Changes in corneal topography following 25-gauge transconjunctival sutureless vitrectomy versus 20-gauge standard vitrectomy

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Short title: Corneal changes in 25- and 20-gauge vitrectomy

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Abstract

Purpose: To evaluate the changes in regular and irregular corneal astigmatism after 25-gauge transconjunctival sutureless vitrectomy and 20-gauge standard vitrectomy.

Design: Prospective observational comparative case series.

Participants: Subjects were 32 eyes of 32 patients undergoing 25-gauge transconjunctival sutureless vitrectomy (25G group) and 25 eyes of 24 patients undergoing 20-gauge standard vitrectomy (20G group).

Methods: Corneal topography was obtained preoperatively and at 2 weeks and 1 month postoperatively.

Main Outcome Measures: The dioptric data of the central 3mm zone of the cornea were decomposed using Fourier harmonic analysis into spherical power, regular astigmatism, asymmetry, and higher-order irregularity.

Results: None of the four Fourier indices changed throughout the observation period in the 25G group. In the 20G group, regular astigmatism, asymmetry, and higher-order irregularity were increased significantly at 2 weeks after vitrectomy ($p<0.05$, Wilcoxon signed-ranks test), and returned to the preoperative levels by 1 month. The spherical power in the 20G group did not change after surgery. For regular astigmatism, asymmetry and higher-order irregularity, the 20G group showed significantly greater surgically induced changes than the 25G group ($p<0.05$, Mann-Whitney's U test).

Conclusions: The 25G transconjunctival sutureless vitrectomy does not induce significant changes in corneal topography, and exerts little influence on the optical quality of the cornea.

Introduction

In recent years, the 25-gauge transconjunctival sutureless vitrectomy system has been developed as a more beneficial and less invasive surgery method than the conventional 20-gauge vitrectomy system. [1,2] The advantages of sutureless, small-gauge vitrectomy include technical simplicity without conjunctival dissection and scleral suturing, less traumatic conjunctival and scleral manipulation, reduced operative time, less intraocular inflammation, and more rapid postoperative visual recovery. [3,4] Therefore, the current 25-gauge transconjunctival sutureless vitrectomy may have less influence on the corneal optical quality after surgery.

Several studies have shown that the corneal contour is significantly changed by 20-gauge standard vitrectomy, inducing postoperative astigmatism. [5-9] The induced astigmatism is usually transient and returns to the baseline level by one to four months after surgery. [5-7] The increase in the postoperative astigmatism may be attributed to the scleral cautery and suturing at the entry port. On the other hand, there have been very few studies on the astigmatic changes after 25-gauge transconjunctival sutureless vitrectomy. Yanyali et al concluded that regular and irregular astigmatism of the cornea did not change when 25-gauge transconjunctival sutureless vitrectomy was used. [10]

Fourier harmonic analyses of corneal topography have been utilized to quantitatively evaluate regular and irregular astigmatism of the cornea. [11] The Fourier method has been applied to the investigation of optical quality of the cornea in eyes with keratoconus, [11-13] pterygium, [14] cataract surgery, [15-17] trabeculectomy, [18] scleral buckling, [19] photorefractive keratectomy, [20-22] penetrating keratoplasty, [11,23,24] overnight orthokeratology, [25] and laser in situ keratomileusis. [26] However, changes in irregular astigmatism after either 25- or 20-gauge vitrectomy have not been reported. This study compared the changes in regular and irregular corneal astigmatism after 25-gauge transconjunctival sutureless vitrectomy and 20-gauge standard vitrectomy.

