

Original article

Keratometric astigmatism evaluation after trabeculectomy

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Abstract

Introduction: Post-operative astigmatism is one of the most important causes for diminution of vision after trabeculectomy. **Objective:** To evaluate the induced corneal astigmatism following trabeculectomy with the use of 8-0 silk suture. **Materials and methods:** A prospective interventional study was done including 100 consecutive eyes of 84 patients who underwent trabeculectomy with the use of 8-0 silk suture. The post-operative induced astigmatism on the 1st post-operative day, 3rd week and after 6 months was determined. **Statistics:** Vector analysis was performed on the data using a computerized method for calculating the surgically induced astigmatism (SIA) for each eye at every time point postoperatively. In order to analyze group changes, we also performed vector decomposition which gave us a mathematical expression of the changes in astigmatism “with the rule” (WTR) or “against the rule” (ATR). **Results:** The mean age of all the patients was 53.31 ± 11.39 years. The mean 1st post-operative surgically induced astigmatism (SIA) was 2.73 D (99 degree) which reduced to 0.41 D (58 degree) at the 3rd week and 0.43 (21 degree) at 6 months. The mean WTR astigmatism was 4.46 D and ART astigmatism was 1.42 D on the 1st post-operative day which was significantly high ($p < 0.0001$). At the 3rd week and 6 months WTR astigmatism (1.40 D and 1.08D) and ATR astigmatism (1.27 D and 1.10 D) showed no significant changes ($p = 0.69, 0.97$ respectively). **Conclusion:** Trabeculectomy with the use of 8/0 silk sutures showed significantly high 1st post-operative day SIA which nevertheless perished fast to a minimum amount at just 3 weeks.

Keywords: keratometer, computerized surgically induced astigmatism calculator, astigmatism, trabeculectomy

Introduction

Trabeculectomy, since its introduction in 1968 (Cairns, 1968) has become the gold standard surgical procedure for progressive open angle glaucoma. Post-operative astigmatism is one of the most important causes for diminution of vision.

Materials and methods

This was a prospective interventional study conducted between March 2011-2012. Following

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ethics committee approval and informed consent. A total 100 eyes of 84 patients were taken. The patients who presented in glaucoma clinic and were advised filtration surgery were included in this study. None of the eyes had any previous ocular surgery or significant corneal opacity. All surgeries were done by two experienced surgeons. A fornix based conjunctival flap was fashioned. Sufficient scleral cautery was then performed using a battery powered bipolar cautery. A 3 mm x 4 mm rectangular sclera trap door was constructed at

the 90 degree meridian and an anteriorly positioned internal sclerostomy of size 1 - 1.5 mm in diameter was achieved with a Kellys punch. A small basal peripheral iridectomy was performed. Superficial sclera flap was sutured with two 8/0 silk sutures. The conjunctiva was closed with the same suture material. The postoperative medications routinely used were atropine 1% drops three times a day for one week, antibiotic- steroids drops for one month in a tapering dose. No suture manipulations by laser or otherwise were done post-operatively.

Statistics

The data were analysed using the automated keratometry (Nikon Retinomax Kplus 2) and SIA calculator version 2.1 were performed at 1st post op day, 3 weeks and 6 months post-operatively. Vector analysis was performed on the data using a computerised method of calculating the surgically induced astigmatism (SIA) for each eye at every time point postoperatively.

All changes were compared with the preoperative data set and expressed in terms of plus cylinders. SIA is based on the theory that the combination of two cross spherocylinders produces a third spherocylinder. This provides a vector of induced cylinder for each eye at each time point.

Each astigmatism data was converted into Cartesian coordinates based system, where each astigmatism vector was assigned a position represented (x, y) $x = a \cos 2p$ where **a** is magnitude of astigmatism $y = a \sin 2p$ where **p** is the axis of steep meridian. x and y values generated for both pre op and postoperative data. Thus we now have **Xpre, Ypre** and **Xpost, Ypost**.

To calculate SIA

$$X_{SIA} = X_{post} - X_{pre}$$

$$Y_{SIA} = Y_{post} - Y_{pre}$$

Astigmatism vector

$$\text{Magnitude} = \sqrt{X_{SIA}^2 + Y_{SIA}^2}$$

$$\text{Angle} = 0.5 \times \text{arc tan} (Y_{SIA} / X_{SIA})$$

With this equation we analysed the aggregate astigmatism data (centroid) by using mean X- Y value of pre, post and SIA .

In order to analyse group changes, we also performed vector decomposition which gave us a mathematical expression of the changes in astigmatism “with the rule” (WTR) or “against the rule” (ATR). WTR astigmatism is defined as corneal steepening in the vertical meridian corresponding to a positive induced cylinder at 90 degrees and ATR being the reverse. This results in magnitude of change WTR and ATR for each eye. Student paired- t test was performed on the collective WTR and ATR data at each time point to determine whether there was a statistically significant induction of astigmatism in either axis with respect to the other.

