ROLE OF IOL POWER

We used an average K reading of 45.00 diopters in the *Prior Study* and 46.00 diopters in the *Current Study* for calculation of IOL power to use in combined, IOL exchange, and secondary IOL cases. We compared the spherical equivalent results at the five postoperative intervals for those eyes in which an IOL was placed at the time

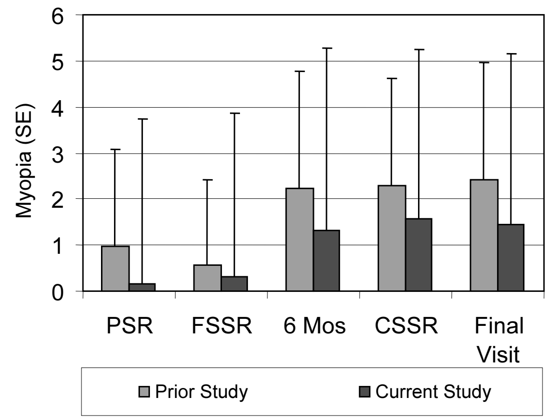

FIGURE 1

Postoperative myopic refractive spherical equivalent (CSSR, completion of selective suture removal; FSSR, following selective suture removal; PSR, prior to suture removal).

TABLE I: SPHERICAL EQUIVALENT AND ASTIGMATISM AT FOLLOW-UP INTERVALS

VARIABLE	SUTURE TYPE	PSR	FSSR	6 MO	CSSR	LAST VISIT
Spherical equivalent	Prior study	-0.97 ± 2.11	-0.58 ± 1.83	-2.23 ± 2.54	-2.28 ± 2.34	-2.41 ± 2.56
	Current study	-0.16 ± 3.59	-0.30 ± 3.57	-1.32 ± 3.96	-1.58 ± 3.66	-1.44 ± 3.72
	P value	.14	.60	.27	.25	.19
Refractive astigmatism	Prior study	4.23 ± 3.08	3.32 ± 1.90	2.24 ± 1.73	2.18 ± 1.14	2.05 ± 1.04
	Current study	5.13 ± 2.60	3.76 ± 2.37	3.07 ± 2.02	2.56 ± 1.74	2.81 ± 1.82
	P value	.13	.37	.049	.20	.008
Keratometry	Prior study	5.48 ± 2.75	3.70 ± 2.14	2.59 ± 2.34	2.12 ± 1.28	2.02 ± 0.93
	Current study	7.17 ± 3.95	4.86 ± 3.18	4.34 ± 3.00	3.98 ± 3.09	4.19 ± 2.94
	P value	.14	.11	.031	<.001	<.001
Simulated K	Prior study	6.10 ± 2.82	4.49 ± 2.61	3.67 ± 1.88	2.27 ± 1.07	2.33 ± 1.20
	Current study	7.13 ± 3.93	5.18 ± 3.24	3.64 ± 2.56	3.29 ± 2.36	3.58 ± 2.03
	P value	.18	.28	.95	.039	.001
SRI	Prior study	1.82 ± 0.43	1.58 ± 0.48	1.45 ± 0.47	1.32 ± 0.46	1.13 ± 0.40
	Current study	1.76 ± 0.47	1.55 ± 0.53	1.40 ± 0.53	1.28 ± 0.47	1.29 ± 0.53
	P value	.53	.77	.70	.75	.21
SAI	Prior study	1.68 ± 0.77	1.58 ± 1.12	1.33 ± 0.87	1.07 ± 0.51	1.06 ± 0.46
	Current study	1.72 ± 0.99	1.50 ± 0.98	1.39 ± 1.07	1.29 ± 0.95	1.31 ± 0.93
	P value	.85	.72	.84	.16	.28

CSSR, completion of selective suture removal; FSSR, following selective suture removal; PSR, prior to suture removal; SAI, surface asymmetry index; SRI, surface regularity index.

of the penetrating keratoplasty procedure and those eyes without IOL placement. Table II demonstrates the comparative results. Where significant, IOL placement in the Current Group has lower myopia; the difference, however, was not significant at the final examination.

Finally, we compared IOL placement alone in both the *Prior Study* and the *Current Study* (average K, 45.00 diopters versus 46.00 diopters). Table III shows that IOL placement has less induced myopia at all but the final visit; however, the results were statistically significant at only the presuture removal visit and were borderline at 6 months.