Methods

Patients

Fifty-seven eyes of 56 patients undergoing pars plana vitrectomy were included in this study. The patients' demographics are summarized in Table 1. A total of 32 eyes of 32 patients underwent a 25-gauge transconjunctival sutureless vitrectomy (25G group), and 25 eyes of 24 patients received a 20-gauge conventional vitrectomy (20G-group). Exclusion criteria were patients with previous history of ocular surgery, those having corneal diseases and severe refractive error, and moderate and severe cataract. Eyes with complicated vitreoretinal disease such as proliferative vitreoretinopathy, retinal detachment with giant retinal tears, and trauma-induced vitreoretinopathy were also excluded. Eligible patients were randomly assigned to the 25G and 20G group. Indications for vitrectomy were proliferative diabetic retinopathy (13 eyes in the 25G group and 20 eyes in the 20G group), macular hole (8 eyes in the 25G group and 4 eyes in the 20G group), rhegmatogenous retinal detachment (3 eyes in the 25G group and 3 eyes in the 20G group), vitreous hemorrhage (2 eyes in the 25G group and 3 eyes in the 20G group), epiretinal membrane (5 eyes in the 25G group and 0 eyes in the 20G group), and diabetic macular edema (1 eye in the 25G group and 0 eyes in the 20G group).

Surgery

All surgeries were performed under local sub-Tenon anesthesia by a single surgeon (F.O.). The 25G group underwent vitrectomy using the Millennium 25-gauge

Transconjunctival Standard Vitrectomy System (TSV25, Bausch & Lomb, Rochester, NY, USA). Three 25-gauge cannulas were inserted transconjunctively into the eye by means of a beveled trocar. The trocars were then removed. A sutureless contact lens was used to facilitate posterior visualization. A core vitrectomy was performed and a detachment of the posterior hyaloid was induced. Surgery was completed by removal of the entry site alignment cannulas without suture of the conjunctiva and sclera. All 20-gauge surgical procedures were performed using the Alcon Accurus Vitrectomy System. Conjunctival peritomy was performed in the superotemporal and superonasal quadrants, and the sclera was exposed and cautery was applied for hemostasis. 20-gauge sclerotomies were applied and an infusion cannula positioned. At the end of surgery the sclerotomies and the conjunctiva were closed using a 8-0 virgin silk suture.

In both groups, anterior pars plana sclerotomies were performed 4.0 mm posterior to the corneal limbus at the 2-, 9-, 10-o'clock directions in right eyes, and at 2-, 3-, 10-o'clock directions in left eyes. At the completion of surgery, inferonasal subconjunctival antibiotics and corticosteroids were injected in all cases.

Assessment of corneal topography

Corneal topography was obtained using a videokeratography system (TMS-2N, Tomey Co, Japan) before surgery and at 2 weeks and 1 month after surgery. At each measurement point, three topographic images were obtained, and the best-quality measurement was analyzed for regular and irregular astigmatism using the Fourier harmonic method, as described elsewhere.[11,23,27,28] The corneal topography data were obtained in a masked fashion by an experienced examiner (C.O.). The dioptric power of all measurement points was downloaded. Using the Fourier series harmonic analysis, dioptric powers on a mire ring *i*, $F_i(\alpha)$, was transformed into trigonometric components of the following form:

$$F_i(\alpha) = \alpha_0 + c_1\cos(\alpha-\alpha_1) + c_2\cos2(\alpha-\alpha_2) + c_3\cos3(\alpha-\alpha_3) + \ldots + c_n\cos n(\alpha-\alpha_n)$$

Where α_0 is the spherical equivalent of the ring, $2c_1$ is the asymmetry (tilt or decentration), $2c_2$ is the regular astigmatism, and $c_{3\ldots n}$ is the higher-order irregularity components. Among these, the spherical equivalent power (α_0) and regular astigmatism (second harmonic component, n = 2) can be corrected by a spherocylinder lens, whereas the remaining components (n = 1 and n >=3) cannot. Thus, $2c_1$ and $c_{3\ldots n}$ represent corneal irregular astigmatism in a broad sense. Those indices were calculated on rings 1 through 9, which correspond to the central 3-mm zone.[11] Calculation was performed separately for each ring, and the data were averaged to compute a set of data for a given eye.

The research followed the tenets of the Declaration of Helsinki, and informed consent was obtained from all subjects after explanation of the nature and possible consequences of the study.

