Transconjunctival corneoscleral tunnel "blue line" cataract incision

Kurt A. Buzard, MD, Jean-Luc Febbraro, MD

ABSTRACT

Purpose: To report the technique and astigmatic results of the blue line cataract incision.

Setting: The Buzard Eye Institute, Las Vegas, Nevada, USA.

Methods: This prospective study included 411 eyes of 271 patients who had cataract extraction by phacoemulsification with a self-sealing 3.0 mm blue line cataract incision. The blue line incision is performed with a diamond knife transconjunctively, 2.0 mm behind the surgical limbus.

Results: Mean patient age was 68 years (range 40 to 94 years) and mean preoperative astigmatism, 0.96 diopter (D) ± 0.78 (SD).Uncorrected visual acuity at 1 day was 20/40 or better in 47% of patients. Mean spherical equivalent was −0.57 ± 0.78 D at 6 months. Mean postoperative astigmatism measured with a subtraction method was 1.00 ± 0.84 D at 6 months. Vector analysis showed an induced astigmatism of −0.47 ± 1.00 D at 1 month, −0.58 ± 0.81 D at 3 months, and −0.57 ± 0.99 D at 6 months. No complications such as wound leakage or hyphema occurred.

Conclusion: The blue line incision combines the efficiency of the clear corneal with the safety of the scleral tunnel cataract incision and appears to be relatively astigmatically neutral. *J Cataract Refract Surg 2000; 26:242–249 © 2000 ASCRS and ESCRS*

The cataract incision has received intense scrutiny over the past several years.[1–4] As the size of the incision has been reduced, the location of the external entry has shifted from the more traditional scleral tunnel toward the clear corneal approach. The reason for this shift in technique has been primarily increased efficiency but has also been justified by reduced requirements for cautery (thus decreasing postoperative astigmatism) and the trend toward topical anesthesia.[5–7] It is by no means certain that the shift of the external opening of the incision toward the cornea is beneficial, and in fact it is our contention that it is a negative development with disadvantages that are hidden by the smaller size routinely used for clear corneal incisions.

Documented negative aspects of the clear corneal incision include increased induction of regular and irregular astigmatism,[8–11] increased loss of endothelial cells,[12] poor wound healing,[13] and less flexibility in positioning the incision.[14,15] The clear corneal incision is unforgiving, and if the side of the tunnel is incised or the entrance torn, suture closure can be problematic. In addition, if wound extension is required, it is almost mandatory to create a separate incision, increasing iatrogenic trauma to the eye. All these factors present a steep learning curve to the surgeon who wishes, for reasons of efficiency, to transition to this incision, and to the experienced surgeon who must contend with the issues listed above.

Ernest and Neuhann,[16] among others, have promoted the concept of moving the external entrance of the incision more posteriorly to promote better wound healing. Although the benefits of this relatively small

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Reprint requests to Kurt A. Buzard, MD, The Buzard Eye Institute, 6020 Spring Mountain Road, Las Vegas, Nevada 89146, USA.

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posterior movement are clear, we believe that even greater benefits (more predictable wound closure, more flexibility for extension and suturing, and more convenience in terms of grasping the wound lip) can be obtained by placing the incision even farther posteriorly.

We propose moving the incision approximately 1.0 to 2.0 mm behind the surgical limbus to obtain the healing benefits demonstrated by Ernest and Neuhann[16] and to obtain other benefits of a traditional scleral tunnel incision. The external landmarks of the surgical limbus are well known and include a bluish translucent zone, 1.0 to 1.2 mm wide at the superior limbus when the conjunctiva is removed. The zone correlates with the internal structures of the angle by Kasner.[17] This bluish translucent zone is located posterior to the anterior limbal border and is visible if the limbus is dissected free of conjunctiva.[18,19] With the conjunctiva intact, the anatomic landmarks change, the bluish area is now visible between cornea, and the sclera represents an area approximately 2.0 mm wide in which the conjunctiva is firmly attached to the sclera. We defined the blue line as the posterior aspect of this zone and place the incision in this location because with the firm attachment anterior to the incision, no chemosis develops and a natural miniperitomy forms with sagging of the mobile conjunctiva posterior to the incision (Figure 1).