POSTOPERATIVE ASTIGMATISM

Prior to suture removal (PSR) at 6 weeks, the mean refractive astigmatism was 5.13 ± 2.60 diopters, keratometric astigmatism was 7.17 ± 3.95 diopters, and simulated K was 7.13 ± 3.93 diopters (Figures 2, 3, and 4). Following initial suture removal (FSSR), astigmatic measurements were made about 1 month later and the mean refractive astigmatism was 3.76 ± 2.37 diopters, keratometric astigmatism was 4.86 ± 3.18 diopters, and simulated K was 5.18 ± 3.24 diopters. Six months postoperatively, mean

TABLE II: SPHERICAL EQUIVALENT COMPARISON BETWEEN IOL AND NO IOL GROUPS AT FOLLOW-UP INTERVALS

MEASUREMENT TIME	GROUP	SPHERICAL EQUIVALENT MEAN (SD)	*P* VALUE
PSR	IOL	1.3 (2.7)	<.001
	No IOL	-1.3 (3.8)	
FSSR	IOL	0.4 (3.2)	.14
	No IOL	-0.8 (4.0)	
6 Mo	IOL	-0.1 (2.9)	.005
	No IOL	-2.5 (4.4)	
CSSR	IOL	-0.6 (3.0)	.017
	No IOL	-2.5 (4.0)	
Final	IOL	-1.0 (3.1)	.34
	No IOL	-1.8 (4.2)	

CSSR, completion of selective suture removal; FSSR, following selective suture removal; IOL, intraocular lens; PSR, prior to suture removal.

TABLE III: SPHERICAL EQUIVALENT COMPARISON BETWEEN PRIOR STUDY AND CURRENT STUDY FOR EYES WITH IOL PLACEMENT

MEASUREMENT TIME	GROUP	SPHERICAL EQUIVALENT MEAN (SD)	*P* VALUE
PSR	Prior	-0.7 (1.7)	.003
	Current	1.3 (2.7)	
FSSR	Prior	-0.6 (1.4)	.32
	Current	0.4 (3.2)	
6 Mo	Prior	-1.7 (2.0)	.095
	Current	-0.1 (2.9)	
CSSR	Prior	-1.7 (2.3)	.22
	Current	-0.6 (3.0)	
Final	Prior	-1.5 (2.3)	.58
	Current	-1.0 (3.1)	

CSSR, completion of selective suture removal; FSSR, following selective suture removal; PSR, prior to suture removal.

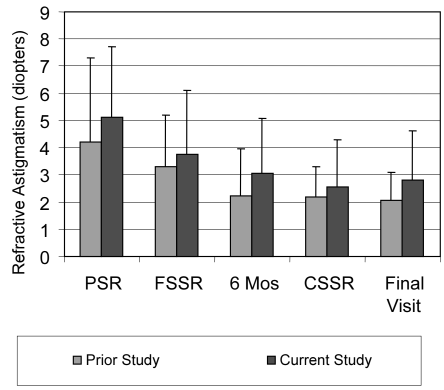

FIGURE 2
Postoperative refractive astigmatism equivalent (CSSR, completion of selective suture removal; FSSR, following selective suture removal; PSR, prior to suture removal).

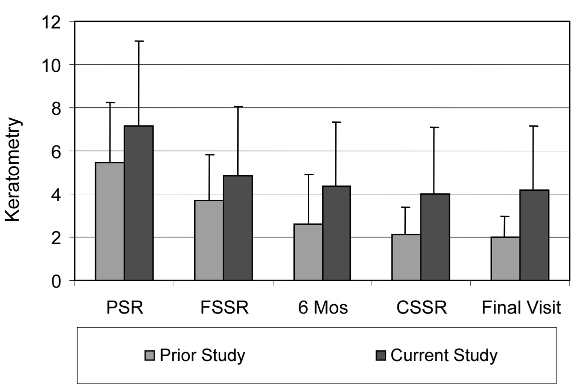

FIGURE 3
Postoperative keratometric astigmatism equivalent (CSSR, completion of selective suture removal; FSSR, following selective suture removal; PSR, prior to suture removal).