Results

In all 57 eyes, no intraoperative complications occurred. In addition, none of the 32 eyes in the 25G group required conversion to conventional 20-gauge vitrectomy, or sutures to close leaking sclerotomies. Although intraocular pressure remained stable throughout the postoperative course in most eyes, 2 eyes in the 25G group exhibited shallow choroidal detachments, which resolved by day 5. Fifteen of 32 eyes in the 25G group and 15 of 25 eyes in the 20G group were filled with gas (20%SF_6). Five of 32 eyes in the 25G group presented on day one with a localized bleb, but all resolved by day 7.

Table 2 summarizes the mean and standard deviation of the Fourier indices in the two groups. Preoperatively, each Fourier index did not differ significantly between the 25G and 20G groups, and all Fourier indices in both groups were within the normal range as reported previously;[29] spherical power 40.81 - 47.13 D, regular astigmatism 0 - 1.04 D, asymmetry 0.02 - 0.68 D, and higher-order irregularity 0.05 - 0.17 D28.

Postoperatively, the 25G group did not show any significant change in any Fourier indices throughout the observation period. The 20G group showed a significant increase at 2 weeks after surgery in the regular astigmatism ($p < 0.05$, Wilcoxon signed-ranks test), asymmetry ($p < 0.01$), and higher-order irregularity ($p < 0.01$), which returned to the preoperative levels by 1 month after surgery. The spherical power in the 20G group did not change after surgery. The asymmetry and higher-order irregularity at 2 weeks postoperatively were greater than the normal range.[29] All Fourier indices throughout the observation period were not significantly different between cases injected with gas and those without gas tamponade in each group.

Table 3 shows the changes in Fourier indices from preoperatively to two weeks postoperatively. The 20G group showed significantly greater surgically induced changes than the 25G group in regular astigmatism ($p < 0.05$, Mann-Whitney's U test), asymmetry ($p < 0.005$) and higher-order irregularity ($p < 0.05$).

Discussion

The advent of 25-gauge instrumentation for pars plana vitrectomy allows for less invasive vitreoretinal surgery utilizing smaller sutureless incisions compared to the conventional 20-gauge system.[1] If case selection is appropriate, the 25-gauge system can be less traumatic in the conjunctival and scleral manipulations, reduce inflammatory tissue reactions, and lead to more rapid postoperative visual recovery.[2-4] In addition, the

25-gauge instrumentation has been shown to be advantageous in the management of vitreous loss during phacoemulsification. [30-32] In this study, we demonstrated that the 25-gauge transconjunctival sutureless vitrectomy does not induce regular and irregular corneal astigmatism, whereas the conventional 20-gauge vitrectomy causes significant alterations in the corneal topography. The findings are consistent with the view that the 25-gauge system is less invasive than the 20-gauge system in terms of influence on the corneal optics.

In this study, we performed Fourier analyses of corneal topography data to evaluate corneal regular and irregular astigmatism following vitrectomy. The corneal contour is well known to be altered after pars plana vitrectomy. Domniz and associates measured the corneal topography in eyes undergoing pars plana vitrectomy by means of videokeratography and reported that the corneal surface cylinder, average corneal power, regularity index, surface asymmetry index, and irregular astigmatism index were increased at 2 days and 1 week after surgery, and returned to the baseline at 1 month after surgery. [5] Similarly, Wirbelauer and associates described a transient increase of keratometric astigmatism at one week after pars plana vitrectomy and its return to the preoperative level at 1 month after surgery. [6] The present findings are consistent with the previous reports. However, the amount of astigmatic changes in our study was about 0.3 diopters at 2 weeks postoperatively, which is much smaller than a range of 1.5 to 3.0 diopters at 2 to 7 days after surgery reported previously. Tear film dynamics affecting the corneal topography may be relevant to the differences between our results and those of previous studies. [33-34] Conjunctival edema and irritant lacrimal fluid production occurring over several days after surgery may influence the dynamic conditions of the precorneal tear film and, hence, increase the amount of astigmatism. In this study, the corneal topography was measured at 2 weeks after surgery when conjunctival edema became undetectable by slitlamp biomicroscopy and patients' complaints. Therefore, it is unlikely that the tear film dynamics affected the corneal surface conditions.