Results

Mean age of all case was 53.31 11.39 years. Out of the 32 eyes of 27 patients, 12 (44.4 %) were male and 15(55.5 %) were female patient. The mean (SD) preoperative intraocular pressure (IOP) on medications was 23.38 (9.78) mm Hg and the mean (SD) IOP at the 1st post operative was 13.91(4.20) mm Hg. (p < 0.0001 by paired t test) and at 3rd week- 12.44 (2.79) mm Hg (p< 0.0001) , and at 6 month was 12.38(3.34) mm Hg (p< 0.0001) None was receiving anti glaucoma medications at 6 months following surgery. Post-op IOP reduction was 40.50% 46.79%, 47.04% at 1st post op, 3rd week and 6 months respectively (table 1).

Table 1

Mean (SD) IOP, measured at pre operative post operative and % reduction . p value calculated by student paired t test.

	MEAN (mm Hg)	SD	% Reduction
Pre- operative (with medication)	23.38	9.78	
1 ST post operative day	13.91 (P <0.0001)	4.20	40.50%
3 RD WEEK	12.44 (P<0.0001)	2.79	46.79%
6 TH MONTH	12.38 (P<0.0001)	3.34	47.04%



Astigmatism (as plus cylindrical formate) was calculated by vector analysis. Pre operative and post operative values for 32 eyes at each time point are given in Table 2(a, b,c,). Table 2 (a) indicates vector analysis at 1st post-op day.

The mean pre-operative astigmatism was 0.13D x159 degrees and surgical induced astigmatism

(SIA) was + 2.73D x 99 degrees at 1st post operative day that was significantly high with the rule (WTR) astigmatism. Mean SIA at 3rd week was +0.41D x 58 degrees (WTR), and at 6th month it was 0.43 D x 21 degrees which is against the rule astigmatism (ATR) .

Table 2(a) vector astigmatism analysis at 3rd week. x and y represent cartesian coordinates of vector coherence indicate reliability of centroid (mean astigmatism)

	Mean (SD) X	Mean (SD) Y	Mean astigmatism (Centroid) Magnitude x axis	coherence
Pre op	0.10 (1.08)	- 0.08 (0.77)	0.13 D x 159 degrees	14%
Post op	- 2.49 (3.25)	-0.95 (1.63)	2.67 D x 101 degrees	71%
SIA	-2.58 (3.10)	-0.87 (1.94)	2.73 D x 99 degrees	72 %

Table 2 (b) Vector astigmatism analysis at 3rd week. The X and Y represent Cartesian coordinates of vector. Coherence indicates reliability of mean astigmatism.

	Mean (SD) X	Mean (SD) Y	Mean astigmatism (Centroid) Magnitude x axis	coherence
Pre op	0.10 (1.08)	- 0.08 (0.77)	0.13 D x 159 degrees	14%
Post op	-0.09 (1.24)	0.28 (0.85)	0.29 D x 54 degrees	61%
SIA	-0.18 (1.15)	0.36 (1.05)	0.41 D x 58 degrees	51%

Table 2(c): The vector astigmatism analysis at 6th months. x and y represent cartesian coordinates of vector .coherence indicate reliability of centroid (mean astigmatism)

	Mean (SD) X	Mean (SD) Y	Mean astigmatism (Centroid) Magnitude x axis	coherence
Pre op	0.10 (1.08)	- 0.08 (0.77)	0.13 D x 159 degrees	14%
Post op	0.40(1.04)	0.20 (0.58)	0.46 D x 13 degrees	47%
SIA	0.31(1.04)	0.29(0.58)	0.43 D x 21 degrees	39%

Table 3 shows the mean decomposed vectors at each time point. The statistical p values relate to comparison of WTR and ATR induced cylinders at each time point by the Welch’s unpaired t test. The mean (SD) pre-operative WTR and ATR astigmatism was 1.03 (1.13) D and 0.84 (0.77) respectively (p=0.57). On the 1st post-operative day induced astigmatism, the WTR and ATR was 4.46 (2.36) and 1.42 (1.14) respectively (p < 0.0001) . On the 1st post-op day the WTR astigmatism was significantly high. On the 3rd week, the induced WTR and ATR was 1.40 (0.76) and 1.27 (0.99) respectively (p 0.69). After 6 months, the mean WTR (SD) and ATR

astigmatism was 1.08 (0.95) and 1.10 (0.88) respectively (p =0.97). At 6 months, the mean ATR astigmatism was higher than WTR but statistically was not significant.

Table 3

Mean (SD) decomposed vector measured by automated keratometry, preoperative and post operative (1st post op, 3rd weeks and 6 months) of 32 eye.