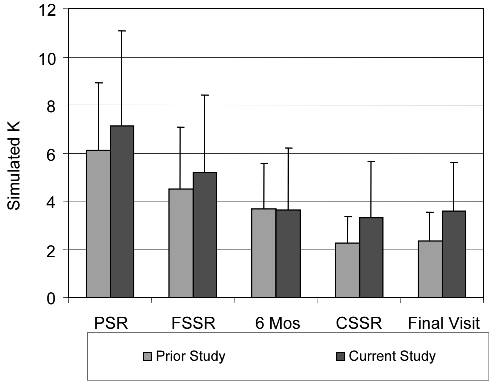

FIGURE 4
Postoperative videokeratoscopic astigmatism–simulated keratometry equivalent (CSSR, completion of selective suture removal; FSSR, following selective suture removal; PSR, prior to suture removal).

refractive astigmatism was 3.07 ± 2.02 diopters, keratometric astigmatism was 4.34 ± 3.00 diopters, and simulated K readings were 3.64 ± 2.56 diopters.

After completion of selective suture removal (CSSR), refractive astigmatism was 2.56 ± 1.74 diopters, keratometric astigmatism was 3.98 ± 3.09 diopters, and simulated K was 3.29 ± 2.36 diopters. At the final visit, refractive astigmatism was found to be 2.81 ± 1.82 diopters, keratometric astigmatism was 4.19 ± 2.94 diopters, and simulated K was 3.58 ± 2.03 diopters (Table I).

The reduction in refractive and keratometric astigmatism was found to be statistically significant at 6 months and at the completion of suture removal compared to presuture removal measurements (P <.001). The difference in the residual refractive astigmatism between the *Prior Study* group, where selective suture removal was used without a tighter continuous suture (average, 2.05 ± 1.04 at final visit) and the *Current Study* group (average, 2.81 ± 1.82 at final visit) was statistically significant (P = .008) (Table I). Likewise, keratometric astigmatism and videokeratoscopy astigmatism were statistically different between the two studies.

SURFACE REGULARITY INDEX AND SURFACE ASYMMETRY INDEX

Prior to suture removal, the average SRI was 1.76 ± 0.47, following initial suture removal, it was 1.55 ± 0.53, at 6 months it was 1.40 ± 0.53, at completion of selective suture removal, it was 1.28 ± 0.47, and at the final examination it was 1.29 ± 0.53 (Figure 5). The difference between SRI prior to suture removal and at the final visit was statistically significant (P <.001).

Prior to suture removal, the average SAI was 1.72 ± 0.99; following initial suture removal, it was 1.50 ± 0.98; at 6 months, 1.39 ± 1.07; at completion of selective suture removal, 1.29 ± 0.95; and at the final examination, it was 1.31 ± 0.93 (Figure 6). The difference from initial to final measurements was statistically significant (P = .05) (Table I).

ANISOMETROPIA

Of the 92 eyes in 84 patients, 10 patients were monocular, precluding a determination of the refractive spherical equivalent in the fellow, blind eye. In addition, 5 patients had both eyes undergoing operation, and anisometropia data are reported for these patients at the final, follow-up visit. Therefore, anisometropia was analyzed in 77 patients.

The difference between the spherical equivalent of the fellow eye and the operated eye at the completion of the study was 2.49 ± 2.25 diopters. This value was 3.22 ± 2.27 diopters in the *Prior Study* group (P = .16).

Of the 77 patients, 29% had 1.0 diopters or less of anisometropia, 55% had 2.0 diopters or less, 66% had 3.0 diopters or less, 86% had 4.0 diopters or less, and 87% had 5.0 diopters or less (Figure 7).

SELECTIVE SUTURE REMOVAL

An average of 2.0 ± 0.8 sutures were initially removed at 6 weeks, and 4.3 ± 2.7 sutures were removed by the final examination. In the *Prior Study* group, 2.2 ± 0.7 sutures were initially removed, and an average of 4.7 ± 2.6 sutures were removed by the final examination (P = .50).

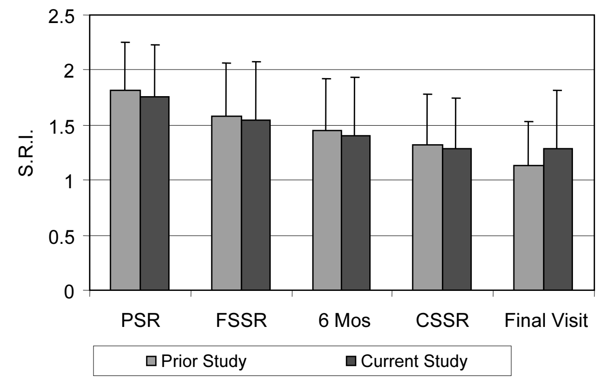

FIGURE 5

Postoperative surface regularity index (SRI) equivalent (CSSR, completion of selective suture removal; FSSR, following selective suture removal; PSR, prior to suture removal).