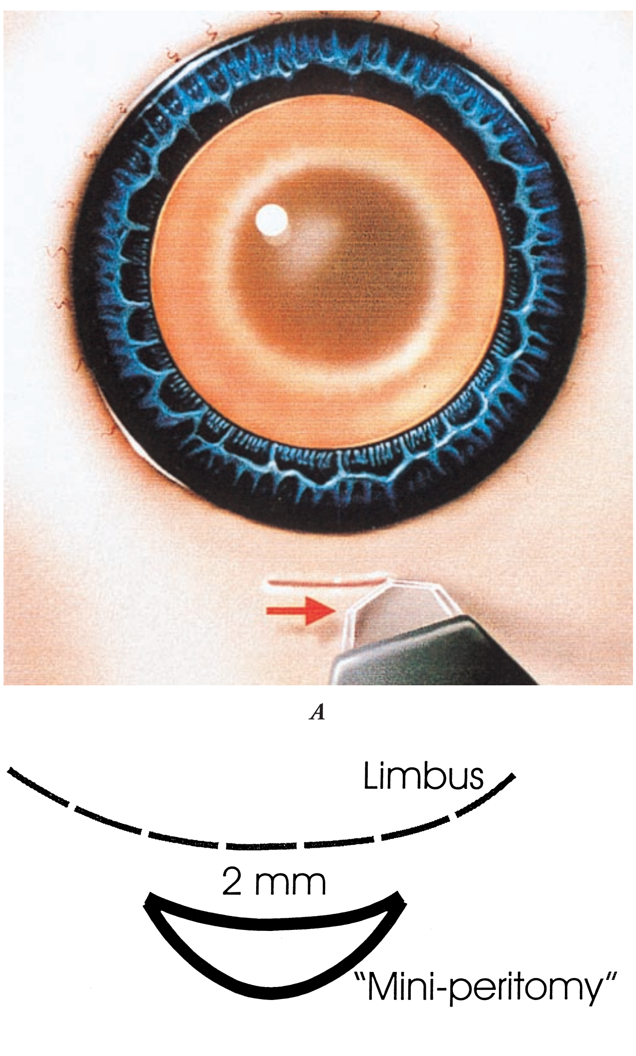

Figure 1. (Buzard) *A*: A 4.0 mm transconjunctival incision is made linearly 1.0 to 2.0 mm from the surgical limbus. *B*: The incision located at the posterior limit of the blue zone creates a miniperitomy.

One disadvantage of the scleral tunnel incision is the loss of efficiency that results from the necessity of performing a peritomy, with its associated trauma/cautery. We found that an incision at the posterior aspect of the blue zone, where the conjunctiva ends firm adherence to the sclera and becomes mobile, is an excellent location for a diamond incision because it creates a natural miniperitomy with minimal trauma and little cautery. This miniperitomy usually does not cause clinically significant chemosis if efficient phacoemulsification is performed and the conjunctival incision is slightly larger (4.0 mm) than the scleral one. Thus, the blue line cataract incision retains the advantages of the scleral tunnel incision with the efficiency of the clear corneal incision.

We describe the surgical technique of the blue line incision and report its visual, astigmatic, and time-based results.

Patients and Methods

The prospective study comprised 411 eyes of 274 patients, 144 men and 130 women, who had sutureless blue line incision for phacoemulsification with foldable intraocular lens (IOL) implantation. Mean patient age was 69 years ± 10 (SD) (range 40 to 94 years). Exclusion criteria study were corneal pathologies such as dystrophies and pterygium, macular degeneration, and previous ocular surgeries such as corneal refractive procedures and penetrating keratoplasty. All surgeries were performed using local retrobulbar or topical anesthesia by the same surgeon (K.A.B.).

Surgical Technique

The blue line incision was performed superiorly and created with a trapezoid diamond knife (Buzard Blue

Line Knife, Mastel Precision). The 6.0 mm long diamond knife has an inside width of 2.7 mm and an outside width of 3.0 mm, with a 100 μm long truncated tip to provide better control during incision creation. The blade of the knife is at least 2.0 mm longer than the standard cataract diamond knife, allowing for more posterior placement of the external wound and, in general, a longer tunnel incision.

