Use of a Disposable Artificial Anterior Chamber for Trans-Epithelial Trephination and Endothelial Keratoplasty

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ABSTRACT
The Barron artificial anterior chamber (Katena, Den- ville, NJ) is an innovative development in corneal transplant and lamellar surgery. The chamber is a specialized device that allows a donor corneoscleral cap of tissue to be anatomically positioned “epithelial side up.” The chamber is used to mount the donor tissue and maintain adequate pressure while lamellar dissection or full thickness trephination is being performed. The Barron artificial anterior chamber is designed in a bright blue color to provide a high-contrast background for visualizing the cornea and aiding in the lamellar dissection of the cornea. This innovative chamber is the only disposable artificial anterior chamber and provides many advantages to surgeons beginning to offer endothelial replacement surgery to their patients.

HISTORICAL PERSPECTIVE
Endothelial cell dysfunction accounts for roughly 50% of the cases requiring corneal transplantation. It is also the prime reason for endothelial lamellar keratoplasty. The indications for corneal endothelial transplantation are corneal endotheliopathies, including Fuchs endothelial dystrophy, pseudophakic or aphakic bullous keratopathy, and posterior polymorphous dystrophy. The other diseases associated with corneal endothelial damage are iridocorneal endothelial syndrome and congenital hereditary endothelial dystrophy.

In 1998, the Dutch ophthalmologist Gerrit Melles described the sutureless posterior lamellar keratoplasty (PLK) technique in which a posterior lamellar corneal disc, consisting of posterior stroma, Descemet membrane, and endothelium, was transplanted through a self-sealing scleral tunnel incision. The PLK presented many advantages compared with full-thickness keratoplasty performed for posterior corneal disorders. The patients achieved fast visual recoveries with stable refractive error within the first weeks after surgery. Because no sutures were used, the surgically induced astigmatism was minimized, suture-related complications eliminated, and the risk of wound dehiscence reduced.

In 2001, Terry and Ousley described a modified technique called deep lamellar endothelial keratoplasty (DLEK). Both surgeries (PLK and DLEK) preserve the preoperative topography with minimal astigmatism and predictable and stable corneal power; they also provide a healthy donor endothelial cell count and function.

By eliminating corneal incisions or sutures, PLK/DLEK surgery prevents the sutures-in, sutures-out changes in astigmatism and corneal topography sometimes observed in penetrating keratoplasty. The visual rehabilitation of patients receiving PLK/DLEK surgery has also been found faster, safer, and more stable; in addition, patients undergoing PLK/DLEK surgery produce a better final quality of vision compared with those...
undergoing the traditional penetrating keratoplasty surgery.\textsuperscript{10} More recently, a small-incision (size, 5 mm) technique has been studied and found safe and effective for endothelial transplantation.\textsuperscript{1,12}

Many surgeons have now converted to a refined version of posterior lamellar surgery called Descemet stripping endothelial keratoplasty (DSEK), where the donor lamellar dissection is performed manually, or Descemet stripping automated endothelial keratoplasty, where the donor dissection is automated using a microkeratome. The major advantage of DSEK over PLK or DLEK techniques is that it is easier to perform because it does not require recipient lamellar dissection and excision of the recipient button using intraocular scissors.\textsuperscript{13} There is less potential for trauma to the anterior chamber and lens, which is important in phakic eyes, and there is no reduction in stromal thickness, which minimizes the concern about inducing ectasia in eyes that have had previous refractive surgery that thinned the cornea.\textsuperscript{14} In addition, because Descemet stripping creates a smoother surface, less haze formation has been reported.\textsuperscript{10,12}

In addition to the Barron artificial anterior chamber, there are 2 other types of artificial anterior chambers currently in use to support the dissection of the donor corneoscleral button. The Moria automated lamellar therapeutic keratoplasty system (Moria/Microtek Inc, Doylestown, PA) includes a reusable stainless steel artificial anterior chamber used to support the corneoscleral rim. It is designed with a gearless track on the base plate to accept the use of a microkeratome head. The grooved base plate enables the microkeratome to pass across the cornea maintaining the same plane and direction.\textsuperscript{15} The Moria chamber offers the surgeon a reusable chamber and a fast method of preparing donor tissue of any diameter.\textsuperscript{16} The Bausch & Lomb artificial anterior chamber is also available to surgeons (Bausch & Lomb, St Louis, MO).

