Effect of disagreement between refractive, keratometric, and topographic determination of astigmatic axis on suture removal after penetrating keratoplasty

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Abstract

***Background/aims*—Post-keratoplasty astigmatism can be managed by selective suture removal in the steep axis. Corneal topography, keratometry, and refraction are used to determine the steep axis for suture removal. However, often there is a disagreement between the topographically determined steep axis and sutures to be removed and that determined by keratometry and refraction. The purpose of this study was to evaluate any difference in the effect of suture removal, on visual acuity and astigmatism, in patients where such a disagreement existed.**

***Methods*—37 cases (from 37 patients) of selective suture removal after penetrating keratoplasty, were included. In the first group "the disagreement group" (n=15) there was disagreement between corneal topography, keratometry, and refraction regarding the axis of astigmatism and sutures to be removed. In the second group "the agreement group" (n=22) there was agreement between corneal topography, keratometry, and refraction in the determination of the astigmatic axis and sutures to be removed. Sutures were removed according to the corneal topography, at least 5 months postoperatively. Vector analysis for change in astigmatism and visual acuity after suture removal was compared between groups.**

***Results*—In the disagreement group, the amount of vector corrected change in refractive, keratometric, and topographic astigmatism after suture removal was 3.45 (SD 2.34), 3.57 (1.63), and 2.83 (1.68) dioptres, respectively. In the agreement group, the amount of vector corrected change in refractive, keratometric, and topographic astigmatism was 5.95 (3.52), 5.37 (3.29), and 4.71 (2.69) dioptres respectively. This difference in the vector corrected change in astigmatism between groups was statistically significant, p values of 0.02, 0.03, and 0.03 respectively. Visual acuity changes were more favourable in the agreement group. Improvement or no change in visual acuity occurred in 90.9% in the agreement group compared with 73.3% of the disagreement group.**

***Conclusions*—Agreement between refraction, keratometry, and topography was associated with greater change in vector corrected astigmatism and was an indicator of good prognosis. Disagreement between refraction, keratometry, and topography was associated with less vector corrected change in astigmatism, a greater probability of decrease in visual acuity, and a relatively poor outcome following suture removal. However, patients in the disagreement group still have a greater chance of improvement than worsening, following suture removal.**

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Corneal astigmatism after penetrating keratoplasty (PK) is a common complication that can prevent a good visual outcome in an eye with a clear graft and an otherwise healthy visual system. It arises from many causes related to the recipient cornea,[1 2] trephination of the donor material,[3–5] trephination of the recipient bed,[6–10] suturing of the donor cornea to the recipient bed,[11–13] and during postoperative management.[14]

Many procedures are adopted to reduce astigmatism after corneal graft. Selective suture removal is the most common practice adopted postoperatively while the sutures are in place. The effect of suture removal on post-PK astigmatism has been documented in many studies.[15–19] The theoretical advantage of selective suture removal is that the surgeon can modify astigmatism while sutures are in place, allowing the patient to receive spectacles or contact lenses between the fifth to seventh postoperative month. However, it should be borne in mind that removal of two adjacent sutures early in the postoperative period could result in slippage and the formation of a step at the graft-host interface.

Clinical examination, refraction, keratometry, and topography are the standard tools used to define the sutures to be removed. Refraction and keratometry indicate only one steep corneal meridian while corneal topography can identify one or more steep semimeridians, which are not necessarily 180° apart. In most cases the astigmatism is fairly regular, and refraction, keratometry, and corneal topography indicate the same astigmatic meridian and identify the correct sutures to be removed. However, in some cases, despite the astigmatism being regular, and in most cases where the astigmatism is irregular, refraction, keratometry, and corneal topography are not always consistent in identifying the steep meridians/

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Table 1 Clinical characteristics of patients

Characteristic	Disagreement group No (%)	Agreement group No (%)
Sex		
Male	8 (53.3)	12 (54.5)
Female	7 (46.7)	10 (45.5)
Suture technique		
Combined	9 (60.0)	13 (59.1)
Interrupted	6 (40.0)	9 (40.9)
Presuture removal astigmatism		
Refraction (p = 0.265)	5.37 (1.79)	6.27 (2.71)
Keratometry (p = 0.158)	5.44 (2.24)	6.57 (2.40)
Topography (p = 0.094)	4.44 (2.20)	5.76 (2.32)
Postoperative period (months)		
Mean (SD)	10.33 (5.34)	8.27 (3.09)

p Values are for difference in astigmatism in the two groups as measured by refraction, keratometry, and topography.