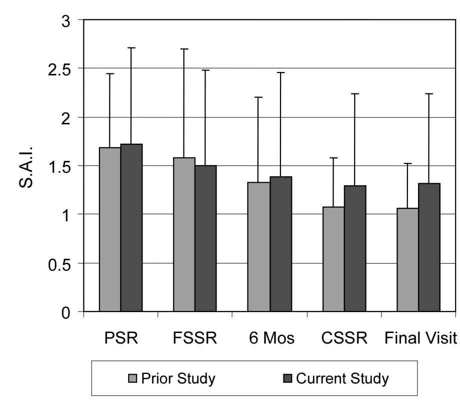

FIGURE 6

Postoperative surface asymmetry index (SAI) equivalent (CSSR, completion of selective suture removal; FSSR, following selective suture removal; PSR, prior to suture removal).

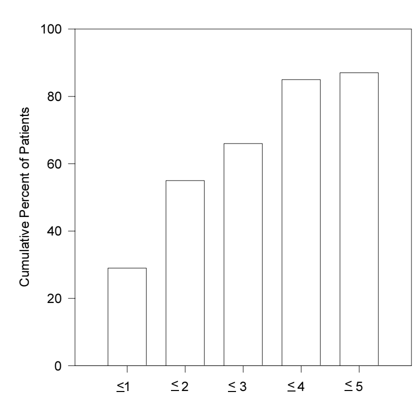

FIGURE 7

Cumulative percentage of postoperative anisometropia.

POSTOPERATIVE VISION

Prior to any selective suture removal, 6 weeks postoperatively, 31% of eyes had a visual acuity of 20/50 or better. About 1 month following initial suture removal, 37% of eyes had a best corrected visual acuity of 20/50 or better. At 6 months, 65% achieved best corrected acuity of 20/50. At the final visit (average, 20.7 months postoperatively), acuity of 20/50 or better was achieved in 59% of eyes and 20/100 or better in 75%.

Of the 15 eyes (16%) with 20/60 to 20/100 acuity, 5 had dry age-related macular degeneration and 5 had other retinal pathologic findings, including chronic cystoid macular edema, epiretinal membrane, diabetic retinopathy, and 2 eyes that had undergone multiple retinal detachment procedures.

Visual acuity of 20/200 or less occurred in 23 eyes (25%). Nine eyes developed graft failure with corneal edema, and 2 had early edema of the graft and retinal disease. In addition, 7 eyes had age-related macular degeneration, 3 eyes had optic atrophy, and 2 eyes had both amblyopia and glaucoma.

FINAL GRAFT STATUS

An optically clear keratoplasty was achieved in 81 eyes (88%) at the final visit. Eleven eyes (12%) had developed corneal edema.

DISCUSSION

The goal of penetrating keratoplasty is to achieve an optically clear transplant with early visual rehabilitation and stable visual function. We strive to minimize astigmatism and anisometropia by surgical technique and, postoperatively, by suture adjustment and manipulation. We previously demonstrated that selected removal of interrupted sutures reduces keratoplasty astigmatism; however, a myopic shift was induced with increasing number of interrupted sutures removed.[11] Presumably, as more sutures are removed, the curvature of the cornea becomes steeper and the myopic shift increases.

In a prospective, randomized clinical trial, visual rehabilitation with decreased postkeratoplasty astigmatism and more regular corneal topography has been attained more rapidly and safely with intraoperative suture adjustment.[17,18] Karabatsas and associates[15] have concluded that postkeratoplasty astigmatism can be decreased similarly with either adjustment of a single running suture or selective removal of interrupted sutures; they also concluded that there is no advantage of single continuous adjustable suturing over interrupted and continuous suturing.

The current study was undertaken to determine whether the myopic spherical equivalent and anisometropia could be reduced while achieving an acceptable degree of astigmatism. In an attempt to meet this goal, fewer interrupted sutures were removed, the continuous suture was made tighter than in the *Prior Study*, and the average predicted K reading was increased from 45.00 diopters in the previously reported study to 46.00 diopters in the *Current Study*, for calculations of IOL power in those eyes undergoing combined and IOL exchange or secondary placement.