	WTR	ATR	P value
Pre-op	1.03 (1.13)	0.84 (0.77)	0.57
1 st post op	4.46 (2.36)	1.42 (1.14)	0.0001
3 rd week	1.40 (0.76)	1.27 (0.99)	0.69
6. months	1.08 (0.95)	1.10 (0.88)	0.97



WTR = with the rule astigmatism (vertical steepening) measured in dioptres; ATR = against the rule astigmatism (vertical flattening) measured in dioptres. p = probability value by Welch's unpaired t test

Discussion

Trabeculectomy has been shown to control IOP well in long term. Altered visual function induced by changes in corneal curvature following filtration surgery may be distressing to the patient, particularly when changes are marked and continue beyond the first few postoperative months. When measured by automated keratometry, the astigmatism induced in our study was significantly greater 2.73D (100 degree) only at the 1st post-op day which fastly decayed to minimum amount after 3rd week and 6 months (0.41D and 0.43D respectively). In this study we found high astigmatism at first post op day due tightly placed suture. Here we used 8-0 silk suture which has a property to loosen up with time .so we practice to apply tight sutures intraoperatively to reduce the risk of post operative sclera flap leakage and shallow anterior chamber. Deep cautery also contribute to induced astigmatism. Regarding post operative bleb formation and IOP control we found there was well formed bleb and significant IOP control .

The first study to report the changes in corneal curvature following trabeculectomy was done by Hugkulstone (1991). He used an automated keratometer which recorded a mean induced with the rule astigmatic induction of 1 D at 7 weeks following a traditional sized procedure (5x5 mm scleral trap door) and sclera flap secured by use of 9/0 virgin silk suture in 10 eyes. He also notice an immediate initial corresponding increase in horizontal radius, but this is not apparent by two and seven week after surgery.

Claridge et al (1995) using the TMS system that they could identify three subgroups of eyes at 1 and 3 months postoperatively. The largest group had an induced superior steepening of the cornea resulting in a mean WTR astigmatism of about 1D (measured by polar values) which persisted to 1

year following surgery. These results were on eyes which had a 4x3 mm scleral trap door with two 10/0 nylon sutures.

Vernon et al (1999) reported in a study of small flap (2mm x 2mm sclera trap door and 0.75 mm internal sclerotomy) trabeculectomy procedure performed at the 90 degrees meridian on 16 eyes with the use of 10-0 nylon suture. By vector analysis, the mean surgically induced refractive changes (SIRC) in cylinder power vectors induced at 1, 3, 6, and 12 months as measured by manual keratometry were 0.68, 0.38, 0.52, and 0.55 dioptres, and by keratography 0.75, 0.66, 0.59, and 0.64 dioptres. Vector decomposition on the induced vector cylinders on manual keratometry resulted in a "with the rule" mean vector of 0.52 and 0.22 dioptres at 1 and 3 months and an "against the rule" mean vector of 0.16 and 0.16 dioptres at the same time points ($p=0.03$ and 0.28 respectively). The vector decomposition at 6 and 12 months revealed no significant with-the-rule changes. Similar analysis on the videokeratotomy results revealed a significant induced with-the-rule astigmatism until 3 months, but not at 6 and 12 months postoperatively. In comparison, our study showed a high induced astigmatism only at first post op day but at 6th months the mean induced astigmatism was even less than that of microtrabeculectomy

Cunliffe et al (1992) in a study on 16 eyes with manual keratometry utilising a slightly smaller scleral trap door (5x3 mm), found a significant WTR astigmatism up to 2 months but not at 10 months. Unfortunately, there were no intermediate analysis time points in this study.

Rosen et al (1992) used a 3x2 mm scleral trap door and 10/0 nylon suture. The mean vector power induced at 3 months in the study was 1.24 D which is more than what we achieved, 0.41D at just 3 weeks ($p < 0.001$).

Rosen et al (1992) found that five of the eight eyes studied developed between 1.5 and 2.5 D induced astigmatism at 3 months postoperatively when measured with the topographic modeling system (TMS).

A number of suggestions have been put forward to explain the WTR astigmatism induced by the trabeculectomy procedure. Hugkulstone (and later Dietze et al, 1997) mentioned the possibility of tight sutures and suggested a "posteriorly placed wound gape" from the internal sclerostomy as the cause. Cunliffe et al (1992) suggested that the internal sclerostomy allowed the corneal edge of the trabeculectomy to sink slightly thus decreasing the vertical radius of the cornea. Rosen et al (1992) considered that the cautery was the main factor as the induced astigmatism appeared to be greater when excessive cautery was used in one patient. Vernon et al (1998) suggested that the size of internal sclerostomy and amount of cautery play a main role in induced astigmatism.

Conclusion

Trabeculectomy with the use of 8/0 silk sutures showed significantly high 1st post-operative day SIA which nevertheless perished fast to minimum amount at just 3 weeks.

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