Table 2 Indications for surgery by group

Indication for surgery	Number	
	Disagreement group	Agreement group
Keratoconus	5	5
Fuch's dystrophy	4	4
Keratitis (herpes simplex virus)	—	5
Pseudophakic bullous keratopathy	2	2
Regraft	1	3
Aphakic bullous keratopathy	—	2
Miscellaneous indications	3	1
Total	15	22

semimeridians and disagreement can occur among them. This disagreement creates some questions regarding selective suture removal in management of post-PK astigmatism. How does the astigmatism change after suture removal when there is a disagreement among refraction, keratometry, and topography? The purpose of this study was to evaluate whether agreement or disagreement between refraction, keratometry, and corneal topography has any influence on changes in astigmatism and visual acuity after suture removal.

Patients and methods

This prospective study included 37 eyes of 37 corneal graft patients subjected to selective suture removal for high post-PK astigmatism (more than 3 dioptres of refractive astigmatism). Consecutive patients with readable corneal topographic maps as well as recordable refraction and keratometry were considered. Cases with irregular astigmatism, where the topography pattern was such that the software was unable to provide a dioptric value and an axis, were not included. Thus, cases of irregular astigmatism of the mixed, steep/flat, localised steep, horseshoe, and unclassified categories, as described by Karabatsas *et al*[20] were excluded. Only one episode of suture removal (the first or second) for each patient was included. Suture removal was done 5 months or more after corneal graft. The patients were divided into two groups according to agreement or disagreement between refraction, keratometry, and topography in defining the sutures to be removed. When refraction, keratometry, and topography pointed to the same suture to be removed, they were considered to be in "agreement". This was within 11 degrees in cases secured with 16 interrupted sutures where the angle between every two sutures was 22.5 degrees, and within 15 degrees in cases secured with 12 interrupted sutures combined with a 12 bite running suture, where the angle between every two interrupted sutures was 30 degrees. The number of patients in the disagreement group was 15 (40.54%) and in the agreement group was 22 (59.46%). There were 20 males and 17 females. All cases had high post-keratoplasty astigmatism (refractive astigmatism >3 D). The disagreement group included four cases with regular astigmatism, three cases with oblique astigmatism, and eight cases with bi-oblique astigmatism (prolate irregular, oblate irregular, and triple).[20] The agreement group included 13 cases with regular astigmatism, six cases with oblique astigmatism, and three cases with bi-oblique astigmatism (prolate irregular, oblate irregular, and triple).[20] Suture technique used to secure the corneal grafts was either 16 interrupted 10-0 nylon sutures or a 12 interrupted 10-0 nylon sutures combined with a 12 bite single running 10-0 nylon suture (Table 1). The indication for corneal grafts was keratoconus in 10 cases, Fuch's endothelial dystrophy in eight cases, corneal scarring due to viral keratitis in six cases, bullous keratopathy in six cases, and other miscellaneous indications in seven cases (Table 2).

Each patient followed a protocol of examination including measurement of uncorrected and best corrected visual acuity. A trained optometrist performed refraction and keratometry, and the steep meridian was defined. Sutures that would be removed according to refraction and keratometry were identified as the two sutures, one at either end, of the steep meridian. No sutures were removed according to refraction and keratometry. Corneal topography was done with EyeSys corneal analysis system (Houston, TX, USA) and the sutures to be removed were defined on the topographic map. All sutures were removed according to the topographic examination—that is, in the steep semimeridians. Only two sutures, one relating to each steep semimeridian, were removed. Agreement or disagreement between refraction, keratometry, and topography were noted and recorded.

After 4–6 weeks, all patients were reexamined including measurement of uncorrected and best corrected visual acuity, refraction, keratometry, and topography. Presuture and post-suture removal results were compared regarding change in astigmatism and visual acuity.