The eye was stabilized by grasping in the inferior conjunctiva and drawing the eye downward with a 0.5 forceps. The blue line incision was constructed by creating, with the side of the diamond knife, a 4.0 mm incision through the conjunctiva about 1.5 to 2.0 mm behind the surgical limbus (represented by an anatomic appearance of a blue line) (Figure 1, *A*). In most cases, the conjunctiva sagged away from the incision, and the resulting conjunctival gaping created a miniperitomy (Figure 1, *B*). The assistant applied steady drops to hinder bleeding, ensuring visualization of the exterior incision.

A scleral groove was not made, but the knife tip was used to trace the external incision and cut remaining adherent Tenon's tissue. The knife was placed parallel to the posterior sclera, and pressure was applied to slightly indent the sclera with the knife, pushing forward to begin the scleral tunnel incision (Figure 2, *A*). As the incision progressed, progressive pressure was placed on the heel of the diamond knife to prevent early interior entry caused by the changing curvature at the limbus between sclera and cornea (Figure 2, *B*). Finally, when the knife tip approached the desired location for the internal corneal incision, the heel of the knife was rotated slightly upward, creating a slight dimple in the corneal surface. The corneal dimple was relieved when the knife tip penetrated Descemet's membrane (Figure 2, *C*). The knife was then inserted until the "shoulders" were at the level of the internal corneal incision, which was 2.7 mm wide. The blue line incision resulted in an approximately square 3.0 × 3.0 mm scleral tunnel incision (Figure 2, *D, E*). Light cautery was applied to the conjunctival edge to control bleeding.

A side-port incision was made with the same diamond knife, viscoelastic material was instilled in the anterior chamber, and a capsulorhexis was performed with a cystotome. Hydrodissection and hydrodelineation were performed, and standard divide and conquer technique phacoemulsification was used to remove the cataract. A 3-piece silicone IOL with a 6.3 optic and a 13.5 overall diameter (AQ2010V, Staar) was implanted with an injector in the capsular bag under viscoelastic protection; the incision was not enlarged.

The viscoelastic material was removed with irrigation and aspiration. A wound leakage test was performed by injecting saline through the side port, checking along the incision and on the sclera. Corneal hydration to obtain a watertight wound was required in about 5% of cases.

Examinations and Data Analysis

Patients were examined preoperatively and 1 day, 1 week, and 1, 3, and 6 months postoperatively. Preoperative data included age, sex, keratometric astigmatism (Humphrey Instruments Inc.), and corneal topography (EyeSys Technologies). Postoperative data included uncorrected visual acuity (UCVA), keratometric astigmatism, spherical equivalent, and corneal topography.

Astigmatism analysis was based on objective measurement according to keratometric readings. Changes in keratometric cylinder were evaluated by the simple subtraction method, which disregards axis changes, and Holladay and coauthors'[20] vector analysis, which takes into account surgically induced astigmatism (SIA) related to axis changes. Different plots were performed on corneal topography between preoperative topography and postoperative measurements to assess induction of irregular astigmatism.

Relaxing incisions at the slitlamp were made when postoperative astigmatism was 1.50 diopters (D) or greater according to the technique and methods previously described.[21] Among the main group of 411 eyes, 364 (Group A) had mild astigmatism (less than 1.50 D) and did not require an arcuate incision postoperatively; 47 eyes (Group B) had relaxing incisions at approximately 1 month to correct residual astigmatism and improve refractive outcome. This distinction was considered in the astigmatic analysis, and the astigmatic results of the 2 groups are presented separately.

A single-factor analysis-of-variance test was used to show the variation over the total observation period. A 2-sample *t* test was used between specific intervals in the observation period. A *P* value less than 0.05 was considered significant.

