A small astigmatically neutral cataract incision is one of the fundamental benefits of phacoemulsification and foldable intraocular lenses (IOLs). When intracapsular and standard extracapsular surgery were the mainstay of ophthalmology, the customary surgical approach was the fornix-based peritomy, followed by a superior limbal or scleral incision, closed with interrupted and/or running sutures. Astigmatic instability, associated with uneven suture tension in the short term and wound separation with flattening of the corneal curvature in the long term, was an unfortunate but unavoidable feature of these long incisions. Phacoemulsification has been embraced by ophthalmic surgeons in large part because small incision surgery provides patients with an opportunity for more rapid visual recovery and for greater refractive stability.

**Evolution of the Sutureless Incision in Phacoemulsification**

McFarland reported the first series of patients undergoing phacoemulsification with a sutureless incision in 1990. His original approach involved a standard scleral tunnel technique, performed superiorly with a conjunctival peritomy.\(^1\) Ernest analyzed McFarland’s sutureless incision and observed that McFarland’s scleral tunnel involved a dissection into corneal tissue. He theorized that the water-tight nature of the incision was due in large part to an internal corneal flap that behaved like a flutter valve. Ernest subsequently performed cadaver studies and, utilizing manometric pressure testing, concluded that the strongest and most stable design for a sutureless incision was one in which the width and depth of the incision were equal.\(^2\) In the early 1990s, foldable IOL technology had not evolved sufficiently to allow IOLs to be inserted through incisions smaller than 3.5 to 4 mm. For this reason, Ernest initially advocated scleral- or limbal-based incisions with an internal corneal flap of 1.5 mm or more.\(^3\) With improvements in IOL delivery systems in the mid-1990s, it became possible to perform the entire phaco procedure with lens implantation through an incision of 3 mm or less. Once incisions were of this size, both limbal and “clear corneal” incisions were found to be of virtually equal strength as long as the equality of incisional width and internal length were maintained.\(^4\) Topographic studies, moreover, performed by Menapace and his colleagues on a variety of clear corneal incision configurations determined that square incisions in which the internal length of the incision equaled its width provided the greatest astigmatic stability both in the short and longer term.\(^5\)
The widespread use of topical anesthesia techniques that require no patch postoperatively have helped to fuel the adoption of the clear corneal sutureless incision, first described by Fine in 1994. Partly for reasons of improved surgical efficiency, partly for better cosmesis, and partly for greater refractive stability, a majority of US cataract surgeons now perform temporal clear corneal incisions without sutures. A recent survey reveals that approximately 75% of American Society of Cataract and Refractive Surgery members now favor this clear corneal approach when performing phacoemulsification. It should be noted that there has been some confusion over the years regarding the classification of incisions by location. This has led to misunderstanding and disagreements, fostered in some instances by nothing more than differences in semantics. A straightforward classification by Fine suggests that the term clear corneal be used for incisions with an external entry anterior to the conjunctival insertion. Using Fine’s nomenclature, limbal incisions are those made through the limbus and conjunctival insertion, and scleral corneal incisions are those posterior to the limbus, usually requiring a peritomy.

Three basic entry approaches for clear corneal incisions have been proposed. Charles Williamson has suggested that a shallow groove be made at the entry site. Using Williamson’s technique, anterior dissection of the incision into corneal stroma begins at the base of the groove. David Langerman has described the use of a deeper groove of approximately 450 microns that he believes may add stability to the incision. With Langerman’s technique, the corneal tunnel begins at approximately two-thirds of the depth of the groove. Fine advocates a single plane entry without a groove. All three of these approaches have been utilized successfully by thousands of surgeons. Recent optical coherence tomographic (OCT) imaging, reported by Fine and his colleagues, suggests that the creation of an entry site groove may result in a slight radial slippage of the corneal flap both externally and internally. This separation of the external and internal flap margins was not seen on OCT images of clear corneal incisions made with a single plane entry. These findings need to be confirmed with additional studies, but they suggest that grooved incisions may result in more flattening of the corneal curvature in the axis of the incision than single plane incisions. Other minor objections to grooved incisions are that a gap caused by the groove at the incision entry can result in a mild foreign body sensation, mucous pooling, and a more prolonged disruption of epithelial coverage of the incision.