In the future, nonmechanical methods of lamellar dissection may provide an alternative to the technically challenging manual PLK dissection. The advantage of nonmechanical cutting techniques is the avoidance of mechanical distortion during trephination, resulting in smooth, almost perpendicular cut edges. These precise cut edges can potentially reduce the vertical tilt and the horizontal torsion of the graft in the recipient bed and, in so doing, reduce postkeratoplasty astigmatism.\textsuperscript{17}

The use of the femtosecond laser to prepare the recipient bed has been demonstrated by the use of in vitro laboratory models. The femtosecond laser can be effective for resecting opaque corneal tissue even at increased depth settings, although further studies are needed to determine the effect of opacity on depth accuracy and resection quality.\textsuperscript{18} The femtosecond laser technology used for DLEK surgery has been found to make the surgery much faster and easier for the surgeon; however, the exact laser spot settings (power, size, pattern, and overlap) of the laser will need to be determined to produce consistently smooth stromal planes in the edematous cornea.\textsuperscript{19}

The use of an excimer laser is another technique for nonmechanical trephination. The main advantage of this new nonmechanical cutting technique is that it is performed from the epithelial side in both the donor and the recipient; thus, it avoids mechanical distortion during trephination by creating smooth and congruent cut edges.\textsuperscript{20} The resulting perpendicular cut edges in the donor and the recipient eliminates a major factor for postkeratoplasty astigmatism.\textsuperscript{17} However, care has to be taken to choose the right exposure parameters, such as repetition rate and rotation speed, to reduce the thermal effects of the laser.\textsuperscript{21} Excimer laser trephination can be performed from the epithelial side using an artificial anterior chamber and is a noncontact alternative to mechanical trephination.\textsuperscript{22}

The Er:YAG laser has been shown in experimental studies to be another alternative to mechanical trephination of the cornea. This technique produces better alignment and improved congruency of the donor and recipient corneal cut edges, resulting in reduced and more regular astigmatism and better spectacle-corrected visual acuity.\textsuperscript{23} One limiting factor of this technique is the thermal stromal damage inflicted on the cornea. Further studies on the endothelial changes and wound healing aspects of the Er:YAG laser trephination will need to be conducted before this technique can be developed for clinical use.\textsuperscript{23}

\section*{Technique}

To benefit from the convenience of the Barron artificial anterior chamber, the practitioner must have an understanding of the components used.\textsuperscript{24} The chamber is composed of 3 pieces: base with tissue pedestal, tissue retainer, and locking ring (Fig. 1). The base has 2 ports with silicone tubing: in-line pinch clamps and female Luer-Lok connectors. Either port may be used to inject or aspirate viscoelastic material, balanced salt solution, preservation media, or air (Fig. 2). After the donor corneoscleral button is placed onto the base, the tissue retainer is then carefully placed over the unit with the guideposts aligned; then, the tissue retainer is advanced to the bottom of the base. The artificial anterior chamber is then secured by placing the locking ring over the unit and turning it until the locked position is reached. Once the donor corneoscleral button is sealed onto the artificial anterior chamber, the surgeon is able to adjust the pressure
within the unit by injecting the desired solution through the 2 available ports (Fig. 3).

The Barron artificial anterior chamber is designed in a bright blue color to provide a high-contrast background for visualizing the cornea and aiding in the lamellar dissection of the cornea. This innovative chamber is the world’s only disposable artificial anterior chamber. The entire unit is sterile and disposable for convenience. The chamber is designed with a peripheral angle so that the surgeon can still use a regular set of lamellar dissection instruments with the disposable chamber (Fig. 4).

The chamber is designed to safely facilitate the positioning, securing, and pressurization of the donor cornea during corneal transplant and lamellar surgery procedures. The design of the chamber allows the surgeon to firmly hold the 14- to 18-mm donor cornea on a bed of viscoelastic material, pressurize it, and cut it from the epithelial side. In this way, the recipient and donor corneas are cut from the same direction—the epithelial side. Cutting from the epithelial side produces a better donor-to-host match, which may reduce the surgically induced astigmatism.

The following is a step-by-step description of the procedure in preparing the donor corneoscleral button using the Barron artificial anterior chamber.