Azar-Arevalo and associates reported a persistent increase in the corneal surface regularity index and surface asymmetry index for more than 6 months after conventional vitrectomy.[8] However, the number of subjects was limited in their study, and cases undergoing combined scleral buckling, cataract surgery, and silicone tamponade were included. Thus, the influence of vitrectomy alone on corneal topography could not be evaluated. In contrast, since we did not include cases undergoing phacoemulsification and scleral buckling, the current study can assess the influence of vitrectomy per se on the regular and irregular astigmatism of the cornea.

The transient corneal surface changes after pars plana vitrectomy may be due to corneoscleral sutures.[5-9] The lyses of the suture after pars plana vitrectomy have been reported to reduce the postoperative corneal astigmatism by more than 5.0 diopters.[9] Bergman reported that scleral cautery near the incisions changed corneal curvature by causing thermal contracture of the treated tissue and immediate central steepening.[35] The 25-gauge procedure does not require either incision suture or scleral cautery, and probably resulted in little corneal topographic changes. Thus, the 25-gauge vitrectomy procedure possesses apparent advantages over the conventional 20-guage vitrectomy procedures in that minimum changes are produced in corneal topography by surgery.

In conclusion, the 25-gauge transconjunctival sutureless vitrectomy does not induce significant changes in postoperative corneal topography, and, thus, the procedure exerts little influence on optical quality of the cornea.

References

1. Fujii GY, De Juan E Jr, Humayun MS, et al. A new 25-gauge instrument system for transconjunctival sutureless vitrectomy surgery. Ophthalmology 2002;109:1807-12.

2. Fujii GY, De Juan E Jr, Humayun MS, et al. Initial experience using the transconjunctival sutureless vitrectomy system for vitreoretinal surgery. Ophthalmology 2002;109:1814-20.

3. Lakhanpal RR, Humayun MS, de Juan E Jr, et al. Outcomes of 140 consecutive cases of 25-gauge transconjunctival surgery for posterior segment disease. Ophthalmology 2005;112:817-24.

4. Ibarra MS, Hermel M, Prenner JL, et al. Longer-term outcomes of transconjunctival sutureless 25-gauge vitrectomy. Am J Ophthalmol 2005;139:831-6.

5. Domniz YY, Cahana M, Avni I, et al. Corneal surface changes after pars plana vitrectomy and scleral buckling surgery. J Cataract Refract Surg 2001;27:868-72.

6. Wirbelauer C, Hoerauf H, Roider J, et al. Corneal shape changes after pars plana vitrectomy. Graefes Arch Clin Exp Ophthalmol 1998;236:822-8.

7. Weinberger D, Lichter H, Loya N, et al. Corneal topographic changes after retinal and vitreous surgery. Ophthalmology 1999;106:1521-4.

8. Azar-Arevalo O, Arevalo JF. Corneal topography changes after vitreoretinal surgery. Ophthalmic Surg Lasers 2001;32:168-72.

9. Slusher MM, Ford JG, Busbee B. Clinically significant corneal astigmatism and pars plana vitrectomy. Ophthalmic Surg Lasers 2002 ;33:5-8.

10. Yanyali A, Celik E, Horozoglu F, et al. Corneal topographic changes after transconjunctival (25-gauge) sutureless vitrectomy. Am J Ophthalmol 2005 ;140:939-41.

11. Oshika T, Tomidokoro A, Maruo K, et al. Quantitative evaluation of irregular

astigmatism by Fourier series harmonic analysis of videokeratography data. Invest Ophthalmol Vis Sci 1998;39:705-9.

12. Oshika T, Tanabe T, Tomidokoro A, et al. Progression of keratoconus assessed by Fourier analysis of videokeratography data. Ophthalmology 2002;109:339-42.

13. Tomidokoro A, Oshika T, Amano S, et al. Changes in anterior and posterior corneal curvatures in keratoconus. Ophthalmology 2000;107:1328-32.

14. Tomidokoro A, Oshika T, Amano S, et al. Quantitative analysis of regular and irregular astigmatism induced by pterygium. Cornea 1999;18:412-5.