Concerns of Hypotony and Endophthalmitis

The concern has been raised that sutureless clear corneal incisions may be associated with a higher risk of endophthalmitis. A series of 15,000 clear corneal procedures at the Moran Eye Center at the University of Utah revealed an incidence of endophthalmitis of one in 400, whereas a smaller series of 1200 cases performed with corneoscleral tunnel incisions at the same institution showed no cases of postoperative infection. Likewise, Nagaki et al and Cooper et al have reported a higher incidence of endophthalmitis with clear corneal vs scleral tunnel incisions at their institutions. Other authors have suggested a temporal correlation between an apparent overall increase in the rate of endophthalmitis and the widespread use of clear corneal sutureless incisions.

One widely held belief is that postoperative hypotony is a major risk factor for endophthalmitis. Shingleton et al have reported an intraocular pressure of 5 mm or less in 20% of patients with clear corneal sutureless incisions during the first 30 minutes after cataract surgery. McDonnell and colleagues, using India ink in the vicinity of sutureless clear corneal incisions, have demonstrated the ingress of extraocular fluids under conditions of hypotony. Poor wound construction, especially in more anteriorly located incisions, is widely believed to be a major risk factor for postoperative hypotony.

Other structural factors may predispose to hypotony and postoperative endophthalmitis. Miller and his colleagues at Bascom Palmer Eye Institute observed that 86% of cases of endophthalmitis at their institution occurred with the clear corneal incisions placed in an inferotemporal location. Other investigators have pointed out that incarceration of a flap of Descemet’s membrane into the posterior lip of the incision may lead to hypotony. Thermal injury, excessive manipulation, and “fish mouthing” of the incision are other causes for poor sealing and increase the risks of hypotony.

Meticulous Construction Necessary

Masket and Belani have demonstrated that sutureless clear corneal incisions that are meticulously constructed with a square or “nearly square” configuration show no evidence of hypotony in the early postoperative period. Monica and Long have described the long-term safety of clear corneal “tunnel” incisions.
and Fine, Hoffman, and Packer have reported a large series of sutureless clear corneal incisions over a 10-year period without a single case of endophthalmitis. I have had a similar experience. I have performed over 8000 clear corneal incisions without a case of postoperative infection. It must be understood, however, that the threshold for placement of corneal sutures should be very low. It is impossible for any surgeon to make a “perfect” clear corneal incision with every effort. At the end of each case, every incision must be critically evaluated and carefully tested. If there is evidence that the internal length of the incision is too short or that the incision is poorly constructed in any way, the incision should be sutured.

**ASTIGMATIC CONSIDERATIONS**

Phacoemulsification surgeons today fall into two groups: those who always approach the eye from a temporal location and then perform limbal relaxing incisions when necessary in the steep axis, and those who make their incision on the steep corneal axis and then make limbal relaxing incisions, as needed, opposite and adjacent to the incision. The temporal clear corneal incision is favored by many because of ease of access and because of the astigmatic neutrality afforded by this approach. While studies have shown that small scleral corneal tunnel incisions made superiorly result in astigmatic changes similar to small temporal clear corneal incisions, clear corneal incisions made superiorly clearly result in greater and less predictable astigmatic shifts than do temporally placed clear corneal incisions. It has even been demonstrated that superior oblique clear corneal incisions result in greater astigmatic shifts than do temporal clear corneal incisions. These studies confirm the usefulness of the temporally placed clear corneal incision for the maintenance of astigmatic neutrality, but they suggest that incisions placed superiorly should be scleral corneal.

**STEP-BY-STEP APPROACH TO THE CLEAR CORNEAL INCISION**

**Step 1. Stabilize the Globe.** Stabilize the globe using a ring holder placed at the limbus (Figure 2-1).

**Step 2. Enter at the Limbal Arcade.** Using a trapezoidal blade that is precisely matched in width to your phaco tip, enter at the end of the terminal vessels in the limbal arcade. Placement of the entry at this location allows the surgeon to develop an incision that is as long internally as it is wide without extending too far into the anterior cornea and also helps the surgeon to avoid cutting through the conjunctiva (Figure 2-2). If the incision is made too posteriorly, infusion of fluids with the phaco tip can create conjunctival chemosis that can result in pooling of extracocular fluids over the surface of the cornea and reduced visualization. If conjunctival chemosis occurs, it can be relieved easily by snipping through the conjunctiva radially and in both lateral directions at the limbus.

