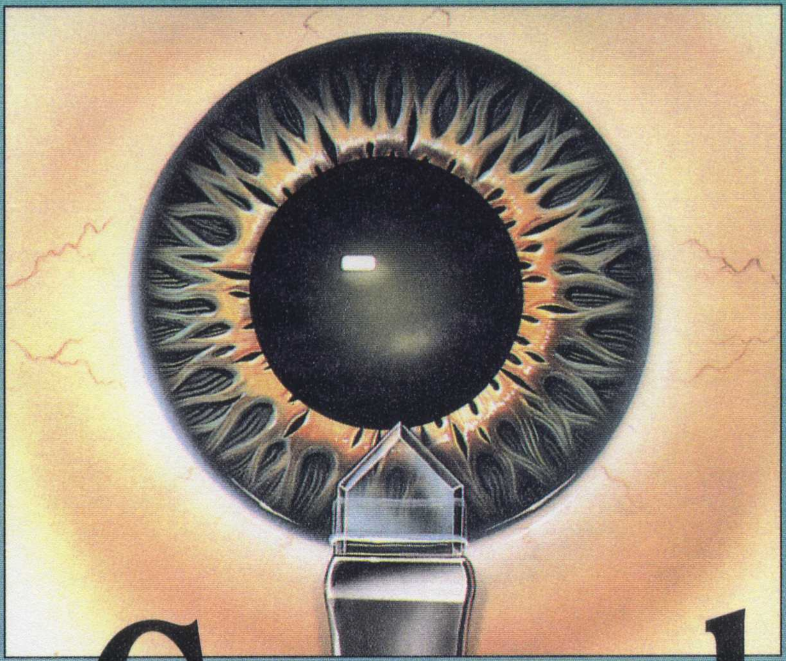
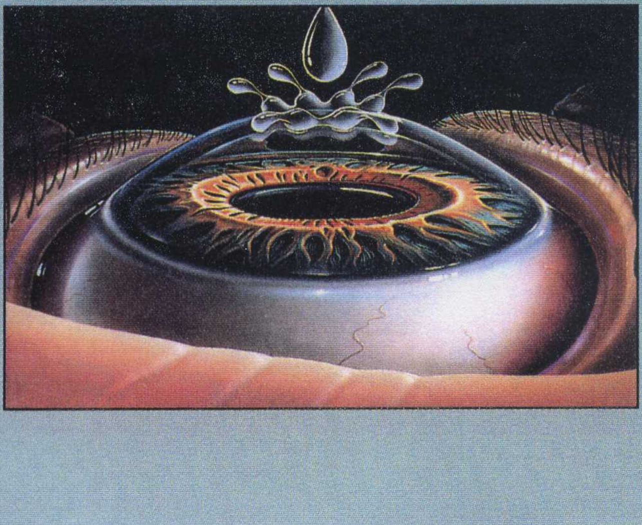


Clear-Corneal

CATARACT SURGERY

& Topical Anesthesia



I. HOWARD FINE
RICHARD A. FICHMAN
HARRY B. GRABOW

Introduction

I. Howard Fine, MD

In 1968 Charles Kelman declared that the proper way to remove a cataract is to perform phacoemulsification through a clear-corneal incision utilizing a triangular-tear ("Christmas tree") capsulotomy, grooving and cracking the nucleus in the posterior chamber.[1]

A number of other surgeons favored corneal incisions. An enthusiastic American proponent of the corneal-incision approach to cataract extraction (and of controlling surgically induced astigmatism in general) has been Richard Troutman.[2] Physicians in other countries have been interested as well, including Harms and Mackensen in Germany,[3] Eric Arnott in England,[4] Albert Galand in Belgium,[5] and Robert Stegmann in South Africa.[6] Perhaps the leading proponent in the modern era of phacoemulsification is Kimiya Shimizu of Japan.[7]

I believe that, in 1993, cataract surgeons are going back to the future—Kelman's 1968.

During the past decade, advances in cataract surgery have eliminated the use of routine peripheral iridectomy, significantly reduced surgically induced astigmatism, eliminated the need for postoperative restrictions on the patient thanks to improved wound integrity, and eliminated the need for cortical cleanup as a separate step through the use of cortical cleaving hydrodissection.[8]

A major advance in the past few years has been the development of small-incision cataract surgery with a foldable IOL inserted through a self-sealing scleral tunnel incision.[9,10] Small-incision sutureless surgery has dramatically reduced surgically induced astigmatism and complications such as wound slippage and hyphema. However, sutureless surgery through a scleral tunnel incision presents some problems. The procedure requires conjunctival incisions with their attendant bleeding and the need for cautery. A scleral tunnel also can cause oarlock problems with the phaco handpiece and hyphema from scleral vessels.

Recently, a number of surgeons have embarked on independent studies of an approach to cataract surgery that may obviate these problems: foldable IOLs inserted through small self-sealing corneal tunnels. In this section, you will be introduced to the approach from a number of perspectives by just a few of the surgeons who are convinced that corneal incisions have a guaranteed role in the future of cataract surgery.

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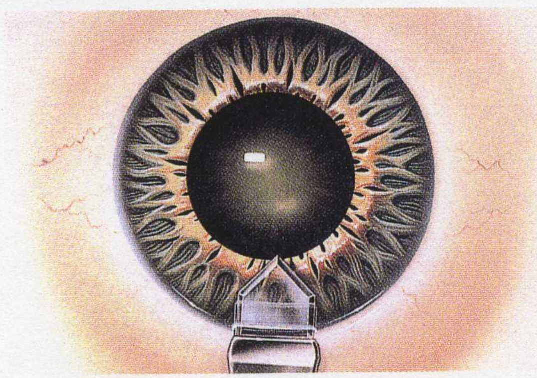
Corneal Tunnel Incision With a Temporal Approach



I. Howard Fine, MD

BACKGROUND AND DEVELOPMENT

I came upon the concept of a clear-corneal tunnel incision almost 15 years ago when I began to do secondary anterior chamber lens (ACL) implantations through clear-corneal incisions at the temporal edge of the cornea. The incisions were closed with three interrupted 10-0 nylon sutures, which were allowed to remain in place for about three months. Within a short period of time after suture removal, these incisions became extremely stable with respect to refraction and did not experience subsequent against-the-rule-drift as did my incisions at 12 o'clock. Dr. Thomas Cravy and I discussed this phenomenon several times after he did a large series of cataract extractions from the temporal side and documented decreased against-the-rule astigmatic shift compared to superiorly placed incisions.[1]

Seven years ago, when foldable silicone lenses became available to me, I began to use clear-corneal incisions for my patients with functioning filtering blebs. In order to avoid disturbing the bleb, I made a 3-mm incision central to the conjunctival insertion in clear cornea. After the cataract extraction, the incision was widened to 4 mm for implantation of a foldable IOL. Finally, the incision was closed with two radial sutures (Figure 1.1). Due to the small size of these incisions, the patients were rapidly visually rehabilitated.

More recently, I modified the procedure by making a longer corneal tunnel and closing the incision with a single stitch tangential to the limbus. The patients experienced very little surgically induced astigmatism and rapid visual rehabilitation, largely due to the small wound (Figure 1.2 and 1.3). I subsequently developed a systematic approach to a self-sealing corneal tunnel incision located at the temporal limbus, and presented my initial experience in April 1992 in San Diego at the annual meeting of the American Society of Cataract and Refractive Surgery[2] and in Sao Paulo at the International Symposium sponsored by the Brazilian Society of Cataract, Intraocular Implant and Refractive Surgery[3].

CONCEPT AND RATIONALE

My concept of the most desirable self-sealing clear-corneal tunnel incision was a paracentesis. The paracentesis or side-port incision that we all knew was a

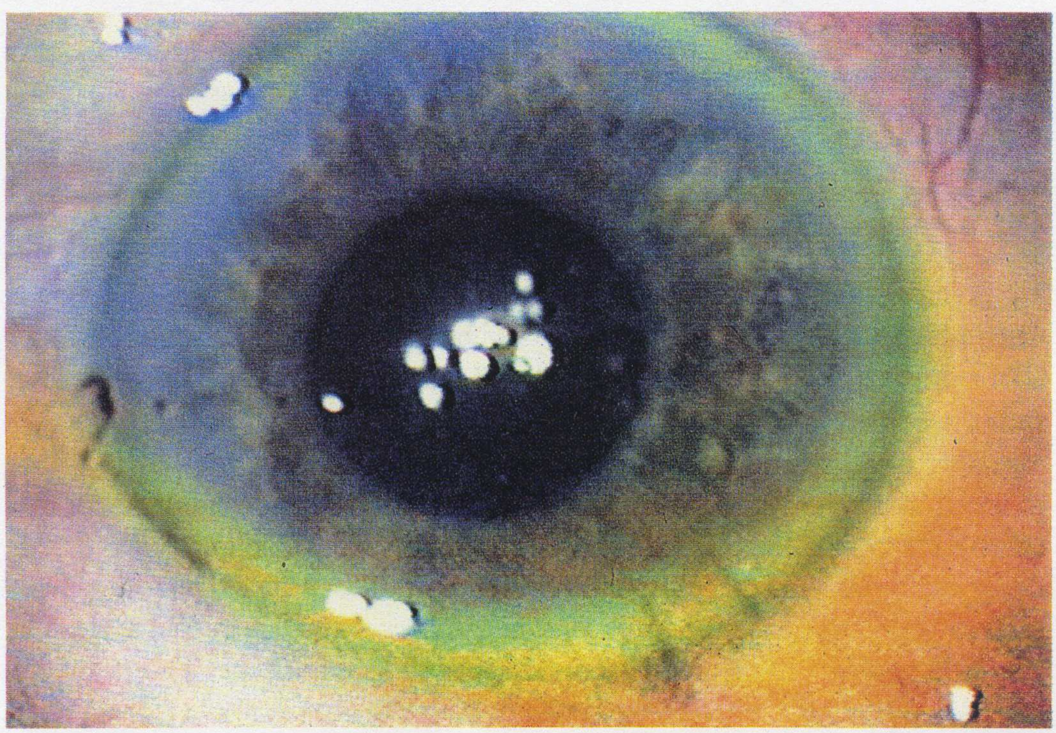


Figure 1.1: Fluorescein testing of a radially sutured corneal incision for cataract extraction and lens implantation in the presence of a filtering bleb.