CALCULATION OF NET DECREASE IN ASTIGMATISM

In refraction and keratometry: by subtraction of the amount of astigmatism before and after suture removal regardless of changes in axis.

In topography: by subtraction of post-suture removal dk value (difference in the topography generated simulated keratometry values between the steep and flat meridians) from that of the pre-suture removal dk value.

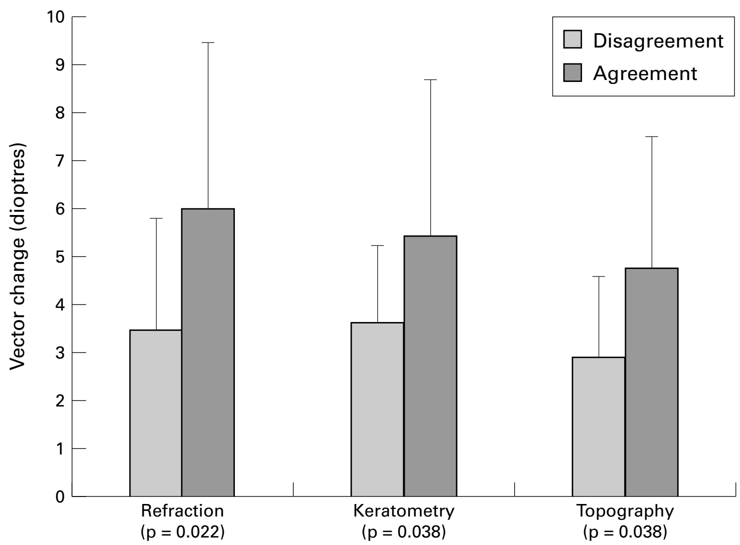

Figure 1 Vector corrected change in astigmatism after suture removal in the two groups. There was a statistically significant increase in vector corrected change in astigmatism, measured by refraction, keratometry, and topography, following suture removal in the agreement group when compared with the disagreement group.

Table 3 Best corrected visual acuity change and vector corrected change in astigmatism after suture removal. There was no significant difference in the vector corrected change in astigmatism between patients where visual acuity decreased and did not decrease (remained same or improved) following suture removal

Visual acuity	*Refraction Mean (SD)*	*Keratometry Mean (SD)*	*Topography Mean (SD)*
Decreased (n=6)	4.61 (2.83)	4.22 (1.81)	3.08 (1.42)
Not decreased (n=31)	5.05 (3.49)	4.73 (3.04)	4.11 (2.63)
Statistical significance	NS	NS	NS

NS = not significant.

CALCULATION OF VECTOR CORRECTED CHANGE IN ASTIGMATISM

This includes measurement of the change in refractive, keratometric, and topographic astigmatism after suture removal regarding the axis shift and amount of astigmatism, as proposed by Jaffe and Clayman.[21]

VISUAL ACUITY CHANGES

Standard projected Snellen visual acuity chart was used for measurement of both uncorrected and best corrected visual acuity (UCVA and BCVA respectively). Visual acuity was considered improved if it improved by one line or more on the standard Snellen's chart measured by an experienced optometrist under a standard level of illumination. It was considered decreased if visual acuity decreased by one line or more and not changed if the patient achieved the same line on the chart. This was applied to both uncorrected and best corrected visual acuity. The relation of BCVA to net decrease in astigmatism and vector corrected change in astigmatism was investigated.

STATISTICAL ANALYSIS

Student's *t* test and χ^2 were used for statistical analysis. A p value <0.05 was considered statistically significant.

Results

The demographic data of patients in the present study showed no statistically significant differences between the two groups in age, sex, follow up period, suture technique, and diagnosis.

PRESUTURE REMOVAL VALUE OF ASTIGMATISM IN THE TWO GROUPS

Disagreement group: refraction was 5.37 (SD 1.79), keratometry was 5.44 (2.24), and topography was 4.44 (2.2).

Agreement group: refraction was 6.27 (2.71), keratometry was 6.57 (2.4), and topography was 5.76 (2.32).

The difference between these values (mean (SD)) was not statistically significant (p = 0.265, 0.158, and 0.094 respectively).