**Step 3. Make the Intrastromal Length of the Incision Equal to the Width of the Incision.** Direct the tip of the blade anteriorly under direct visualization until the tip of the blade has reached an intrastromal length equal to or slightly longer than the width of the blade (Figure 2-3). If the incision is made much longer than the width of
the incision, introduction of the phaco tip may create folds in Descemet's membrane, which makes visualization of the anterior chamber difficult. As emphasized above, incisions shorter than the width of the incision are likely to leak.

Step 4. **Complete the Internal Incision.** Direct the tip of the blade parallel to the iris plane and enter the anterior chamber (Figure 2-4). Be sure that the internal incision is complete, but be careful; if you are using a side cutting blade, do not enlarge the incision inadvertently. This can result in poor fluidics during the procedure and an incompetent incision at the end of the case.

Step 5. **Carefully Examine and Hydrate the Incision.** At the end of the procedure, fill the anterior chamber and inspect the incision carefully.

Figure 2-4. Complete the internal incision by directing the tip of the blade parallel to the iris plane and enter the anterior chamber.

Figure 2-5. Examine the incision carefully to make certain that the architecture of the incision is square.

Figure 2-3. Direct the tip of the blade anteriorly under direct visualization until the tip of the blade has reached an intrastromal length equal to the width of the blade.

Figure 2-6. Gently hydrate the margins of the incision and all side ports with BSS. Make sure that there is no evidence of incarceration of a Descemet's flap in the incision and that the incision is secure even to rigorous external pressure.

Make sure that there is no evidence of incarceration of a Descemet's flap in the incision, that the architecture of the incision is square, and that the incision is secure even to rigorous external pressure (Figure 2-5). Gently hydrate the margins of the incision and all side ports with balanced salt solution (BSS) (Figure 2-6).

Step 6. **If the Incision Is Not “Rock Solid” Perfect, Suture It.** If the incision is poorly constructed or if it can be made to leak with rigorous external pressure, suture the incision and then reexamine. If a Descemet's flap is observed, gently irrigate the flap into the anterior chamber and suture the incision. Use additional sutures, if necessary, to ensure competency.
Incisions

Step-by-Step Approach to the Scleral Corneal Incision

Step 1. Perform a Peritomy. Create a fornix-based peritomy, removing all Tenon’s fibers for better hemostasis. Cauterize lightly. Excessive cautery can result in scleral shrinkage, which can lead to increased postoperative astigmatic changes and poor approximation of the margins of the external incision (Figure 2-7).

Step 2. Create a Scleral Groove and Scleral Tunnel. Make a scleral groove 1 to 2 mm posterior to the limbus at a depth of approximately 250 microns (Figure 2-8). The width of the scleral groove should be equal to or only slightly wider than the width of the keratome, which will be used to make the internal entry into the anterior chamber. Using a “crescent blade,” create a scleral tunnel by dissecting into clear cornea at least 1.5 mm anterior to the limbus (Figure 2-9). Care must be taken not to make the scleral groove and tunnel dissection significantly wider than the keratome used to enter the anterior chamber. This may lead to difficulties with chamber maintenance as it may result in a widening of the internal incision and excessive outflow of irrigating fluids during phacoemulsification.

Step 3. Complete the Internal Incision. Using a keratome that is precisely matched to the width of your phaco tip, direct the blade parallel to the iris plane and enter the anterior chamber at the end of the scleral tunnel (Figure 2-10). The use of a keratome that is too narrow for the phacoemulsification instrument may lead to restriction of flow through the irrigation sleeve, overheating of the phaco tip, and thermal injury to the incision. The use of a keratome that is too large results in excessive outflow around the irrigation sleeve and difficulties with anterior chamber maintenance during the procedure.

Step 4. Examine and Hydrate the Incision. If the Incision Is Not Perfect, Suture It. At the end of the procedure, examine the incision carefully. The incision should be square or nearly square with an internal corneal incision of at least 1.5 mm. If the incision appears well constructed, gently hydrate the margins of the incision and all side ports with BSS and fill the anterior chamber (Figure 2-11). If a Descemet’s flap is observed, gently irrigate the flap into the
anterior chamber and suture the incision. If the incision is poorly constructed or if it leaks with rigorous external pressure, suture the incision and reexamine. Use additional sutures, if necessary, to ensure competency.

REFERENCES