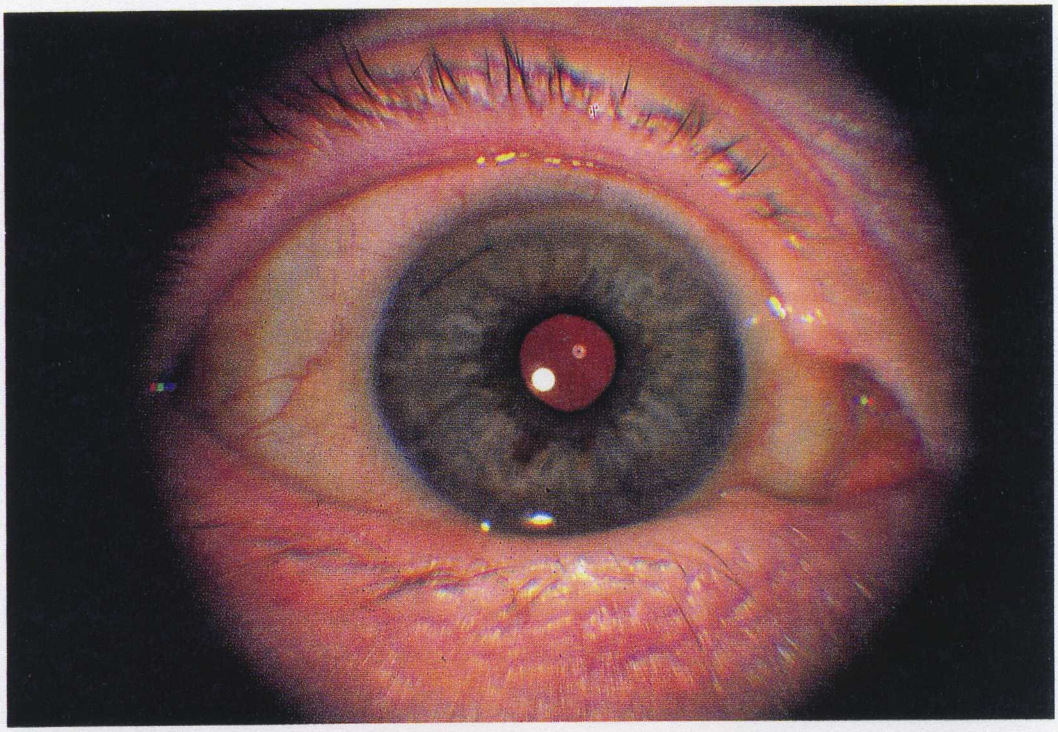


Figure 1.2: "Single-stitched" corneal tunnel incision.

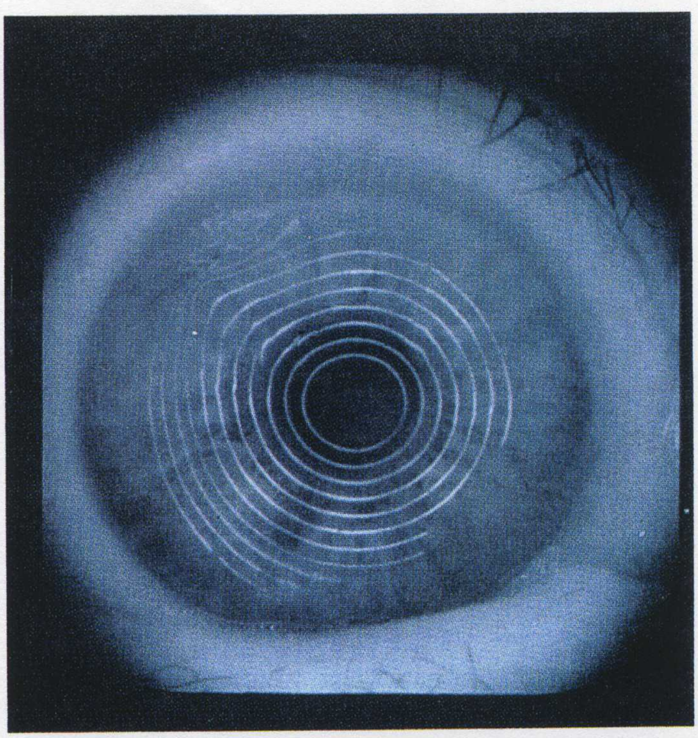


Figure 1.3: One day postoperative photokeratoscopy of patient in Figure 1.2.

straight beveled incision that was both self-sealing and astigmatically neutral. This was what I believed we could create with the available instrumentation and foldable-IOL technology or small modifications to the existing technology.

A diamond knife is used to create a straight beveled incision whose construction is identical to a paracentesis. The tunnel has a relatively straight-line entry through epithelium as well as into the AC through Descemet's membrane. This architecture is essential for the wound to be self-sealing. The advantage of this type of entry is that there is good maneuverability of the phaco handpiece and the lens inserter through the tunnel. There is also less likely to be flattening around the wound.

The temporal location of the incision provides four advantages: 1) at this location the eye drains naturally out the lateral canthus beneath the wound so the surgeon is never working under water; 2) should some slight flattening occur around the wound, the temporal location is farthest from the visual axis and so there will be less impact on the corneal curvature at the visual axis; 3) the wound is parallel to the effect of both lid blink and gravity. With a 12-o'clock incision, gravity and lid blink can cause drag on the incision, but a temporal location means that flattening with resultant against-the-rule astigmatism is less likely;[1] and 4) the location makes the procedure easier to perform. The temporal location provides adequate exposure of the limbus with limited opening of the lids. There is no need to turn the eye downward, eliminating the need for a bridle suture. The horizontal position of the iris plane enhances the red reflex resulting in excellent visualization and easier implantation of the lens without obstruction by the brow.

Additional advantages of the corneal tunnel incision include the fact that rapid healing of the corneal epithelium creates a tissue seal very soon after surgery in addition to the hydrostatic valve seal. It is of special benefit for patients with functioning filtering blebs and for cataract candidates who may need glaucoma filtering surgery in the future. The procedure also lends itself extremely well to topical anesthesia. It allows for considerable decrease in surgical time and therefore a lowering of surgical costs.

TECHNIQUE FOR CORNEAL TUNNEL INCISION

The surgical technique involves placement of the surgeon on the side or at the superior corners of the table with the assistant positioned at the head of the table. A Fine–Thornton fixation ring (Mastel Instruments) (Figure 1.4), with the opening to the left, atraumatically stabilizes the eye (Figure 1.5). A 1-mm-wide

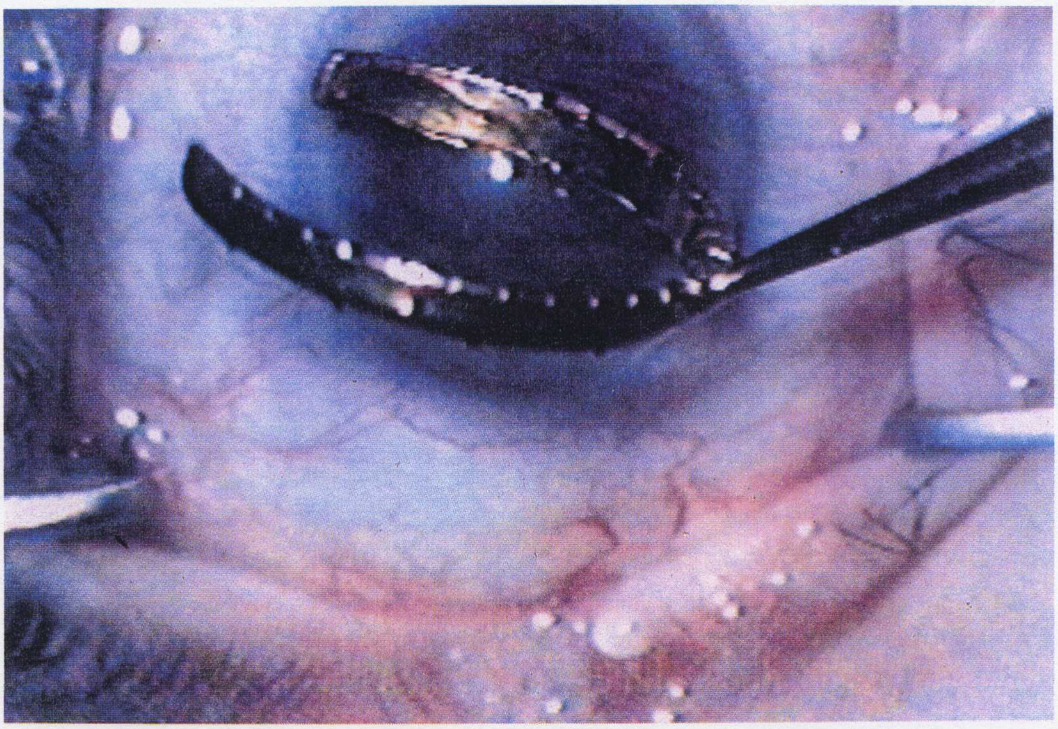


Figure 1.4: Fine–Thornton fixation ring.

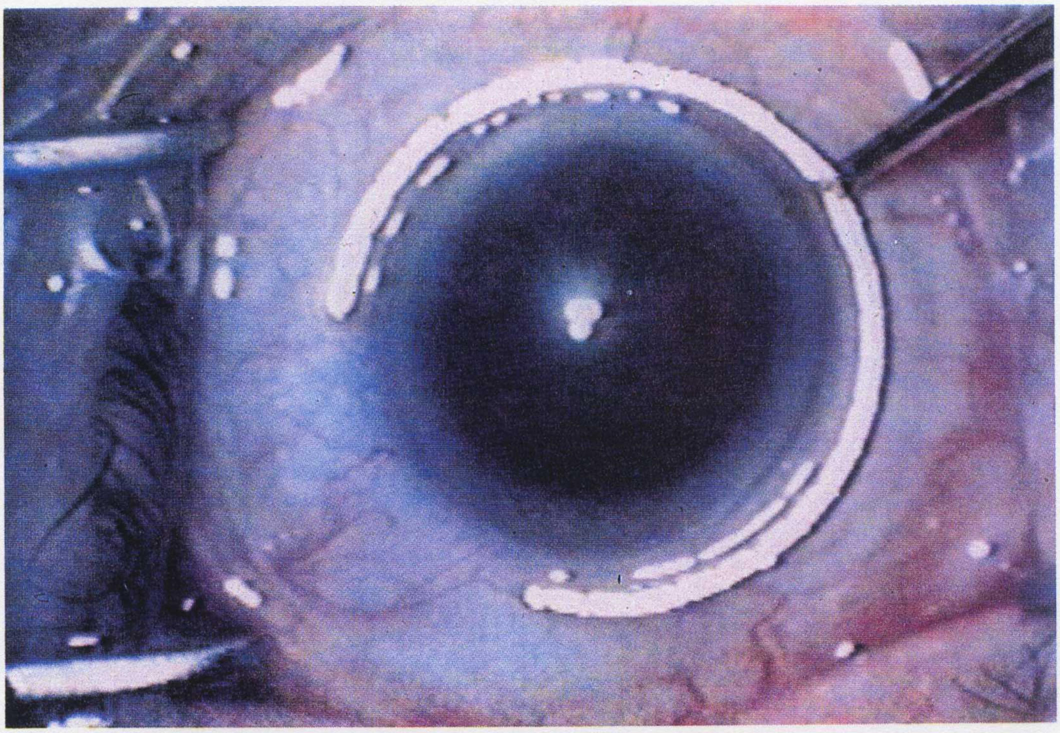


Figure 1.5: Fine–Thornton fixation ring atraumatically stabilizing the eye.

paracentesis is made at the left (Figure 1.6) after which viscoelastic is exchanged for aqueous humor without overfilling the eye. This creates a stable eye that distorts minimally and allows for reproducible entry with a diamond knife.

The Fine–Thornton ring is turned to give access to the temporal incision and a 3-mm-wide diamond keratome enters the corneal surface just anterior to the corneal vascular arcade after the blade has been *flattened* against the surface of the globe. This creates and allows for a straight-line entry through the epithelium.

The blade I currently use is produced by Huco Co., of Hauterive, Switzerland, and is seen in Figure 1.7. The blade, beveled up and down on all edges, is 4-mm long, 3-mm wide, and 0.17-mm thick. The distance between the 90° tip and the 45° shoulders is 2 mm. The angled mount and blade can be retracted into the handle for protection between uses.