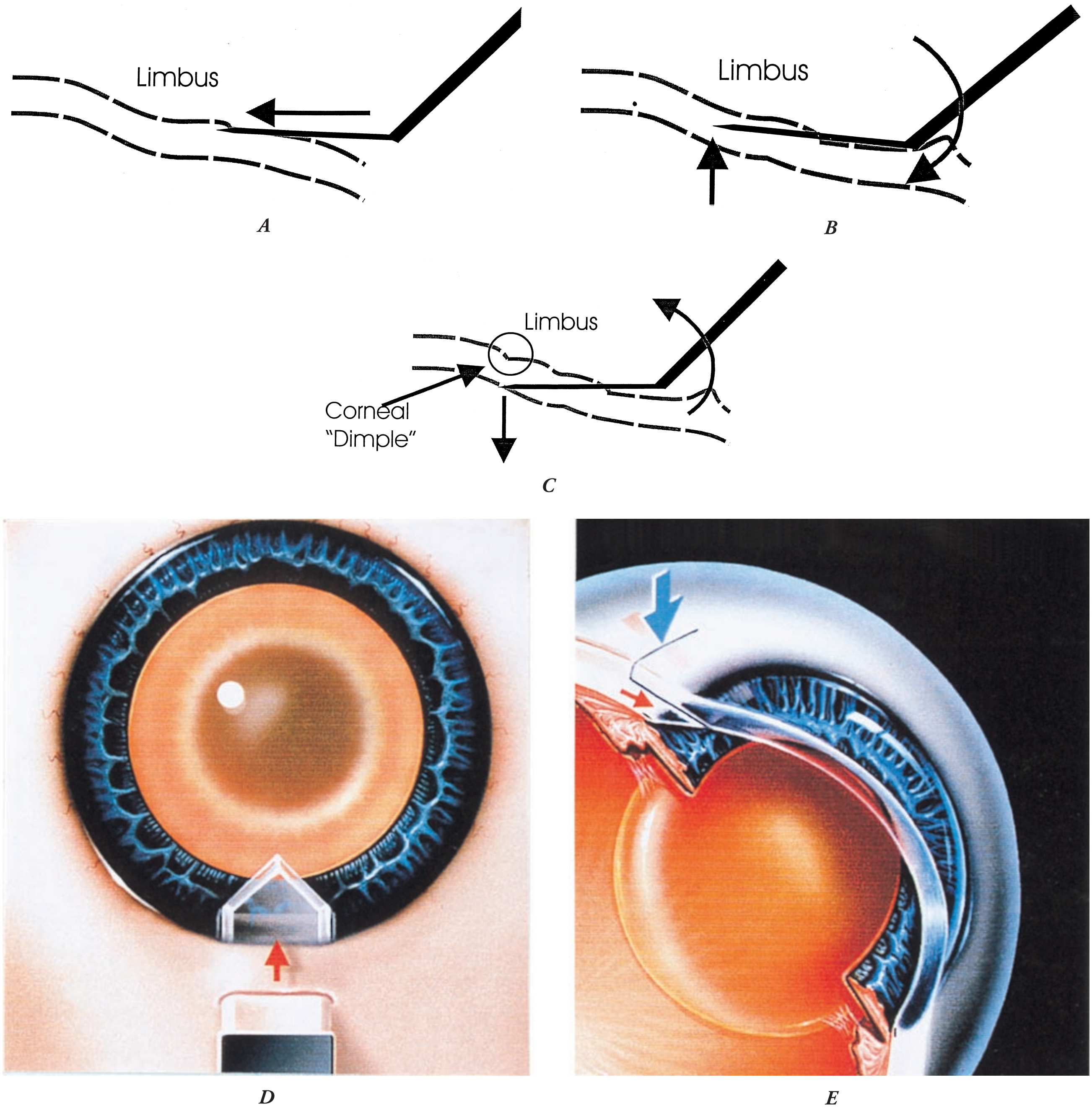

Figure 2. (Buzard) *A*: The beginning of the scleral tunnel is made by placing the knife parallel to the sclera and applying pressure to indent the sclera. *B*: The construction of the tunnel is performed with progressive pressure applied on the heel of the diamond knife. *C*: The heel of the knife is rotated upward to perform the internal corneal incision, which creates a corneal dimple. *D*: The blue line incision results in an approximately square 3 × 3 scleral tunnel incision. *E*: A cross-section of the blue line incision shows the 2-plane incision.

Results

Postoperative data were available in 93% of the cases at 1 month, 74% at 3 months, and 26% at 6 months.

Refractive Stability and Safety

In this study, 47% patients at 1 day and 83% at the last postoperative visit achieved a UCVA of 20/40 or better (Figure 3). Regarding the procedure's safety, no

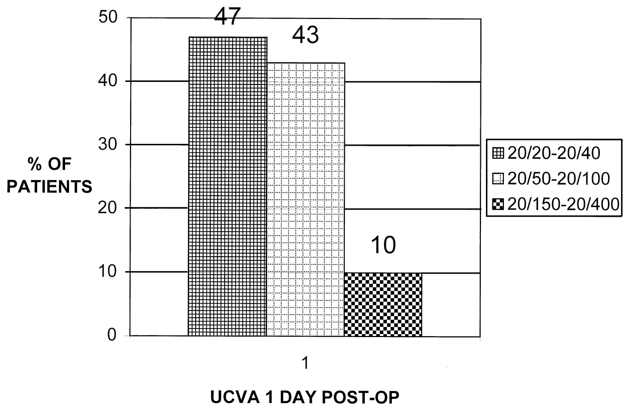

Figure 3. (Buzard) Frequency histogram of UCVA 1 day postoperatively.