Residual myopia, as measured by spherical equivalent, appears to be reduced in the *Current Study* at each of the five reported follow-up times. However, the resultant myopia was not significantly different from that obtained in the *Prior Study*. The greatest difference was demonstrated at the initial PSR time, and at the last visit, more than 1½ years following surgery.

Selective suture removal was modified in a conscious attempt to reduce anisometropia. Although we were not able to statistically demonstrate a significant reduction in myopia by eliminating those cases in which the fellow eye was myopic, nevertheless, the current study did result in a reduction in anisometropia compared to the *Prior Study* (2.49 ± 2.25 diopters versus 3.22 ± 2.27 diopters). Since the *Current Study* did not have the requirement of interrupted suture removal with astigmatism over 3 diopters, somewhat fewer interrupted sutures were removed in the *Current Study*.

By comparison, although we have demonstrated a reduction in spherical equivalent myopia and anisometropia, the resultant astigmatism was significantly increased by the last visit. This increase seems to result from the tighter retained, continuous suture, rather than the number of interrupted sutures removed, since there was no difference in the selective suture removal at the final examination (*Current Study*, 4.3 ± 2.7; *Prior Study*, 4.7 ± 2.6).

While it might be anticipated that retention of more interrupted sutures and a tighter continuous suture would result in an increase in irregular astigmatism, there was no difference in either SRI or SAI at any time interval. Except for a trial contact lens fitting, these two indexes are probably our best indicators of residual irregular astigmatism.

There is also a suggestion that the choice of using 46.00 diopters for IOL calculations in the *Current Study*, compared to 45.00 in the *Prior Study*, may be the most significant factor contributing to a lessening of the myopic spherical equivalent. In the *Current Study*, those patients that received an IOL, either as part of a combined penetrating keratoplasty and cataract extraction or as an IOL exchange or secondary IOL placement, had a significantly less myopic result than those eyes that underwent penetrating keratoplasty without IOL placement, at the examinations prior to suture removal, at 6 months, and at the completion of suture removal, but not for the final follow-up visit (Table II). In addition, a comparison of the *Current Study* to the *Prior Study*, for eyes that received IOL placement, demonstrates a trend toward less induced myopia in the *Current Study* prior to suture removal and at 6 months postoperatively (Table III).

CONCLUSION

A tighter continuous suture, an increase in the average keratometry to 46.00 diopters for IOL calculation, and somewhat less aggressive selective suture removal have resulted in the following:

- A trend toward reduction in residual postoperative myopia
- A significant increase in residual astigmatism
- No significant difference in irregular astigmatism, as measured by surface regularity index (SRI) and surface asymmetry index (SAI)
- A reduction in anisometropia
- An apparent greater reduction in myopia by using 46.00 diopters for calculations of IOL power for those eyes receiving IOL placement, in contrast to eyes undergoing penetrating keratoplasty without IOL placement

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DISCUSSION

Dr Woodford S. Van Meter. Dr Forster and colleagues have previously published in 1997 that removal of selective interrupted sutures can decrease postkeratoplasty astigmatism, an observation noted by multiple other corneal surgeons. The authors previously reported in 1997 that removal of multiple sutures was associated with more residual myopia than removal of fewer interrupted sutures. Today Dr Forster and Dr Dursun present a second cohort of patients in which treatment is altered to address residual myopia by (1) leaving more interrupted sutures in place (2) tying the continuous suture tighter and (3) using postoperative keratometry of 46 diopters instead of 45 diopters for the purposes of IOL calculation.

Data from the current cohort of 92 eyes in 84 patients are presented for spherical equivalent refraction, keratometry, refractive astigmatism, and three other parameters from video keratography: simulated keratometry, surface regularity index (SRI) and surface asymmetry index (SAI). Anisometropia is also examined in the current cohort, excluding monocular patients and patients with bilateral surgery. The results suggest that over 50% of patients had 2 diopters or less of anisometropia, (although the specific patient numbers and exclusion criteria were incomplete). Residual myopic spherical equivalent was reduced in the current study at each of the follow-up times, averaging 1 diopter at last visit, but the reduction was not statistically significant compared to the previous cohort. Of more interest, however, is the fact that, compared to the 1997 study, refractive astigmatism (P=.008), keratometry (P=.001) and simulated keratometry (P=.001) were all higher, suggesting that the tighter continuous suture, while reducing spherical equivalent, can increase residual corneal astigmatism with sutures in place.