When the shoulders of the blade enter the stroma, the tip is turned down so as to cut Descemet's membrane and enter the AC. The knife is advanced in a planar course to the blade mount (Figure 1.8). This results in a 3-by-2-mm corneal tunnel. The peripheral edge of the incision may be grooved perpendicular to the surface of the cornea (150 μm to 400 μm deep with a guarded diamond knife) prior to the stab incision that creates the tunnel. The peripheral lip of the groove

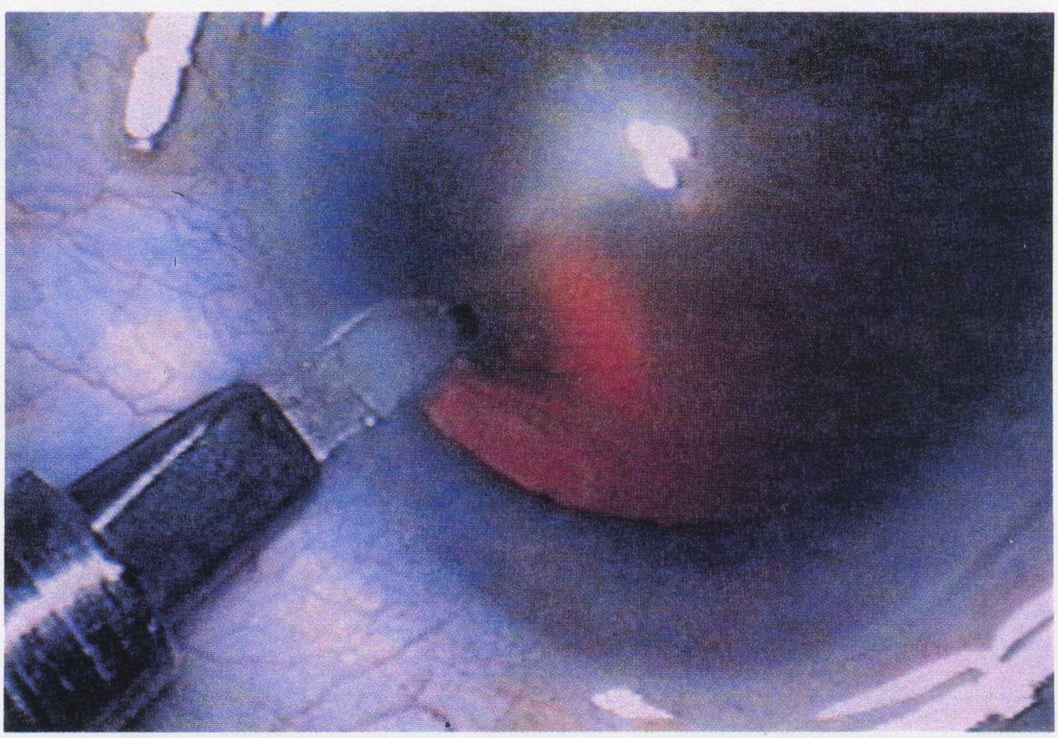


Figure 1.6: The side-port incision.

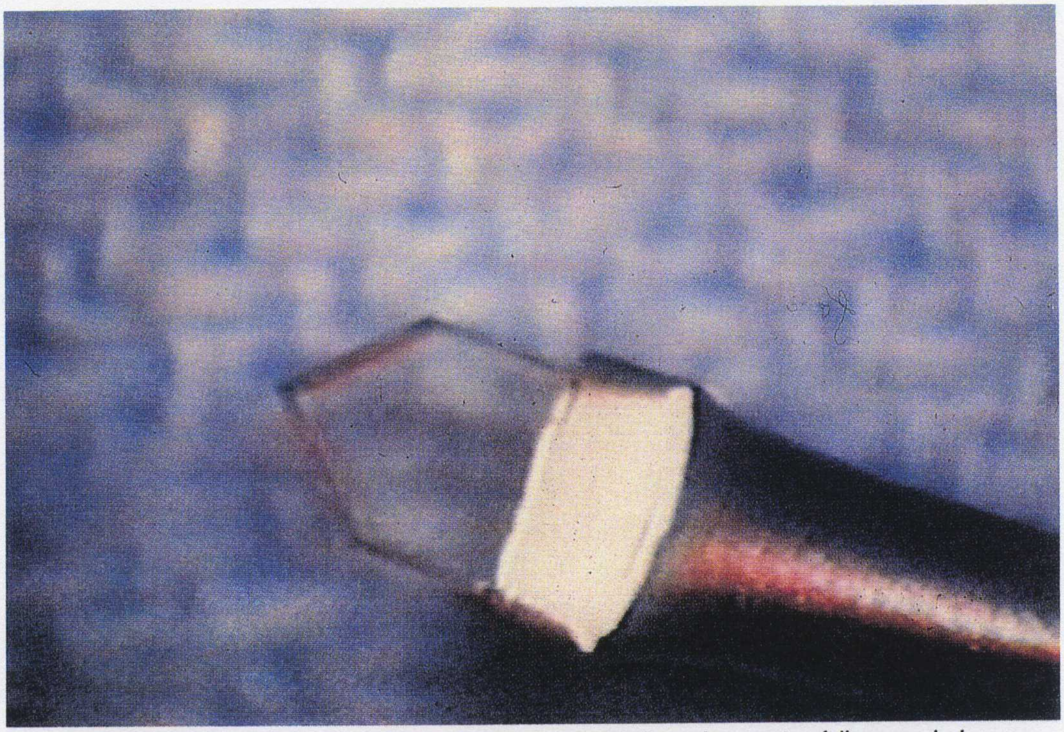


Figure 1.7: Huco 3-mm-wide diamond keratome with the blade and mounting fully extended.

Figure 1.8: Diamond blade within corneal tunnel incision.

is depressed by the diamond and the incision is then made into the AC in the same manner.

PHACOEMULSIFICATION AND SILICONE IOL INJECTION

My standard endolenticular phacoemulsification procedure is then performed. A 5-mm central circular continuous curvilinear capsulorhexis is made followed by cortical cleaving hydrodissection[4] and hydrodelineation. The phaco handpiece is slipped into the incision bevel down without elevating the roof of the tunnel (Figure 1.9). Grooving is begun central to the hydrodelineation cleavage plane, or "golden circle," and does not extend out to the epinucleus (Figure 1.10).

Cracking is nonrotational. The first cracking is done at the distal groove (Figure 1.11) after which the groove to the right is cracked by pressing down in the groove with the second instrument and up with the phaco tip (Figure 1.12). Cracking is performed in the groove to the left by elevating the superior edge with the second instrument and pulling toward the incision with the phaco tip (Figure 1.13). Cross-action forces crack the groove nearest to the incision.

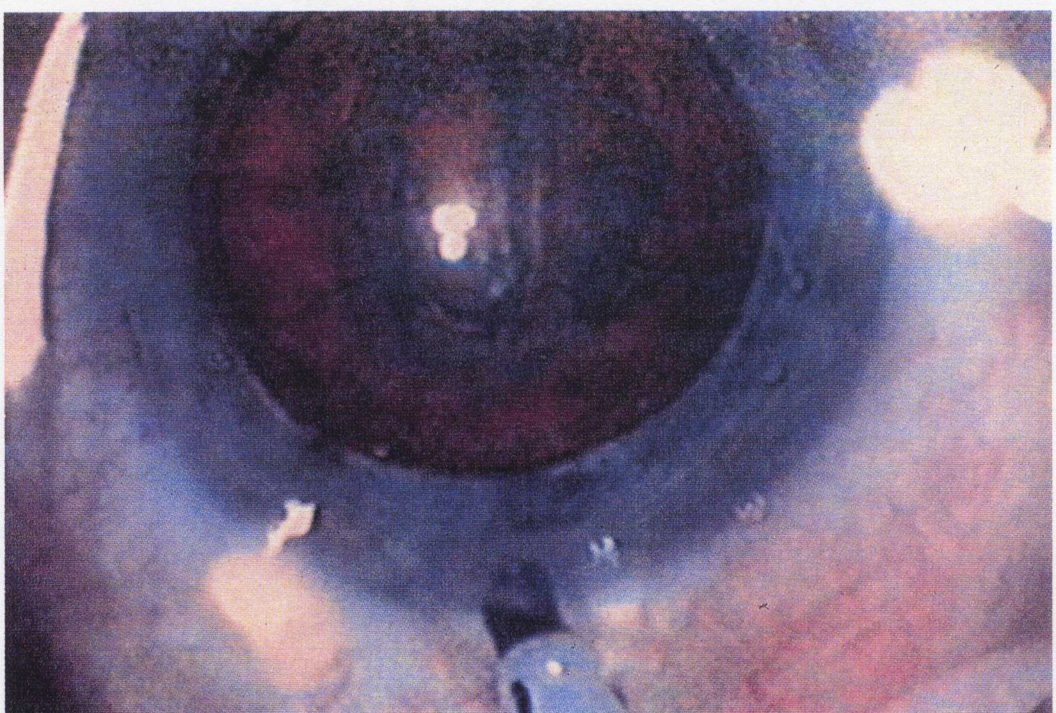


Figure 1.9: Phacoemulsification tip being inserted bevel down without using an instrument on the roof of the tunnel.

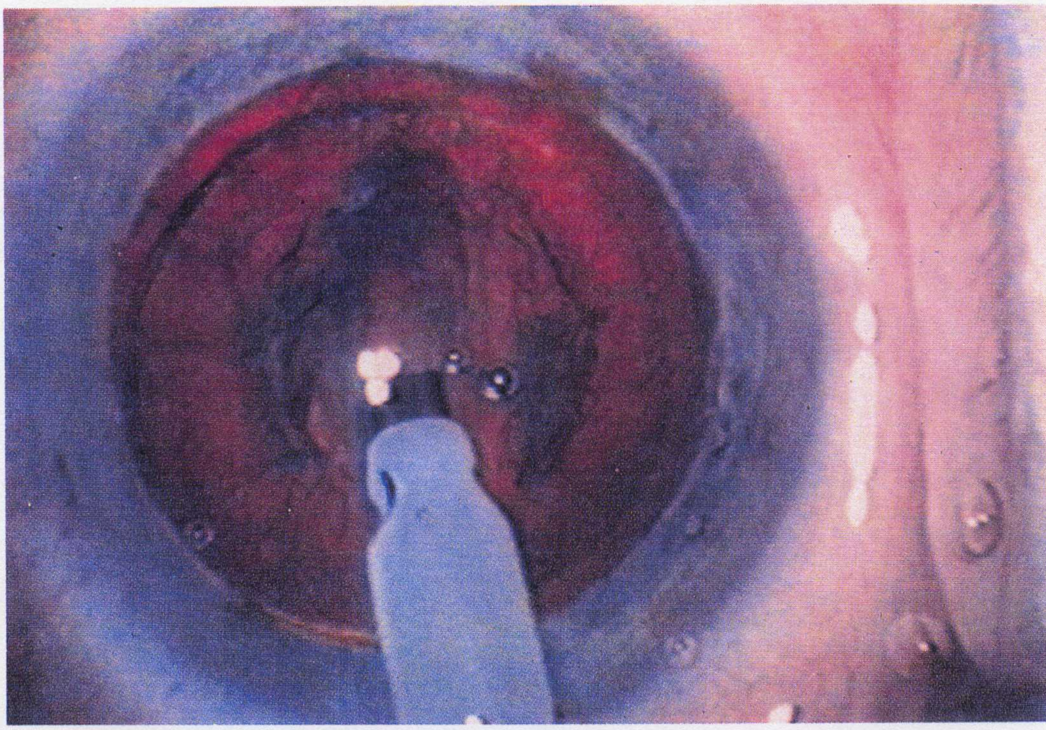


Figure 1.10: Nucleus grooved central to the hydrodelineation demarcation circle.