VECTOR CORRECTED CHANGES IN ASTIGMATISM AFTER SUTURE REMOVAL (BY JAFFE VECTOR ANALYSIS)

The result of vector analysis showed that the change in astigmatism in refraction, keratometry, and topography after suture removal was significantly higher in the agreement group than in the disagreement group (Fig 1). The mean of change in refractive astigmatism in the disagreement group was 3.45 (2.34) dioptres (D) and in the agreement group was 5.95 (3.52) D. This difference was statistically significant (p value = 0.02). The mean of change in keratometric astigmatism was 3.57 (1.63) D in the disagreement group and 5.37 (3.29) D in the agreement group. This difference was statistically significant (p value = 0.03). A similar result was found in topographic astigmatism where the mean change was 2.83 (1.68) D in the disagreement group and 4.71 (2.69) D in the agreement group (p = 0.03). Figure 1 shows the vector corrected change in astigmatism in refraction, keratometry, and topography in the two groups.

VISUAL ACUITY CHANGES AFTER SUTURE REMOVAL

The study showed that the percentage of patients with reduction in best corrected visual acuity following suture removal was lower in the agreement group (9.1%) than in the disagreement group (26.7%). However, this difference was not statistically significant (p=0.1544).

RELATION BETWEEN VECTOR CORRECTED CHANGE IN ASTIGMATISM AND CHANGE IN BEST CORRECTED VISUAL ACUITY

There was a trend towards a greater change in astigmatism (by refraction, keratometry, and topography) in the group with no decrease in visual acuity compared with the group with decrease in visual acuity. The difference between the mean of vector corrected change in astigmatism in the two groups was not statistically significant, as calculated by unpaired *t* test. Table 3 shows the amount of vector corrected change in astigmatism by refraction, keratometry, and topography in patients with decreased visual acuity and in patients in whom visual acuity had not decreased (remained same or improved).

Discussion

This study showed that cases with agreement among refraction, keratometry, and topography in identifying the sutures requiring removal for management of post-keratoplasty astigmatism had higher vector corrected change in astigmatism after suture removal than cases with disagreement.

Refraction and keratometry are limited to describing astigmatism as one steep and one flat meridian, which is inaccurate in keratoplasty patients who have irregular or complex astigmatism.[22]

Computer assisted corneal topography was used to assess the nature of post-keratoplasty astigmatism to identify the location of transverse keratotomies by Maguire and Bourne[23] and Frangieh *et al*.[24] They reported that the steep hemimeridians are typically separated by an angle other than 180° and the flat hemimeridians are often not orthogonal to the steep hemimeridians. There is often asymmetry of power between the two major hemimeridians. They suggested that the steep meridian of post-keratoplasty astigmatism is better conceptualised as two steep hemimeridians. This concept of steep hemimeridians creates a greater chance of disagreement or inconsistency between refraction, keratometry, and topography in identifying the steep meridian.

This inconsistency or disagreement between refraction, keratometry, and topography raises some questions regarding selective suture removal for management of post-keratoplasty astigmatism. How does the astigmatism change after suture removal when there is a disagreement among refraction, keratometry, and topography? Which guide should we follow if there is disagreement? In the present study, we followed corneal topography as a guide for removal of sutures as it covers a greater surface area of the cornea and provides more information in cases of irregular astigmatism. There was disagreement between refraction, keratometry, and topography in 15 (40.54%) cases, which reflects the high incidence of its occurrence.

Disagreement between refraction, keratometry, and topography in the steep meridian could be theoretically related to many factors. Refraction can differ from keratometry and topography due to the effect of other refractive interfaces such as naturally occurring lenticular astigmatism or a tilted intraocular lens and the astigmatism of the posterior surface of the cornea, which cannot be measured with keratometry or Placido disc based corneal topography. (New topography machines based on slit photography to measure the power and astigmatism of the posterior surface of the cornea may help resolve this specific issue.) Similarly, topography can differ from keratometry and refraction as the three measurements may not describe the same part of the cornea[25] or they may be variably influenced by the high incidence of irregular post-keratoplasty astigmatism. This degree of astigmatic irregularity may be more important in the predictability of suture removal than the amount of astigmatism or the number of sutures removed.