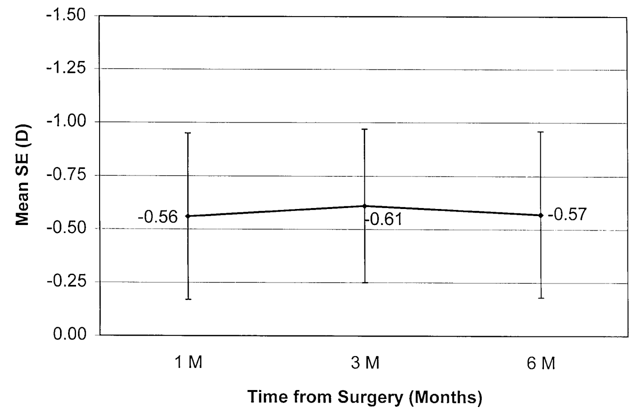

Figure 4. (Buzard) Mean spherical equivalent (SE) and standard deviation (vertical bars) at various periods postoperatively.

wound leakage, measured with the Seidel test,[22] or hyphema occurred in the immediate postoperative period or throughout the study. No other significant intraocular complications such as endophthalmitis or retinal detachment occurred in the study. Approximately 15% of patients reported a minor superior foreign-body sensation, which resolved within the first 2 weeks of surgery in all cases.

Mean spherical equivalent remained fairly stable throughout the follow-up, with no significant differences at each interval. Mean spherical equivalent was -0.56 ± 0.78 D at 1 month, -0.61 ± 0.72 D at 3 months, and -0.57 ± 0.78 D at 6 months (Figure 4).

Astigmatism Analysis

Figure 5 shows the mean preoperative and postoperative astigmatism in the 364 eyes in Group A (no postoperative relaxing incisions) evaluated using the simple subtraction method. The difference between preoperative and postoperative mean astigmatism at each interval was not statistically significant ($P = .06$). Mean astigmatism was 0.96 ± 0.68 D preoperatively and 0.99 ± 0.76 D, 0.89 ± 0.64 D, and 1.00 ± 0.84 D at 1, 3, and 6 months postoperatively.

Vector astigmatic analysis of Group A is shown in Figure 6. Mean SIA was not statistically significant over the postoperative period ($P = .47$). At each interval, the mean SIA was against the wound (ATW) (negative values): -0.47 ± 0.50 D at 1 month, -0.57 ± 0.40 D at 3 months, and -0.52 ± 0.43 D at 6 months. The distribution of the SIA is shown in Figure 7. Induced astigmatism was neutral in 18% of the cases, ATW in

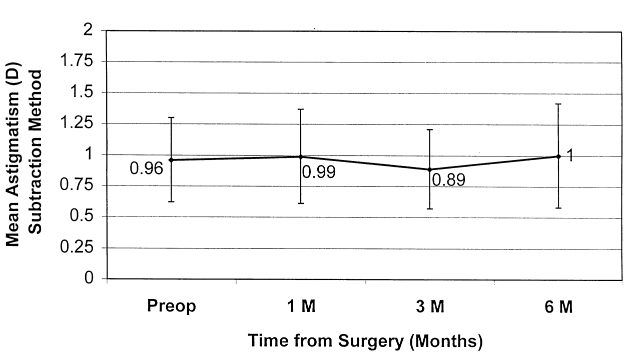

Figure 5. (Buzard) Mean preoperative and postoperative astigmatism over time in Group A evaluated with the simple subtraction method. Vertical bars represent standard deviations.