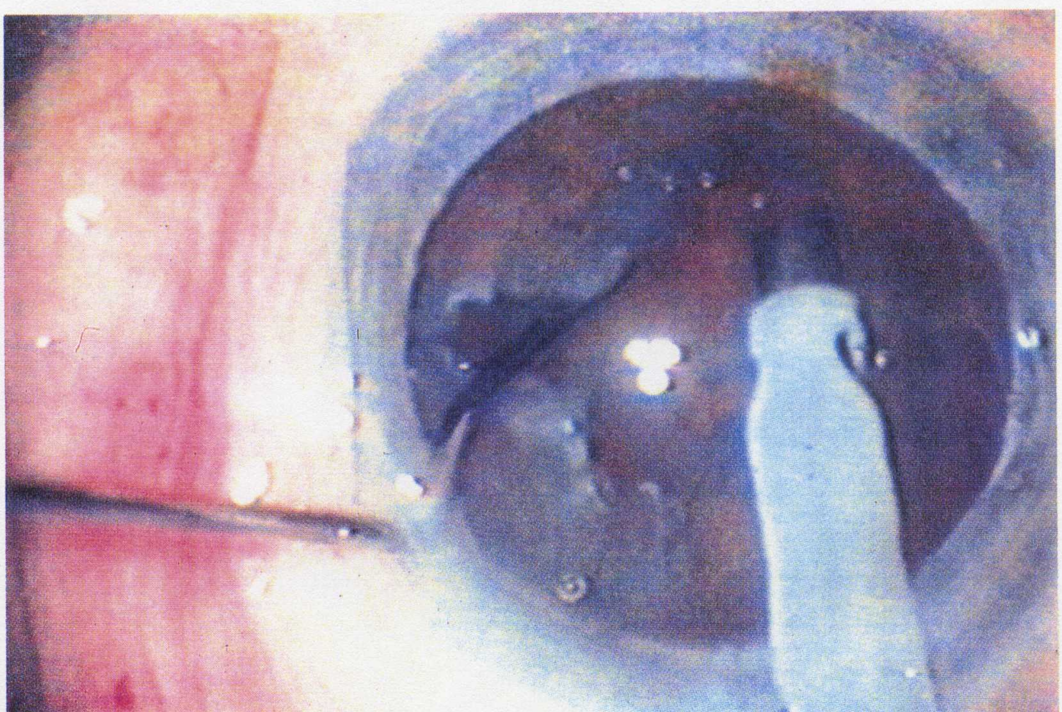


Figure 1.11: Cracking the distal groove.

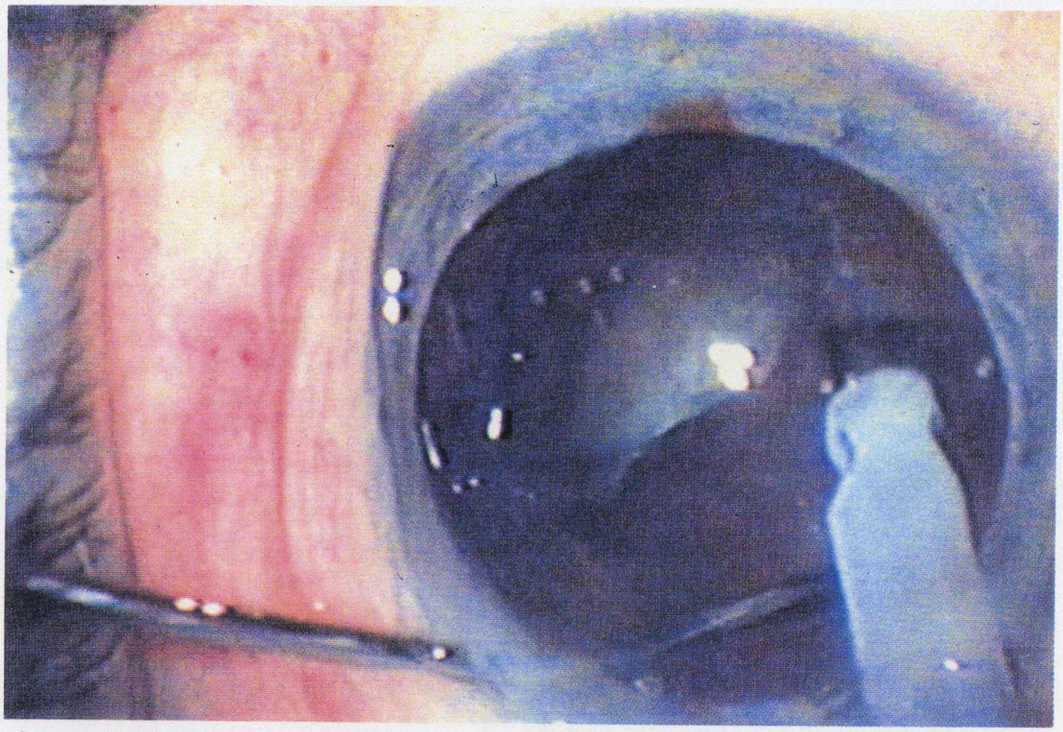


Figure 1.12: Cracking the right groove.

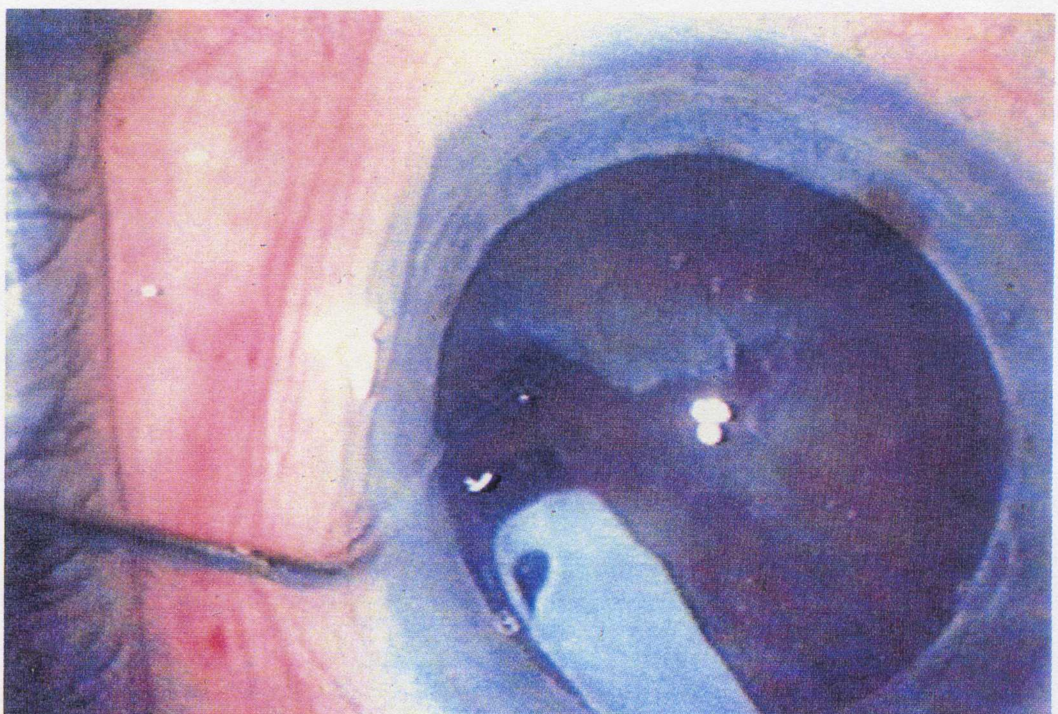


Figure 1.13: Cracking the left groove.

Following that, the bite-sized quadrants are mobilized and completely removed within the epinuclear shell by tilting the blunt periphery down, elevating the sharp apex (Figure 1.14), and occluding the phaco tip at a high vacuum (115-125-mm Hg) in pulsed phacoemulsification mode so as to keep the quadrant on the phaco tip. The second instrument is used to keep the quadrants in a completely endolenticular position so that each of them can be emulsified and removed within the epinucleus (Figure 1.15). The epinucleus free of the evacuated quadrants is seen in Figure 1.16.

The epinucleus is mobilized in its distal portion by aspirating the rim in foot position 2 and pulling it up to the level of the capsulorhexis (Figure 1.17) where the rim of the distal portion is removed. The floor of the distal portion is reposited after which the bowl is rotated 180°. This maneuver is repeated, converting the bowl to a horizontal rectangle. This is then rotated 90° so that the rectangle is in the same meridian as the incision. A flipping maneuver[5] is used to turn the rectangle upside down and remove it from its proximity to the capsule (Figure 1.18, 1.19, 1.20, and 1.21).

The previous trimming of the rim of the epinucleus in two locations allows for this thinned section to mobilize easily in a flipping maneuver through the capsulorhexis. After flipping, the residual epinucleus is removed in most cases

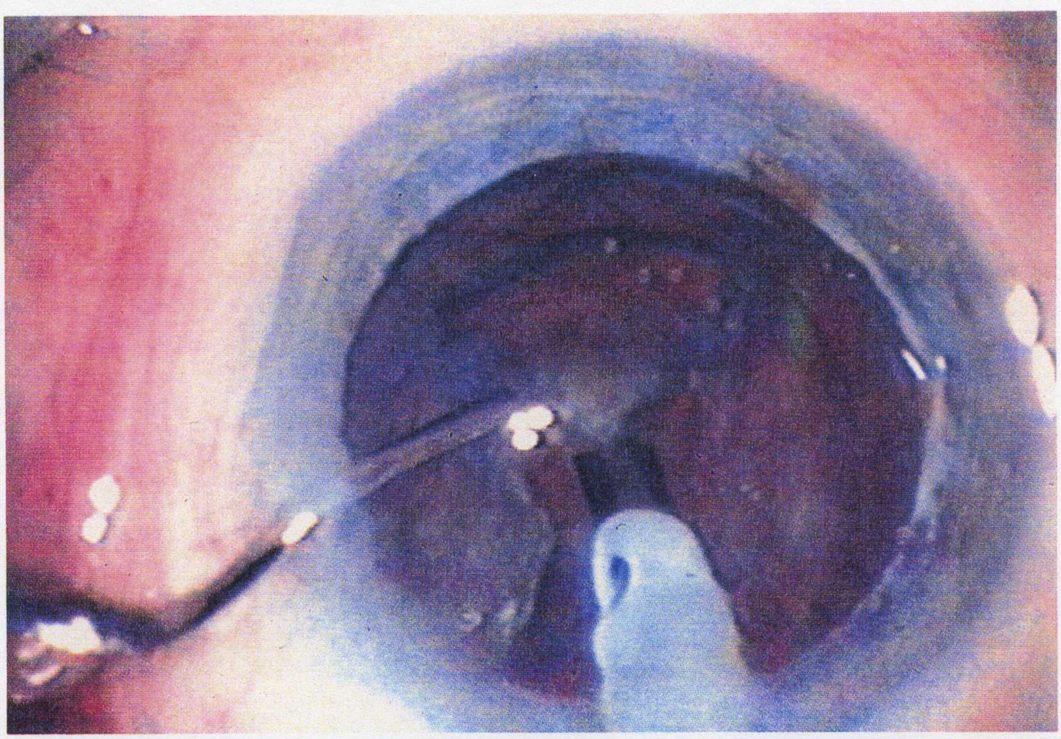


Figure 1.14: Elevating the apex of the quadrant by rotating its blunt periphery down.