1. Disassemble the components of Barron artificial anterior chamber and prepare the instruments on the table. Have available the lamellar dissection instruments, donor trephine punch, guarded trifaceted diamond knife (Thornton arcuate diamond knife; KOI Ophthalmics, Frazer, PA), gentian violet marking pen, corneal preservation media (Optisol-GS; Bausch & Lomb, Irvine, CA), balanced salt solution (Alcon Laboratories, Fort Worth, TX), cohesive viscoelastic material, 25-gauge needle, and Merocel sponges (Medtronic, Jacksonville, FL).
2. Prepare 2 syringes and fill them with desired fluid or air medium (ie, Optisol-GS solution and balanced salt solution). Connect the syringes to the 2 ports attached to the base of the artificial anterior chamber. Keep the pinch locks in the open position.

3. Purge the first port with balanced salt solution and snap the pinch lock shut. Remove the excess solution from the base of the chamber.

4. Using Optisol-GS solution, fill the second port until the fluid covers the base of the chamber. Leave the pinch lock in the open position.

5. Apply viscoelastic material to the endothelial side of corneoscleral button.

6. Place the corneoscleral button on the base of the artificial anterior chamber, avoiding any air pockets to develop under the graft once the corneoscleral button is on the base.

7. Place the tissue retainer over the corneoscleral button, aligning the guideposts; then, advance the tissue retainer to the bottom of the chamber base.

8. Place the locking ring over the tissue retainer. While holding the tissue retainer with 1 hand, use the other hand to rotate the locking ring into the closed position. The donor corneoscleral button is now securely in place.

9. Infuse the Optisol-GS solution through the irrigation port and shut the pinch lock once the desired pressure is achieved.

10. Proceed with the lamellar dissection as follows:
   - Scrape off the epithelium of donor graft. Mark the temporal side and the horizontal direction on donor cornea.
   - Prepare the surface markings on cornea as reference.
   - Make a peripheral incision using the trifaceted diamond knife set at a depth of 0.4 mm.
   - Proceed with typical lamellar dissection using the instrumentation of the surgeon’s choice.

11. Release some pressure within the artificial anterior chamber by unlocking the pinch lock on the Optisol-GS solution irrigation port.

12. Place a Merocel sponge soaked in Optisol-GS solution on the corneal surface and proceed with the preparation of the procedures for the recipient.

13. To remove the corneoscleral button, release the locking ring with 1 hand while holding onto the tissue retainer with the other hand. Grasp the wings of the tissue retainer and gently remove the retainer from chamber base. Take the retainer ring off while keeping the cornea on the chamber base by gently using a needle to retain the donor tissue on the artificial anterior chamber. While the surgeon is separating the cornea from the chamber, the assistant should maintain pressure through the Optisol-GS solution irrigation port to prevent tissue collapse or buckling.

14. Mount the donor cornea (epithelial side down) onto a punch block using the previously made central marking on the surface of the cornea as a guide. Use a donor trephine to punch out the donor disc. Dry the periphery using a Merocel sponge. Ensure that the posterior lamellar disc can be separated from the anterior corneal layers.

15. Fold the disc (endothelial side in) with an approximate 60/40 ratio. Make sure that a very thin layer of viscoelastic material protects the endothelial layer. The disc may now be inserted into the anterior chamber.

Clinical Pearls Using the Barron Artificial Anterior Chamber

- Ensure that the donor corneoscleral button has a wide rim. The diameter should be a minimum of 14 to 18 mm to guarantee a good seal around the artificial anterior chamber before the surgeon begins the lamellar dissection. The surgeon should request this from the eye bank that prepares the donor buttons.
- It is advantageous to use a variety of instruments with various curvatures for the lamellar dissection. The surgeons can use the diverse specialized lamellar dissectors available, switching from straight to curved ones, as necessary. The design of the base of the artificial anterior chamber allows for the entry of instruments with a variety of angles for ease of dissection.

Clinical Pearls During Lamellar Dissection

- Make sure to dissect the center of the cornea very well so that there are no adhesions and that the posterior stroma will easily and homogeneously separate from the rest of the donor cornea.
- Be sure to dissect far to the periphery of the cornea. It is important to dissect right to the limbus to create the widest possible diameter of posterior lamellar/endothelial graft.