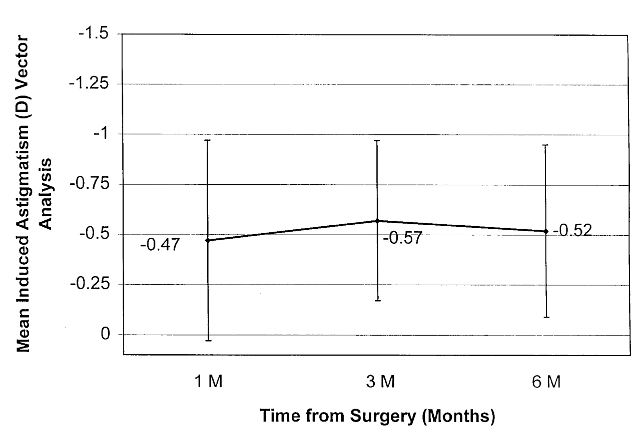

Figure 6. (Buzard) The mean surgically induced astigmatism over time. The negative values during the 6 month follow-up indicate ATW astigmatism. Vertical bars represent standard deviations.

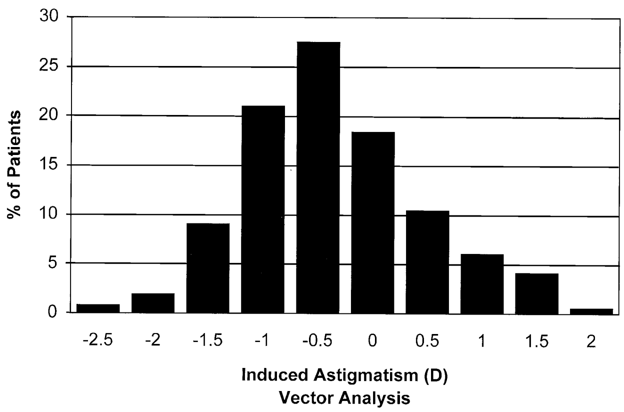

Figure 7. (Buzard) The distribution of SIA at last follow-up. Negative and positive values stand for ATW and with-the-wound astigmatism, respectively.

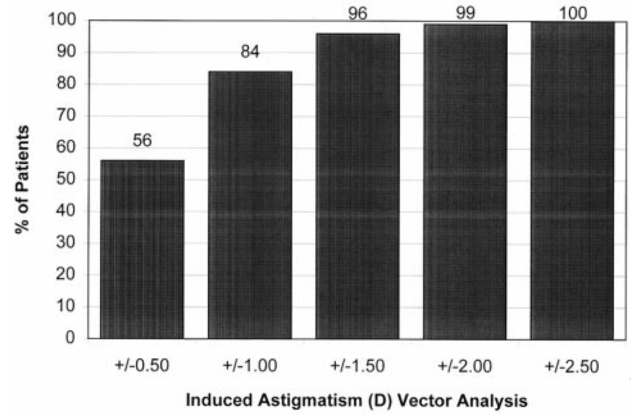

Figure 8. (Buzard) The frequency distribution of SIA at the last follow-up.

60% of the cases, including 27% within ±0.50 D and 48% within ±1.00 D. Fifty-six percent of the patients had an SIA within ±0.50 D, 84% within ±1.00 D, and 99% within ±2.00 (Figure 8).

In the 47 eyes in Group B (relaxing incisions after 1 month postoperatively), mean preoperative keratometric astigmatism was 1.86 ± 0.79 D preoperatively and 1.81 ± 0.78 D at 1 month (Figure 9). No statistical difference was found between the mean preoperative and 1 month induced astigmatism by the subtraction method ($P = .26$). The astigmatic surgery reduced mean astigmatism to 1.00 D.

Corneal topography preoperative and postoperative difference plots showed no evidence of induced irregular astigmatism.

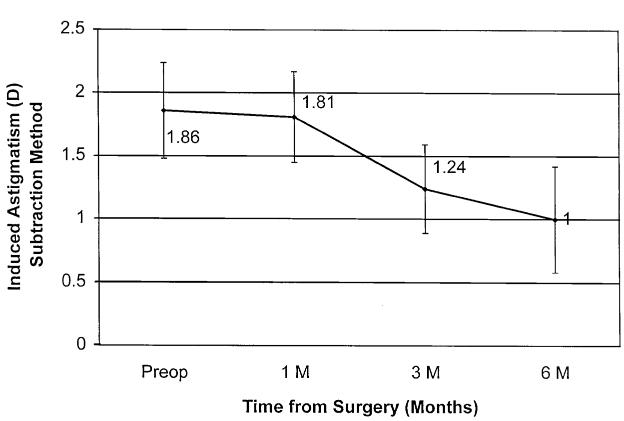

Figure 9. (Buzard) The mean preoperative and postoperative astigmatism over time in Group B evaluated with the simple subtraction method. Vertical bars represent standard deviations.