Strelow and colleagues[22] evaluated the role of computer assisted corneal topography in selective suture removal to reduce astigmatism. They reported that the preliminary choice of sutures to be removed on the basis of refraction, keratometry, and inspection was changed in 20 (69%) of 29 cases, when information added by the topographic map was considered. Topographic guidance for suture removal resulted in a net decrease in refractive and keratometric astigmatism in 21 (72%) cases. The net reduction in astigmatism averaged 1.4, 0.9, and 1.0 D when measured by refraction, keratometry, and topography respectively. They also found that reduction of astigmatism was not different when the clinically chosen suture was changed on the basis of topography.

In comparison with the work of Strelow and colleagues, this study showed that selection of the sutures to be removed according to refraction and keratometry was changed in 15 (40.54%) of 37 cases. There was a reduction in net astigmatism in refraction, keratometry, and topography even when topography changed the selection suggested by refraction and keratometry. The present study showed a reduction in astigmatism in 26 (70%) of 37 cases. This frequency was comparable to the work of Sterlow *et al*.[22] However, there was a net reduction in astigmatism of 1.07, 1.61, and 1.49 dioptres in refraction, keratometry, and topography respectively in the disagreement group, and 2.22, 2.26, and 1.95 dioptres in the agreement group. The reduction of astigmatism in this study appears to be greater than in Sterlow's results especially in the agreement group. This difference in reduction in the magnitude of astigmatism between the disagreement group and agreement group was significant although there was no significant difference in the pre-suture removal astigmatism in the two groups (Fig 1 and Table 1).

Agreement between refraction, keratometry, and topography in the astigmatic axis was associated with a trend towards more reduction in net (absolute) astigmatism in the disagreement group. The difference between groups was statistically significant when calculated by vector analysis. The higher amount of vector corrected change and net reduction in astigmatism in the agreement group, despite lack of any significant difference in the groups before suture removal, may indicate increased accuracy in estimation of the sutures requiring removal. A more complete reduction in the agreement group could also be due to the remaining sutures being of appropriate tension. In the disagreement group more than one episode of suture removal may be required to obtain optimum results, as there is likely to be greater than one semimeridian/meridian in which the sutures are too tight. In irregular astigmatism factors other than suture tension, such as horizontal and vertical misalignment, may be operative and are unlikely to be corrected by suture removal. However, in this study both groups had patients with irregular and regular astigmatism. Hence, this would not entirely explain the greater effect of suture removal in the agreement group.

The improvement in visual acuity was comparable in both groups. There was more chance of a decrease in best corrected visual acuity in the disagreement group. This could be theoretically explained by increased irregular astigmatism or decreased accuracy of selection of the sutures to be removed in cases with disagreement. Other factors, such as vertical or horizontal wound misalignment or the necessity for multiple suture removal in the disagreement group, may also contribute.

The current topography guided criteria for removing sutures to decrease high astigmatism (>3DC) may be questioned. Rather than just removing sutures as indicated by topography, the fact whether there is agreement or disagreement between topography and refraction/keratometry, should probably also be taken into consideration. Perhaps, on occasions when there is disagreement, it may be worthwhile looking at the refraction indicated suture to determine whether it appears tighter than the topography indicated suture. In our opinion, attempts should be made early in the postoperative period (5–6 months) to reduce high astigmatism, particularly in patients where a combined suture technique is used. Early removal of some of the interrupted sutures can be undertaken with less risk of wound slippage or dehiscence, when the running suture is still in place. This should enable early visual rehabilitation by promoting comfortable (temporary) spectacle wearing.

We conclude that in patients with corneal grafts, agreement between refraction, keratometry, and topography is associated with higher vector corrected change in astigmatism and a larger net reduction in astigmatism following topography guided suture removal. Disagreement between refraction, keratometry, and topography is associated with greater probability of decrease in visual acuity following removal of topography guided sutures. This should be borne in mind, although in the majority of patients the visual acuity would improve. When there is disagreement between topography and refraction/keratometry, more than one episode of topography guided suture removal may be required to obtain optimal results.

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