**DISCUSSION**

The artificial anterior chamber allows a donor corneoscleral cap of tissue to be anatomically positioned...
The Barron artificial anterior chamber can be used with penetrating, lamellar, and endothelial keratoplasty techniques, including PLK/DLEK and DSEK. The chamber can be safely used and is indicated for any patient who is a good candidate for endothelial keratoplasty. There are no specific contraindications to the use of the Barron chamber apart from carefully selecting patients who are candidates for endothelial keratoplasty on the basis of their disease process. One contraindication to using this artificial chamber is that the donor corneoscleral button needs to have a wide tissue rim of at least 14 to 18 mm. This is imperative to ensure an adequate seal between the donor corneoscleral button and the chamber itself.

As with any type of instrumentation, the advantages and the disadvantages of using the Barron artificial anterior chamber should be thoroughly reviewed by the surgeon before deciding if using an artificial or reusable chamber is the right decision for their type of practice.

There are 2 main advantages that the use of the Barron artificial anterior chamber provides to surgeons. One is the ability to diminish donor-host mismatch with full-thickness penetrating keratoplasty. Most keratoplasty techniques involve cutting the recipient cornea from the epithelial side and the donor cornea from the endothelial side, which creates inherent differences in the angles of the cuts. These differences can contribute to slight mismatches and subsequent astigmatism. The Barron artificial anterior chamber eliminates the predisposition for incongruently cut surfaces and angles in the donor and the recipient, resulting in better donor button–recipient bed match.

The second benefit is that because of its reduced cost, it also opens up the door for surgeons in smaller centers to learn endothelial keratoplasty techniques and put these techniques into practice in the operating room. The speed of preparation of the donor tissue makes the endothelial keratoplasty procedure less time consuming and cumbersome. The chamber allows for precise placement of the donor cornea and subsequent lamellar dissection because the surgeon can control the pressure better in the anterior chamber by using the 2 injection ports.

A disadvantage in using the Barron artificial chamber is that currently, its design does not allow for the use of the chamber in conjunction with a microkeratome. The rim of the tissue retainer ring does not support the attachment of a microkeratome itself; thus, only a spatula and the lamellar dissection instruments are available for use with the chamber for freehand dissection. However, femtosecond laser dissection could still be possible.

One potential disadvantage or complication in using the Barron artificial anterior chamber is that it may take some experience to get accustomed to the removal of the dissected donor cornea from the artificial anterior chamber. This crucial step at the end of the lamellar dissection may take some practice for surgeons. We have found that the most straightforward procedure is to use a needle to separate the tissue retainer ring from the donor corneoscleral ring.

One possible complication that a surgeon can encounter while using the Barron artificial anterior chamber is the inability to create a seal between the base of the chamber, the donor cornea, and the tissue retainer ring. This is the most crucial step in the lamellar dissection procedure. It is critical that the donor cornea is safely positioned and secured on the artificial anterior chamber before a surgeon embarks on dissection. Once the surgeon is satisfied that there are no bubbles under the cornea and that the position of the donor cornea is correct on the base, the surgeon can place the tissue retainer over the donor button and align the guideposts. A clinical "pearl" for the surgeon using the Barron artificial chamber is to make sure to hold the tissue retainer firmly while rotating the locking ring over the tissue retainer and the base to the closed position. It should be noted that the graft is still able to move once the tissue retainer is placed on top of the chamber base; the seal is not secure until the locking ring is in the closed position. To solve this complication, the surgeon should be vigilant not to allow the movement of the graft between the time of placement of the tissue retainer and the time of closed positioning of the locking ring because the original position of the donor cornea will change if this is permitted to occur.

In the future, the Barron artificial anterior chamber may be designed to allow for the use of an automated dissector, such as a microkeratome. Currently, only freehand dissection is available to the surgeon using this chamber. Other nonmechanical trephination techniques may also become available to be used in conjunction with the disposable artificial chamber. This would open up a wide range of trephination possibilities, such as the use of femtosecond laser, excimer laser, and Er:YAG laser.

There may initially be a steep learning curve for surgeons who make the transition from penetrating keratoplasty to endothelial keratoplasty. The initial challenges in beginning this procedure in a surgeon's practice can be made easier with the use of the disposable Barron artificial anterior chamber.
REFERENCES