Discussion

The goal of the blue line incision is to combine the safety and stability of the scleral incision with the efficiency of the clear corneal incision. In the United States, 40% of surgeons perform the scleral tunnel incision (Review of Ophthalmology, April 1999). Many of these surgeons would like to transition to a more efficient incision; we believe the blue line incision is an excellent option. The location and characteristic of the incision are essentially the same as the scleral tunnel incision but with much greater efficiency with the peritomy. Ernest and coauthors[16] showed that wound stability is greater when the incision is performed with a square pattern. They also found that leakage occurred at a lower external pressure (525 versus 13 psi) and more frequently at a low intraocular pressure (10 to 15 mm Hg) when an incision has a width greater than the length.

Moreover, histological analysis shows that incisions located in a vascular area heal faster than comparable clear corneal locations.[13] The limbal healing process requires 7 days for a vascular incision location but up to 60 days for an avascular one.[13] Clinically, a 3.0 × 3.0 mm square clear corneal incision performed superiorly results in an incision in which induced regular and irregular astigmatism can be relatively close to the visual axis. Smaller incisions (2.0 × 2.0 mm) remain incompatible with the current generation of IOLs and phacoemulsification tips.

Several studies have found that temporal clear corneal incisions are more stable and induce less astigmatism than superior clear corneal ones.[11,14,23] Joo and coauthors[24] showed that temporal clear corneal incisions induce more significant topographical flattening localized in the incisional meridian than scleral tunnel incisions. The blue line incision, because of its location and its architecture, provides excellent resistance to external pressure and gives good astigmatic wound stability over time.

A possible complication, specific to scleral or posterior limbal incisions, is postoperative bleeding. Although intraocular bleeding was not a problem in this study, subconjunctival hemorrhages were more frequent and caused cosmetic concerns in some patients taking aspirin or other anticoagulation medication. A faster refractive recovery with clear corneal incisions than with scleral tunnel incisions has been reported because of the excessive cautery with greater induced astigmatism in eyes with scleral incisions several weeks after the surgery.[25] Sanders et al.[26] report that cautery, applied too heavily, often causes transient induced astigmatism for several weeks postoperatively. The miniperitomy created with the side of the diamond knife allows rapid access to the subsequent stages of the incision creation and contrary to first impressions, does not result in chemosis during actual surgery. The miniperitomy requires a mild cautery, conjunctival in most cases, limiting induced astigmatism.

Flexibility is another advantage of the blue line incision over the corneal incision. In fact, in case of necessity, an extension of the incision can be easily performed without creating wound instability. Moreover, in case of IOL exchange, the same incision can be easily reopened with cyclodialysis without compromising its self-sealing and astigmatically neutral advantages. During the time of surgery, the blue line incision enables the surgeon to grasp the scleral lip without damaging the architecture of the incision or the endothelium.

Our study shows that the blue line incision induced limited postoperative astigmatism. Gills and coauthors,[27] based on Samuelson and coauthors' cadaver study,[28] described the relationship between the location of the external incision and the induced astigmatism. Moreover, if we consider the incisional funnel as defined by Koch,[29] the 3.0 mm blue line incision fits perfectly in the funnel with limited SIA. In our study, the blue line incision appeared to be almost astigmatically neutral, with vector analysis showing a mean ATW SIA of 0.50 D. This amount should be considered slight considering that astigmatism measurements can vary by more than 0.50 D from day to day.[30]

In conclusion, the blue line incision appears to be a reliable transconjunctival corneoscleral incision. Intraoperative chemosis did not occur. This incision combines the efficiency of the clear corneal with the safety and flexibility of the scleral tunnel incision. Astigmatism analysis, by subtraction method and vector analysis, showed the incision to be almost astigmatically neutral.

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From the Department of Surgery, University of Nevada School of Medicine, Las Vegas, Nevada (Buzard), and Department of Ophthalmology, Tulane University Medical Center, New Orleans, Louisiana (Febbraro), USA.

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