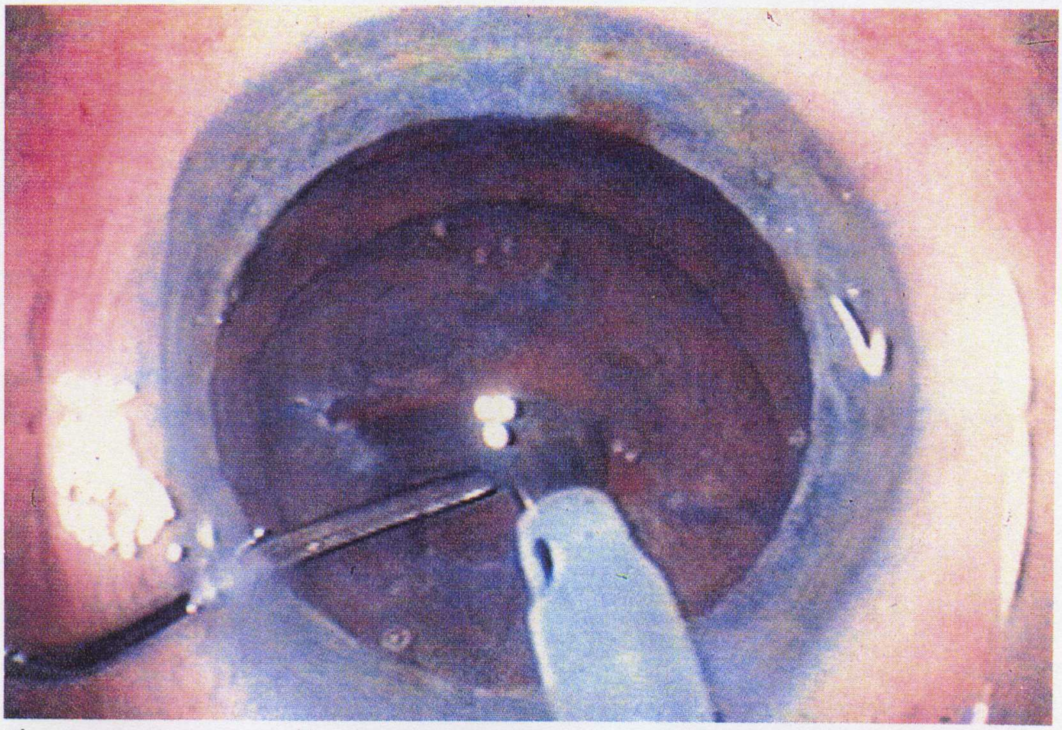


Figure 1.15: Using a second instrument to keep the quadrant within the epinucleus.

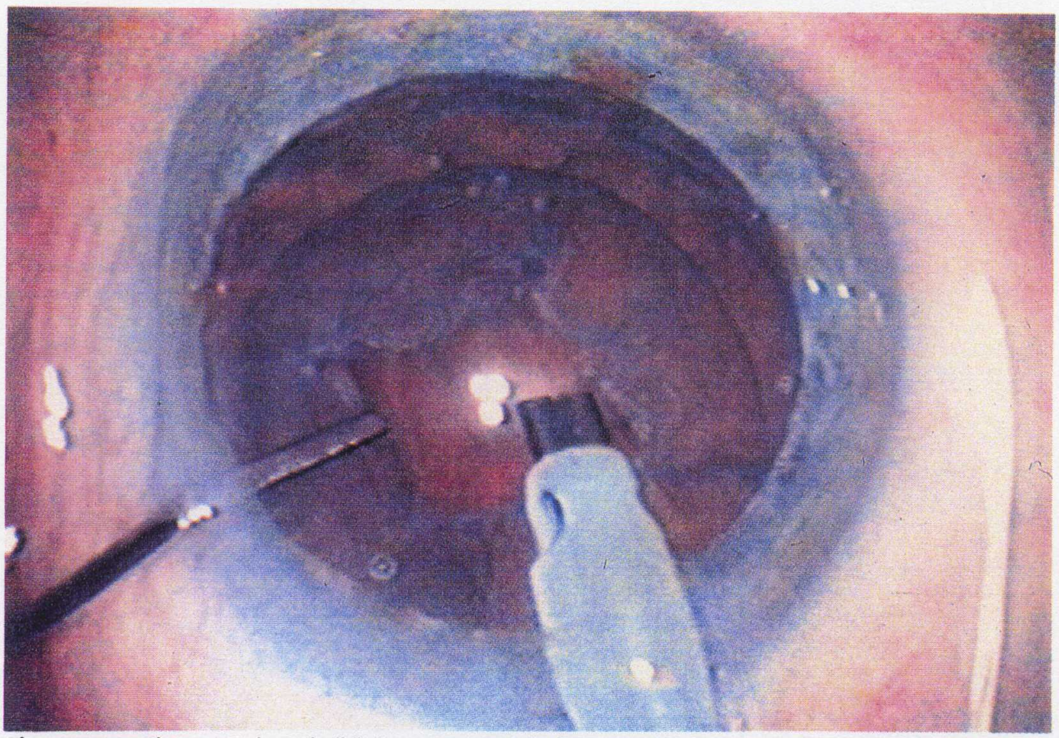


Figure 1.16: The epinuclear shell following removal of the quadrants.

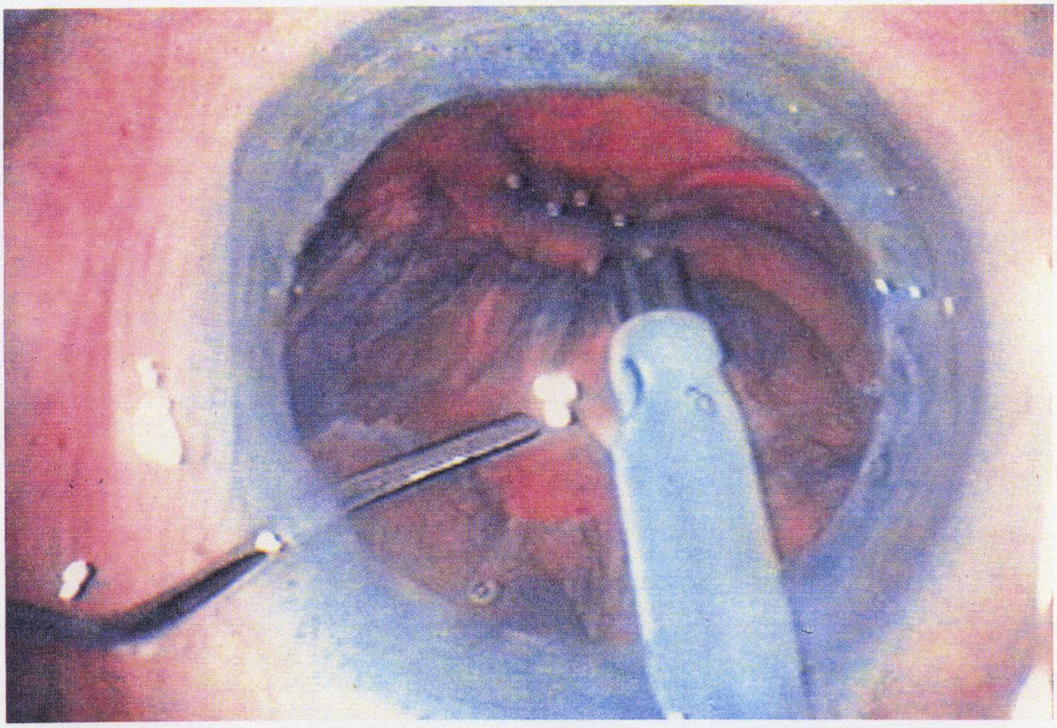


Figure 1.17: Aspiration of the rim of the epinucleus up to the level of the capsulorhexis.

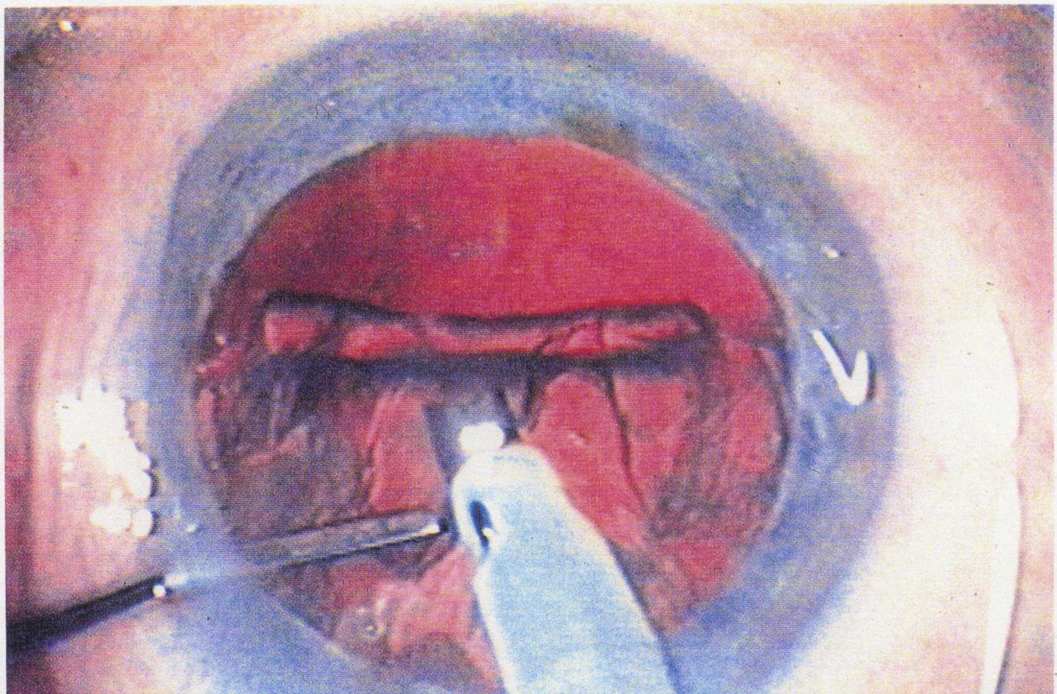


Figure 1.18: Engaging the distal edge of the epinucleus in phaco mode, foot position 2, and pulling it toward the incision.

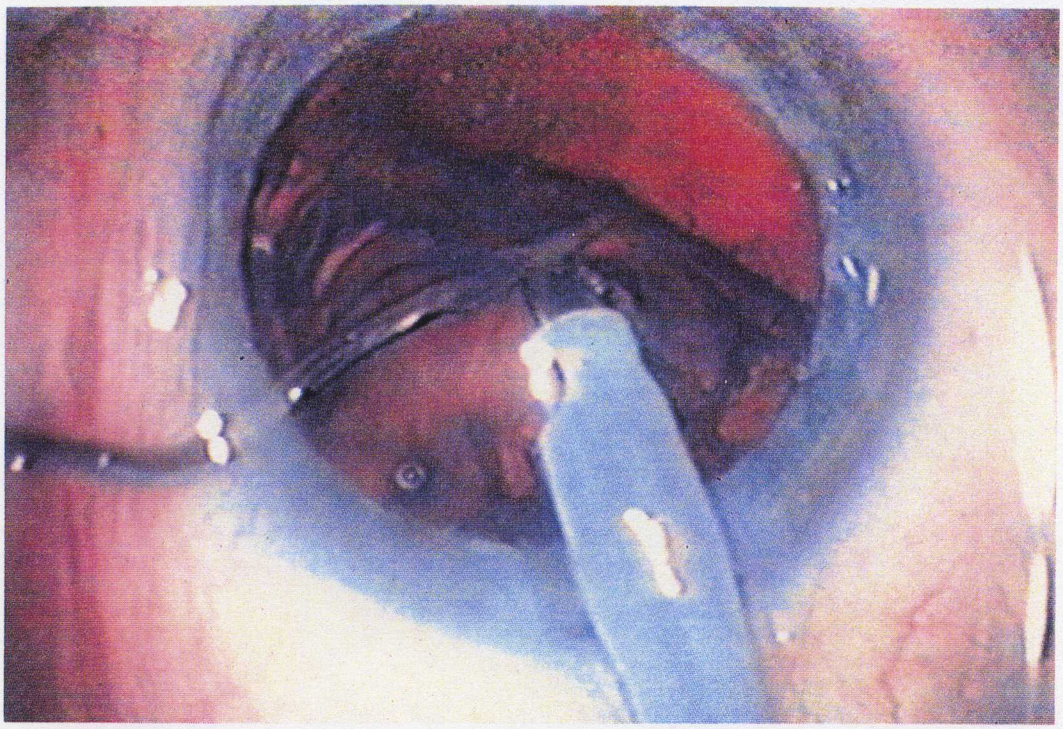


Figure 1.19: Continued traction on the edge of the distal epinucleus toward the incision while pushing in the center of the epinuclear bowl toward the distal periphery.