The manifest refraction astigmatism associated with the tighter continuous suture shows that the mitigation of astigmatism and the control of spherical equivalent refraction are not parallel processes. One might sense that corneal surgeons should use suture adjustment to control astigmatism, which has been shown to make a statistically significant difference in reduction of astigmatism, and utilize IOL adjustment to reduce postoperative spherical equivalent error.

This paper could be strengthened by better stratification of data. Ten percent of patients had surgery on both eyes. Forty-one patients had an IOL implanted with postoperative keratometry adjusted to achieve more myopia, and 51 patients had a keratoplasty only without an IOL implant, leaving two variables that contribute to final spherical equivalent. It would be helpful to note spherical equivalent in those patients with suture adjustment alone, and whether the authors think that perhaps IOL adjustment is a better means of adjusting spherical equivalent than suture tension. There was no information for 19 patients on whether the intraocular lens was in the anterior chamber or posterior chamber (or sutured), and the effect of anterior chamber depth can be significant in dealing with a final end point that varies by 1 or 2 diopters of emmetropia. Finally, one would assume that with Dr Forster's experience, some of these patients might initially have less than 3 diopters of astigmatism and not need any suture adjustment; these patients are not identified but would be a helpful control against those patients in whom suture adjustment is attempted.

The authors underscore the difficulty in objective measurement of subjective changes in surgeon-specific technique. Page 6 of the manuscript reads, "The 12-bite 10-0 nylon continuous suture was then placed somewhat more tightly than the interrupted sutures after adjustment of the intraocular pressure to approximate normal tension".

The authors should also be commended for directing attention to the problems of spherical equivalent as well as astigmatism in confronting postoperative ametropia. Corneal surgeons have long known that the morbidity of 6 diopters of unexpected myopia is nearly as debilitating as 6 diopters of unexpected astigmatism. The authors demonstrate that while IOL power may be the predominant variable in determining postoperative spherical equivalent, other features, which are surgeon controlled and surgeon-specific, come into play in determining final refractive outcome.

In conclusion, my personal thanks go to the authors for their persistent efforts to control of postkeratoplasty astigmatism using suture adjustment. Because patients usually retain corneal sutures for many years, minimizing astigmatism by selective suture removal helps early visual rehabilitation in the majority of patients undergoing penetrating keratoplasty. I encourage the authors to continue following both cohorts of patients for suture-out astigmatism evaluation. Since large, unpredictable changes in astigmatism can occur whenever multiple sutures are removed, it will be interesting to see whether these variations in suture tension and IOL power calculation affect postoperative astigmatism and spherical equivalent after all sutures are removed.

Dr Richard C. Troutman: Were the final measurements taken with all the sutures out? Why didn't you separate cases into a single pathology, which might be more revealing? Might the difference in diameter of the corneal buttons be contributing to the myopia? The final astigmatism was expressed in refractive terms but the keratometric results might be more informative. In all corneal pathologies where vision is compromised, and in particular with keratoconus, it is important to perform penetrating keratoplasty early, rather than late, before these irreversible changes that induce the myopia and astigmatism take place.

Dr Verinder S. Nirankari. What happens when the sutures loosen or break and need to be removed?

Dr George O. Waring. I stopped using tight sutures years ago for two reasons: because it slowed the recovery time and, because it made the ocular surface more difficult to manage. Are you still tying the sutures tight? LASIK after the sutures are out can also be a reasonable adjustment technique.

Dr Richard K. Forster. I'd like to thank Woody Van Meter for his comments. As for Dick Troutman's comments, the continuous sutures were retained, and the interrupted sutures were selectively removed. I do think that the use of same-size grafts, which were only used in the keratoconus cases, may have a role in reducing postoperative myopia. Further to what George Waring mentioned, I think there is a place for using same-size grafts for reduction of anisometropia. For example, if you have a patient whom you want to achieve emmetropia or induce a little hyperopia, you may want to use a same-size graft, much like we do in keratoconus to reduce the myopia. On the other hand,if you want to induce myopia, that can be achieved with an oversized donor corneal button, slightly looser sutures, and selective suture removal. I definitely agree with the comments that the tighter sutures that we employed in this study do increase irregular astigmatism slightly and seem to induce more astigmatism in general, although they seem to reduce anisometropia and myopia. Therefore, we're trying to achieve the appropriate technique in order to ultimately achieve the best visual function after the surgical procedure.