15. Olsen T, Dam-Johansen M, Bek T, et al. Corneal versus scleral tunnel incision in cataract surgery: a randomized study. J Cataract Refract Surg 1997;23:337-41.

16. Hayashi K, Hayashi H, Oshika T, et al. Fourier analysis of irregular astigmatism after implantation of 3 types of intraocular lenses. J Cataract Refract Surg 2000;26:1510-6.

17. Oshika T, Sugita G, Tanabe T, et al. Regular and irregular astigmatism after superior versus temporal scleral incision cataract surgery. Ophthalmology 2000;107:2049-53.

18. Hayashi K, Hayashi H, Oshika T, et al. Fourier analysis of irregular astigmatism after trabeculectomy. Ophthalmic Surg Lasers 2000;31:94-9.

19. Tomidokoro A, Oshika T, Kojima T. Corneal astigmatism after scleral buckling surgery assessed by Fourier analysis of videokeratography data. Cornea 1998;17:517-21.

20. Bessho K, Maeda N, Watanabe H, et al. Fourier analysis of corneal astigmatic changes following photorefractive keratectomy. Semin Ophthalmol 2003;18:23-8.

21. Keller PR, McGhee CN, Weed KH. Fourier analysis of corneal topography data after photorefractive keratectomy. J Cataract Refract Surg 1998;24:1447-55.

22. Tomidokoro A, Soya K, Miyata K, et al. Corneal irregular astigmatism and contrast sensitivity after photorefractive keratectomy. Ophthalmology 2001;108:2209-12.

23. Hjortdal JO, Erdmann L, Bek T. Fourier analysis of video-keratographic data. A tool for separation of spherical, regular astigmatic and irregular astigmatic corneal power components. Ophthalmic Physiol Opt 1995;15:171-85.

24. Kagaya F, Tomidokoro A, Tanaka S, et al. Fourier series harmonic analysis of corneal topography following suture removal after penetrating keratoplasty. Cornea 2002;21:256-9.

25. Hiraoka T, Furuya A, Matsumoto Y, et al. Quantitative evaluation of regular and irregular corneal astigmatism in patients having overnight orthokeratology. J Cataract Refract Surg 2004;30:1425-9.

26. Baek TM, Lee KH, Tomidokoro A, et al. Corneal irregular astigmatism after laser in situ keratomileusis for myopia. Br J Ophthalmol 2001;85:534-6.

27. Raasch TW. Corneal topography and irregular astigmatism. Optom Vis Sci 1995;72:809-15.

28. Olsen T, Dam-Johansen M, Bek T, et al. Evaluating surgically induced astigmatism by Fourier analysis of corneal topography data. J Cataract Refract Surg 1996;22:318-23.

29. Tanabe T, Tomidokoro A, Samejima T, et al. Corneal regular and irregular astigmatism assessed by Fourier analysis of videokeratography data in normal and pathologic eyes. Ophthalmology 2004;111:752-7.

30. Chalam KV, Gupta SK, Vinjamaram S, et al. Small-gauge, sutureless pars plana vitrectomy to manage vitreous loss during phacoemulsification. J Cataract Refract Surg 2003;29:1482-6.

31. Shah VA, Gupta SK, Chalam KV. Management of vitreous loss during cataract surgery under topical anesthesia with transconjunctival vitrectomy system. Eur J Ophthalmol 2003;13:693-6.

32. Chalam KV, Shah VA. Successful management of cataract surgery associated vitreous loss with sutureless small-gauge pars plana vitrectomy. Am J Ophthalmol 2004;138:79-84.

33. Goto T, Zheng X, Klyce SD, et al. A new method for tear film stability analysis using videokeratography. Am J Ophthalmol 2003;135:607-12.

34. Kojima T, Ishida R, Dogru M, et al. A new noninvasive tear stability analysis system for the assessment of dry eyes. Invest Ophthalmol Vis Sci 2004;45:1369-74.

35. Bergmann MT, Koch DD, Zeiter JH. The effect of scleral cautery on corneal astigmatism in cadaver eyes. Ophthalmic Surg 1988;19:259-62.