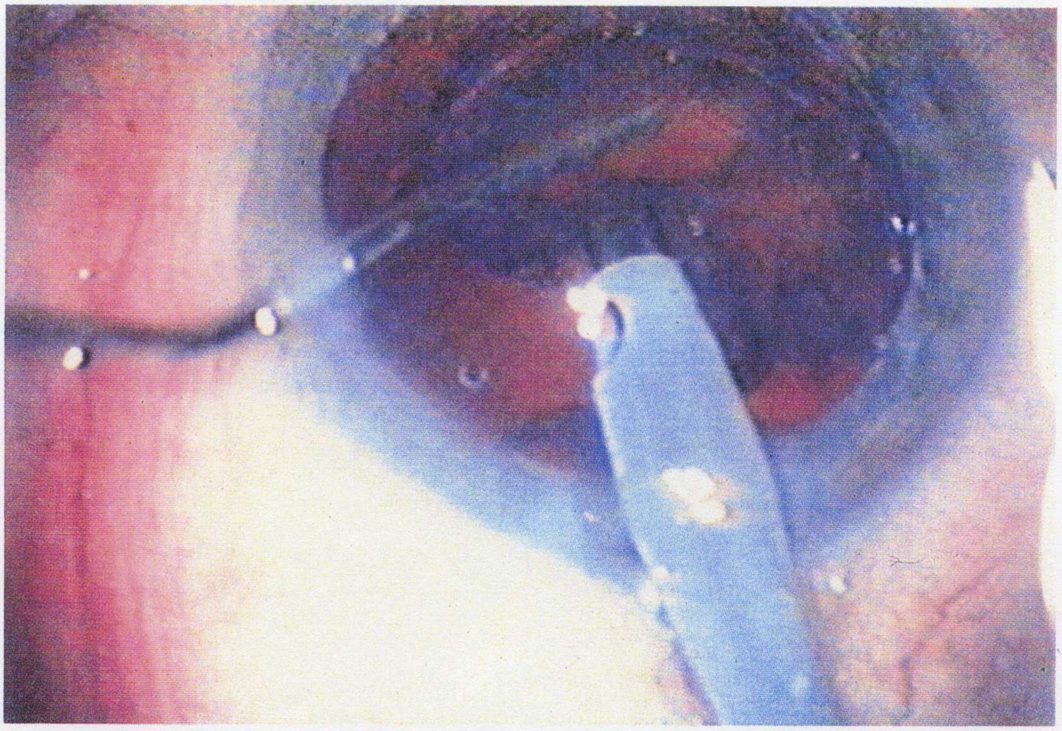


Figure 1.20: Flipping of the epinucleus with the cyclodialysis handpiece now under the epinucleus.

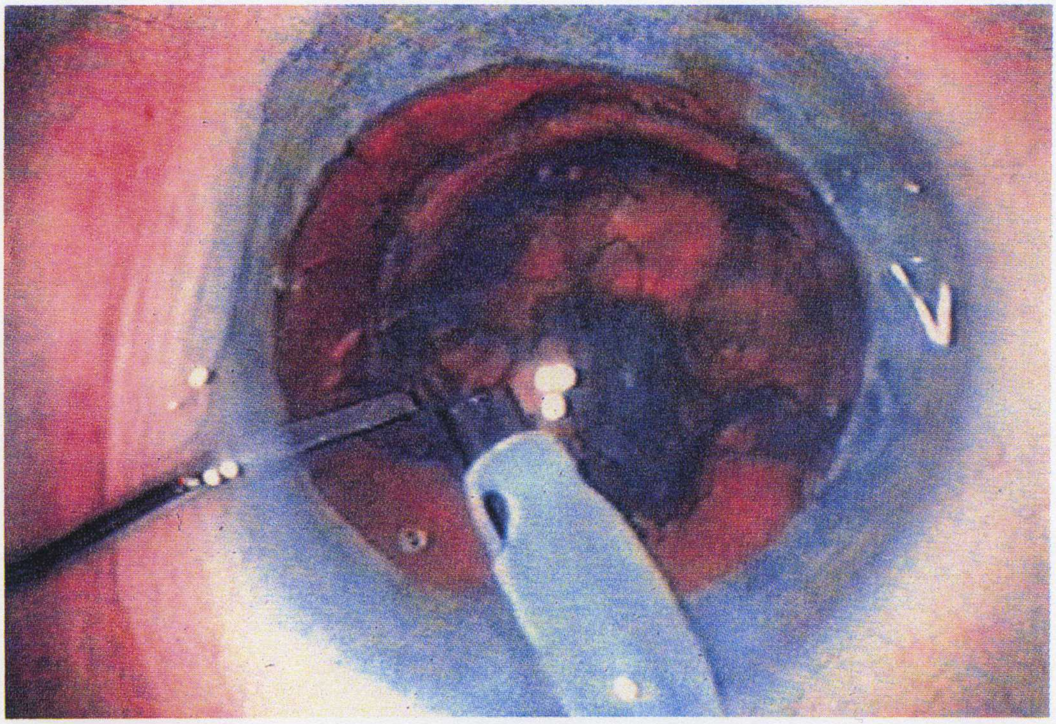


Figure 1.21: Everted epinuclear shell floating freely.

with all of the cortex attached, leaving a clean capsular bag (Figure 1.22). The capsule is expanded with viscoelastic.

The incision does not have to be widened for implantation of a one-piece plate-haptic silicone lens (STAAR Surgical) if the new microinjector with the 45° bevel-down cartridge (STAAR Surgical) is used. The beveled cartridge allows for easy entry into the slitlike corneal tunnel incision without exerting traction on the roof of the tunnel (Figure 1.23). A twisting type of rotation (one way and then the other) and downward pressure as one advances the cartridge into the eye allow the beveled tip to insinuate itself into the incision with minimum distortion of the incision. The accompanying figures document the absence of corneal striae during intraocular manipulation because there is no oarlocking in the shorter corneal tunnel.

The screw mechanism of the STAAR injector is engaged, which allows for delivery of the lens into the eye and implantation directly into the capsular bag (Figure 1.24). The bevel creates a wider opening for the lens to leave the cartridge and allows for implantation with less lens rebound energy and potential trauma to the intraocular structures.

Viscoelastic is removed, the AC is reconstituted through the side port,

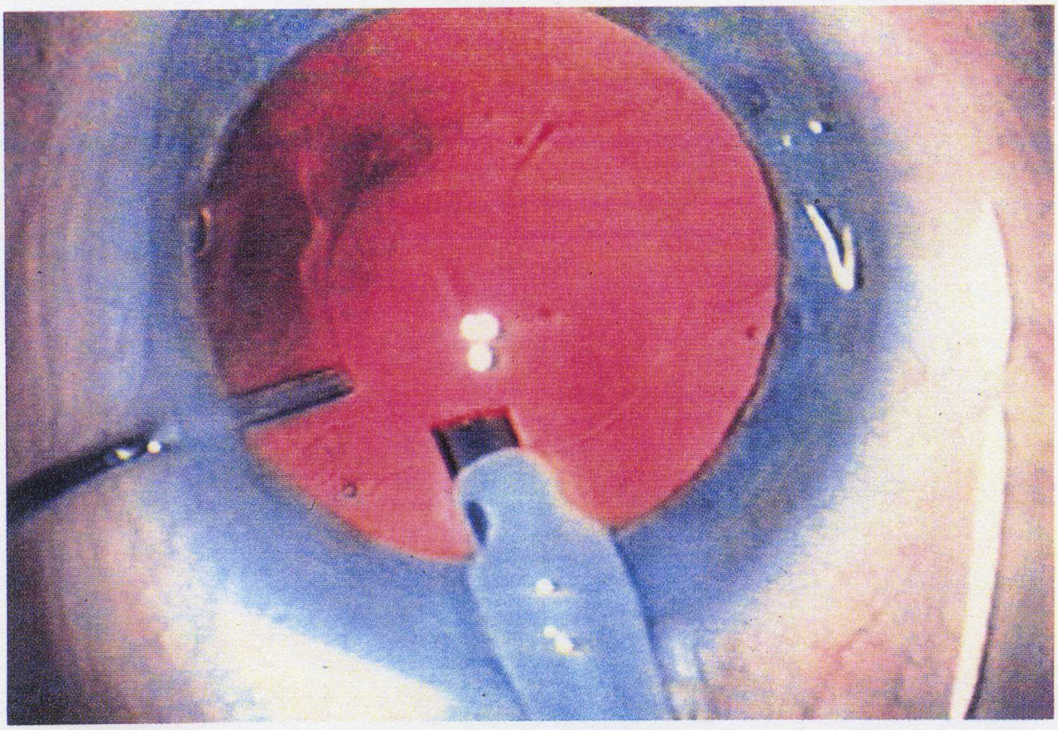


Figure 1.22: Capsular bag following aspiration of the epinucleus, seen to be free of cortex.

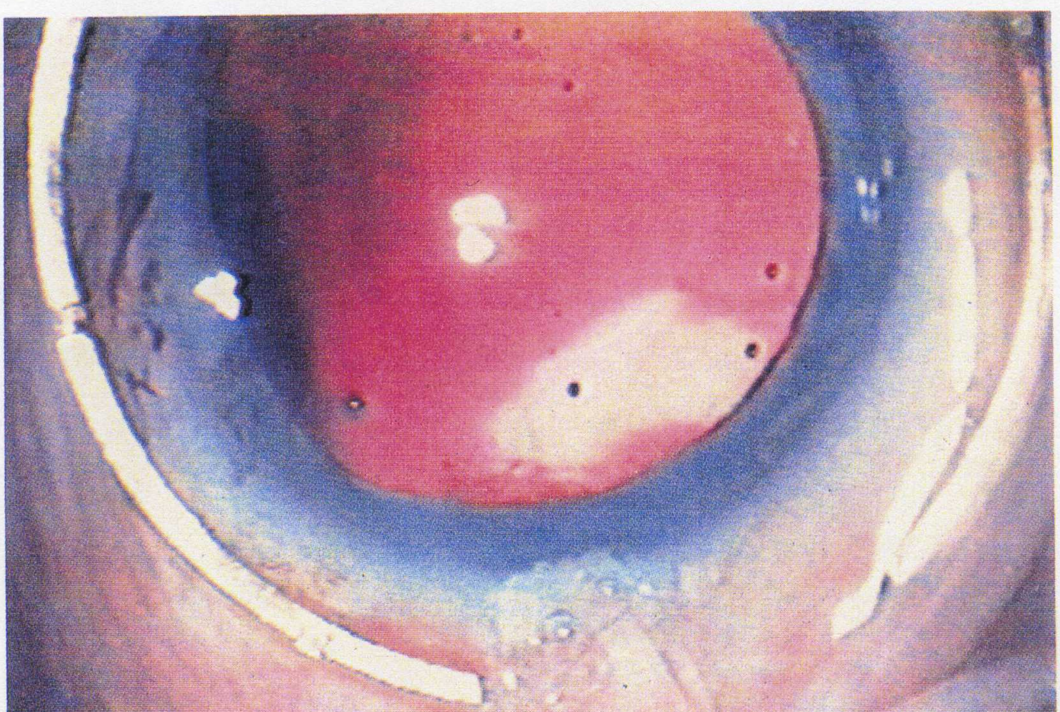


Figure 1.23: Introducing the STAAR cartridge into the scleral tunnel incision.

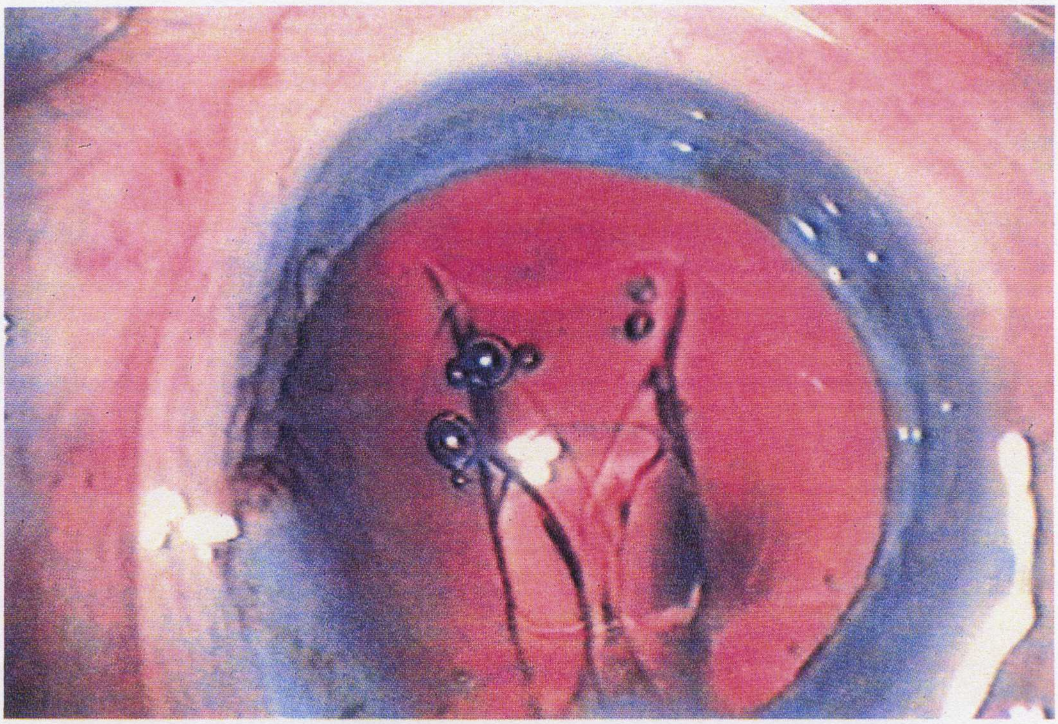


Figure 1.24: Plate-haptic lens unfolding within the capsular bag.

and the incision is tested by pressure on the globe and by staining the incision with fluorescein dye to document that it is indeed self-sealing. If it is not self-sealing, a 26-ga blunt tip cannula on a 2cc syringe is used to forcefully inject balanced salt solution into the sides of the tunnel on both sides (Figures 1.25 and 1.26). This causes temporary stromal swelling, closing the incision in almost all cases.

Qualitative keratometry documents the absence of induced astigmatism (Figure 1.27). If one wishes, a disposable contact lens (Ciba Vision) can be placed over the eye. Postoperatively, eyes operated on in this way appear remarkably uninflamed (Figure 1.28) and have immediate lid blink, motility and vision when topical anesthesia is used.

A new folding system and downsized insertion forceps (Rhein Medical) (Figure 1.29) have been developed for implanting three-piece foldable silicone lenses through clear-corneal incisions (Figure 1.30). With currently available three-piece lenses, enlargement of the tunnel with a keratome to 3.5- or 4-mm is necessary.

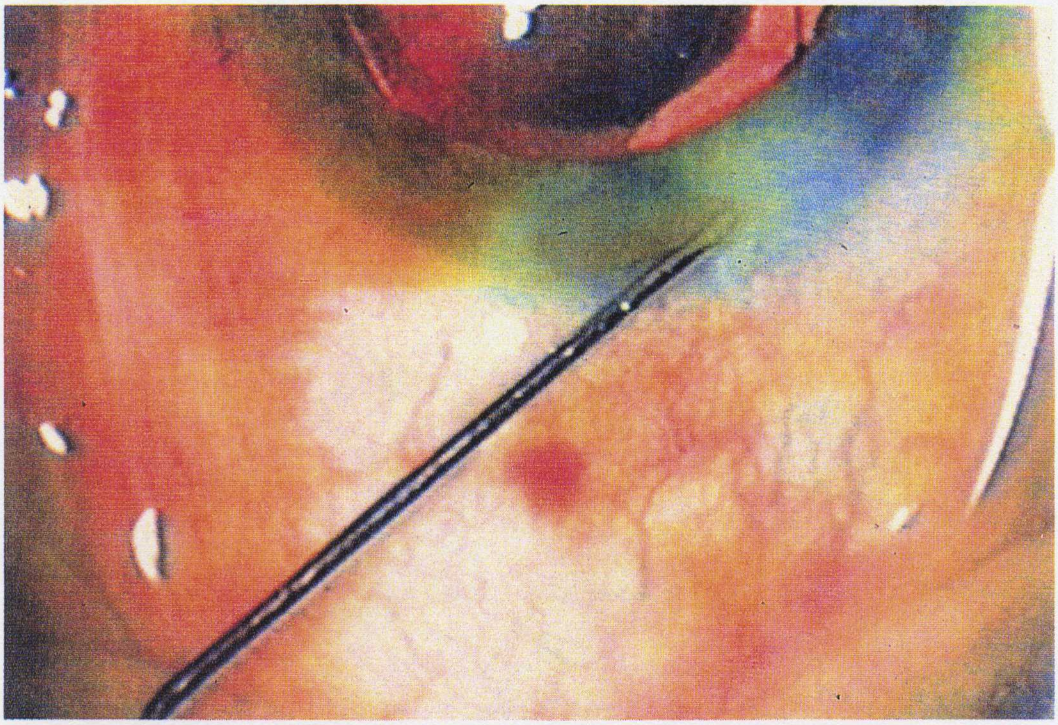


Figure 1.25: Hydration of the side of the corneal tunnel to the right.

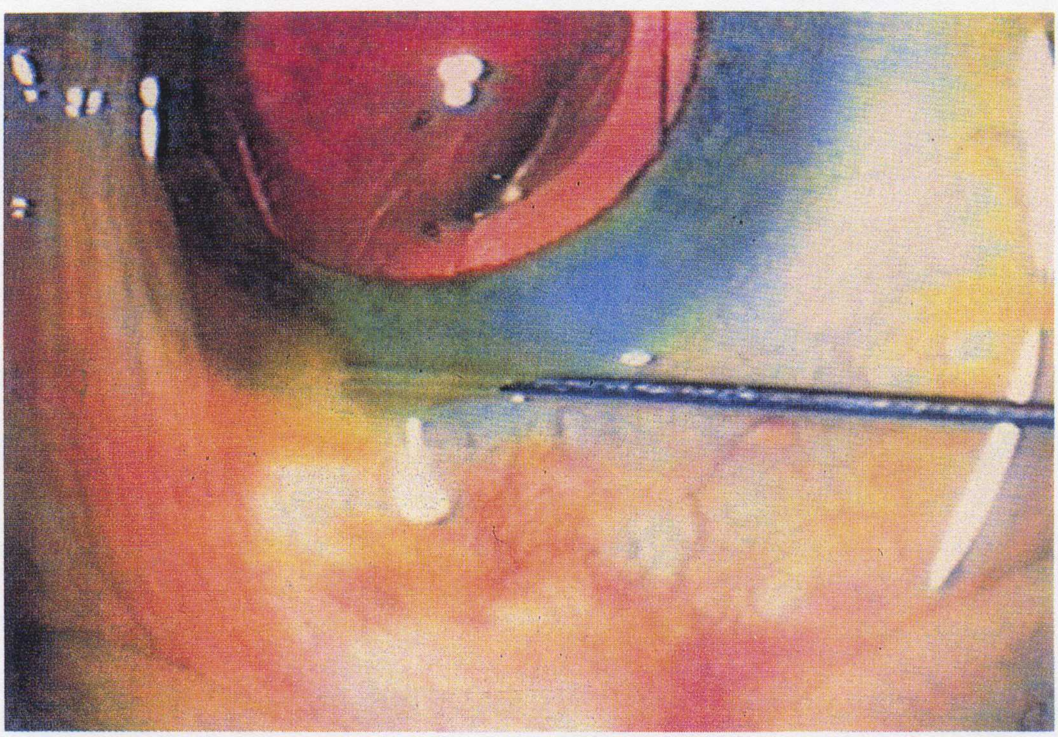


Figure 1.26: Hydration of the side of the corneal tunnel to the left.

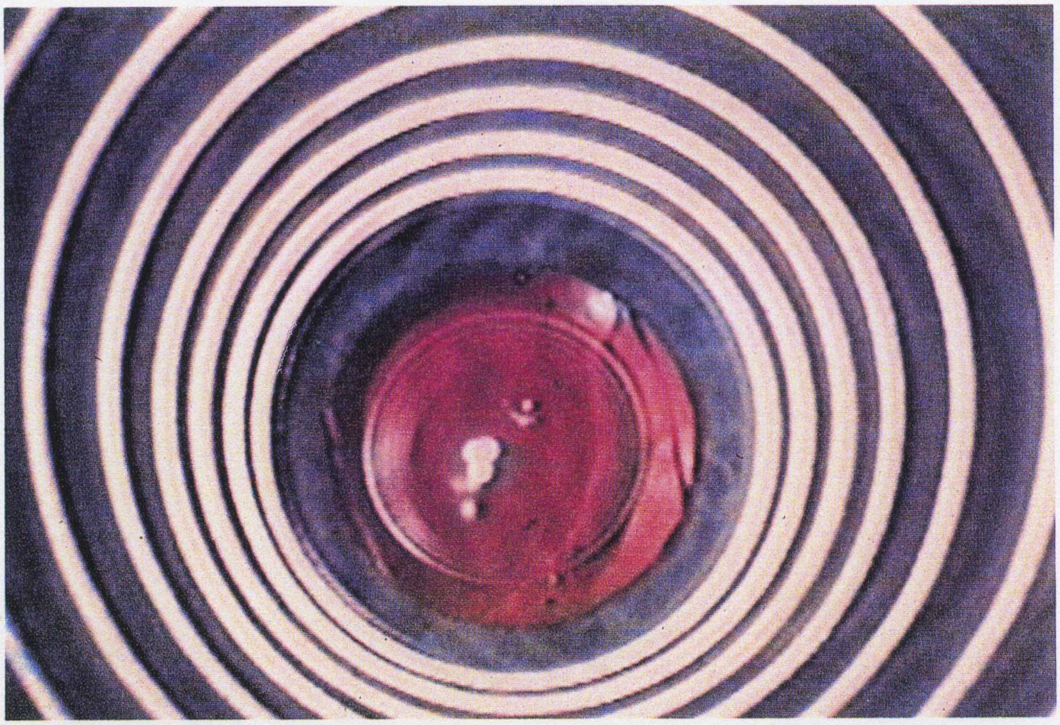


Figure 1.27: Intraoperative keratometry documenting the absence of surgically induced astigmatism.

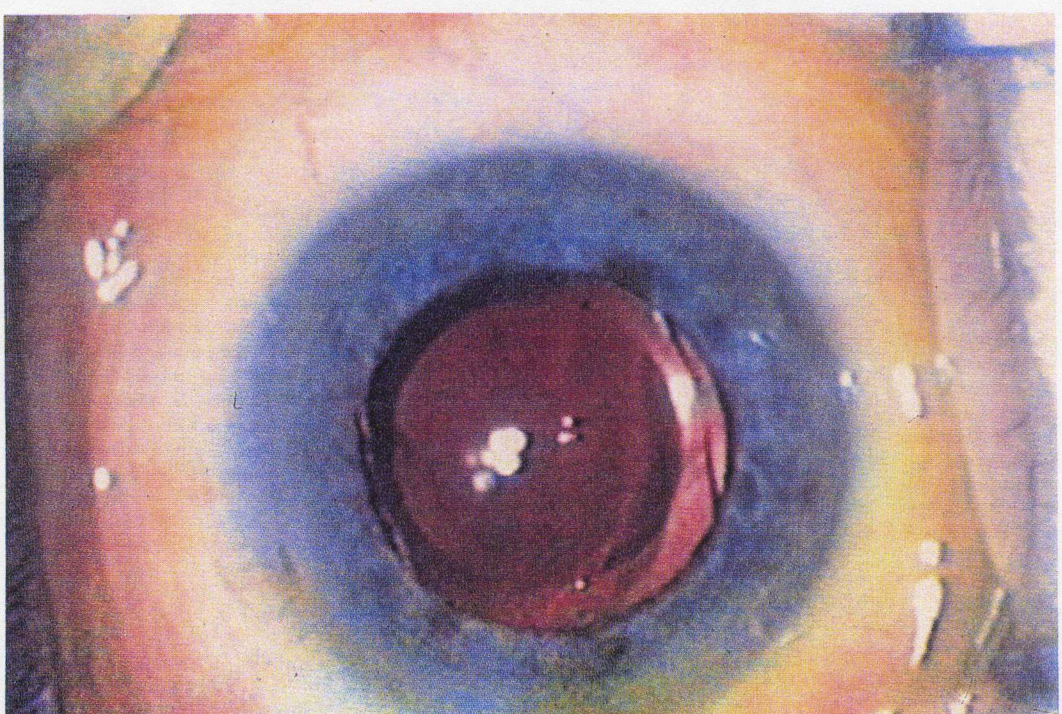


Figure 1.28: Postoperative appearance of the eye.

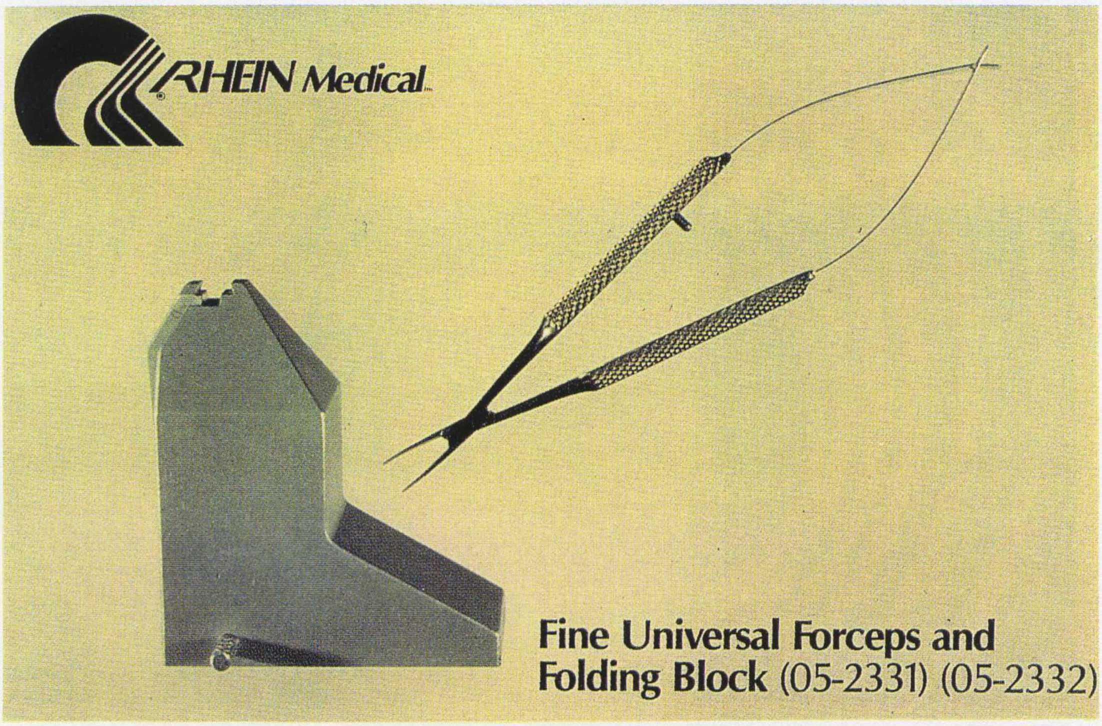


Figure 1.29: Fine Universal Insertion Forceps and Folding Block.

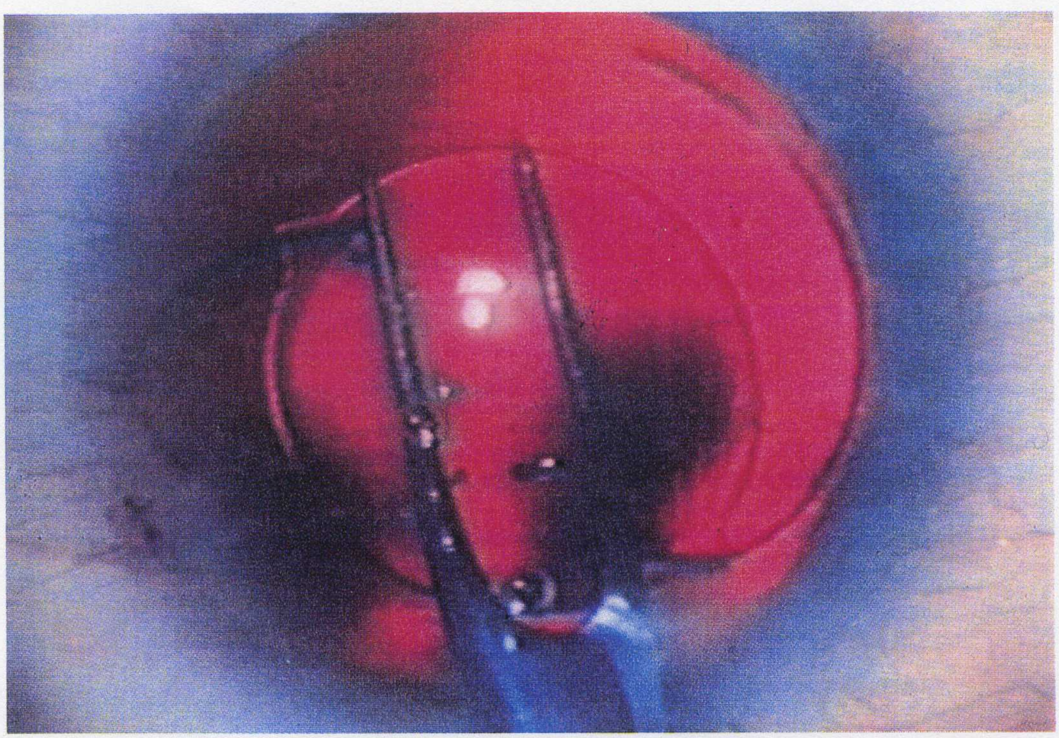


Figure 1.30: Three-piece silicone lens gently unfolding into the capsular bag after release by the Fine forceps.

COMPLICATIONS AND ASTIGMATISM RESULTS

Data from the first 90 patients in whom I've performed this incision were analyzed. Incisions in these cases were almost all 4-mm wide. The preoperative and postoperative corneal astigmatism was examined without regard to axis. At one day postoperative, 45% of the patients remained within 1 D of preoperative keratometric cylinder. At 1 to 2 weeks postoperative, 55% of patients were within 1 D of the preoperative level and 56% of patients had reduced astigmatism relative to their preoperative cylinder level. Only 19% of the patients had an increase in astigmatism of more than 1 D at 1 to 2 weeks postoperative.

The patients experienced an average increase in keratometric cylinder of about 0.5-D at 1 day postoperative. This decreased to a mean level of 0.25 D by the 1-to-2-week examination.

Using vector methods of computing surgically induced astigmatism, we found a mean induced cylinder of approximately 1.5 D at 1 day. This regressed to 1 D at 1 to 2 weeks. For those patients with greater than 6 weeks of follow-up, the mean surgically induced cylinder fell to less than 1 D. Among the patients with best corrected visual acuity of 20/40 or better and for whom we have uncorrected visual acuity data, 61% achieved an uncorrected visual acuity of 20/40 or better.

To put our visual results in perspective, we compared uncorrected visual acuity at 1 day postoperative with data reported by Drs. Paul Ernest[6] and Gale Martin.[7] The data reported by Martin is from a clinical trial with stringent criteria, excluding patients not deemed potentially correctable to 20/40 (essentially excluding all patients with preoperative pathology). Our data on postoperative astigmatism fell within the range reported for sutureless 3.2-mm to 4-mm scleral tunnel incisions reported by Ernest, Grabow, and Martin[6].

In the first 500 patients on whom I used the approach, there have been very few complications. One of the early patients, in whom the incision was made with a metal keratome at 12 o'clock, suffered an infectious endophthalmitis and a poor visual result. One patient with preexisting compromised endothelium suffered mild corneal decompensation but achieved a postoperative visual acuity of 20/40. Approximately 2% of the patients required suture closure at the time of surgery.

In another two cases, a very shallow to flat AC was observed on the first postoperative day. One of the patients responded to placement of a disposable soft contact lens with full reformation of the AC. The other was returned to the operating room on the second postoperative day for placement of a single radial suture. Both patients achieved 20/20 visual acuity.

CONCLUSIONS

The temporal self-sealing corneal tunnel incision for phacoemulsification and foldable-IOL implantation is a new technique. On the basis of the initial series of patients, it appears to produce results comparable to 3.2-mm to 4-mm scleral tunnel sutureless incisions in terms of induced astigmatism and early postoperative visual acuity. The results justify the expanding utilization of the technique.

Current investigation includes attempts at modification of the cartridge to allow for even smaller incisions compatible with downsized phacoemulsification tips. We continue to seek improvements in the diamond knife, and are exploring applications of computerized corneal topography. Expanded clinical studies will compare results of a 3-mm incision to those obtained with a 4-mm incision.

I believe that this new systematized approach to cataract surgery offers many benefits, not only in reduced surgical time and costs, but also in enhanced patient outcomes. I further believe that the approach described will become part of a new standard of care and will help convert many cataract surgeons to foldable-IOL technology.

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