Deep Lamellar Keratoplasty Using Viscoelastic Dissection

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We describe a technique for performing deep lamellar keratoplasty using viscoelastic dissection. Deep lamellar dissections of the cornea using viscoelastic substances (sodium hyaluronate) were performed on 4 eyes of 4 patients. One patient with keratoconus and another with corneal scarring underwent lamellar keratoplasty using the technique as the sole procedure for visual rehabilitation. Two patients (2 eyes) with opaque corneas underwent deep lamellar dissection with removal of stromal tissue to allow visualization of the anterior segment structures prior to penetrating keratoplasty, thereby facilitating separation of iridocorneal adhesions as the Descemet membrane was incised. Deep lamellar dissection was performed without complications related to the procedure in all 4 eyes. The 2 lamellar grafts cleared completely, and both eyes achieved excellent visual acuity with spectacle correction. In the other 2 eyes, deep lamellar dissection provided clear visualization of anterior segment structures during incision of the Descemet membrane. Deep lamellar dissection using viscoelastic substances is a useful technique during lamellar keratoplasty.

Lamellar keratoplasty is a procedure in which a donor graft is placed within a partial depth recipient corneal bed after a lamellar resection has removed abnormal stromal tissue from the host. The procedure can be used to restore the optical or structural integrity of the globe; currently, it is used most commonly during the placement of tectonic grafts to restore normal thickness to globes after loss of tissue from thinning disorders of the cornea.

Today, the procedure is used infrequently for restoration of vision because it is technically more difficult to perform and has traditionally yielded inferior optical results when compared with penetrating keratoplasty. Nevertheless, lamellar keratoplasty has a number of advantages over penetrating keratoplasty. With lamellar keratoplasty, the patient’s endothelium remains intact, eliminating the risk of endothelial rejection, which is the most common cause of graft failure following penetrating keratoplasty. Another advantage of lamellar keratoplasty is that the structural integrity of the globe is better maintained than with penetrating keratoplasty.

There are a variety of techniques for performing lamellar keratoplasty. Traditionally, the lamellar resection has been performed manually, using sharp and blunt dissection. Others have tried using air dissection, microkeratome dissection, dissection using the excimer laser, and hydrodelamination using saline dissection, all with varying degrees of success. Sun and coauthors described a similar technique they termed viscodelamination for the treatment of bullous keratopathy. We describe a technique for performing deep lamellar dissection of the cornea that uses a viscoelastic agent to dissect all of the stromal tissue from the underlying Descemet membrane and endothelium.

SURGICAL TECHNIQUE

Based on our experiences with these cases, we have found the following procedures to be effective (Figure). After determining the appropriate diameter of the tissue to be removed from the patient, a trephine, or a

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combination of a trephine and a rounded blade, is used to create an incision of 80% to 90% thickness into the patient's cornea (Figure, A). A Paufique blade is then used to make a deep incision that runs parallel to the stromal lamellae. This incision should start at the bottom of the trephine incision, moving radially toward the central cornea, creating a 1- to 2-mm pocket. The blade is removed, and a 25-gauge cannula attached to a syringe containing viscoelastic material is introduced into the pocket (Figure, B). The viscoelastic material is slowly injected into this pocket. It is forced through the posterior stromal lamellae along the path of least resistance, causing the Descemet membrane to separate from the posterior stromal tissue (Figure, C). Once the Descemet membrane has begun to detach, the cannula is slowly advanced into the space being created, thereby completing the dissection (Figure, D). Corneal scissors are used to remove the diseased patient tissue by cutting along the groove created by the trephine. A modification of this technique can also be used in corneas with severe opacification. A stab incision can be made into the cornea and viscoelastic material infused through a cannula placed into the incision to separate the Descemet membrane from the overlying stromal tissue. After separation of the Descemet membrane, a trephine can be used to cut a central groove into the recipient corneal bed until a gush of viscoelastic material is seen. The overlying tissue can then be excised using corneal scissors without causing damage to the Descemet membrane.

For lamellar keratoplasties a full-thickness button from a donor cadaver is then cut with a trephine, and the endothelium is removed with a methylcellulose sponge. The donor button is then sutured to the recipient corneal bed (Figure, E). After the donor button has been sutured into place, the remaining viscoelastic material is irrigated out of the interface with a balanced salt solution infused through a 25-gauge cannula.
For penetrating keratoplasties the same techniques are used. Following resection of the diseased stromal tissue from the Descemet membrane, iris-endothelial adhesions and other anterior segment abnormalities can be seen through the transparent Descemet membrane. The surgeon then carefully incises the Descemet membrane and separates adhesions from the underlying tissue, with direct visualization preventing the inadvertent incision of underlying anterior segment structures. The Descemet membrane can then be incised along the trephine incision, and a full-thickness donor button can be sutured to the recipient corneal bed.

### REPORT OF CASES

#### CASE 1

A 48-year-old man with keratoconus had a best-corrected visual acuity of 20/30 OD because of keratoconus; a visual acuity of counting fingers at 2 ft OD was uncorrectable because of previous trauma. He was unable to tolerate spectacle correction because of distortion. His best-corrected visual acuity was 20/25 OS with a rigid, gas permeable contact lens, but he was intolerant of the lens. Deep lamellar keratoplasty as a technique for optical restoration was performed to minimize the risk of graft rejection. Using an 8-mm suction trephine, a partial-thickness groove was made in the recipient corneal bed. The wound was separated in the 10-o’clock position using Colibri forceps, and a rounded blade was then used to make a deep incision that ran parallel to the stromal lamellae. The incision began at the bottom of the trephine incision, moving radially toward the central cornea, creating a 1- to 2-mm pocket. The viscoelastic material, sodium hyaluronate (Healon), was slowly injected into this pocket. It was forced through the posterior stromal lamellae along the path of least resistance, causing the Descemet membrane to separate from the posterior stromal tissue. Corneal scissors were then used to separate the patient’s corneal stromal tissue from the underlying Descemet membrane by cutting along the groove with one blade between the stroma and Descemet membrane. Central stromal tissue was lifted from the eye. The Descemet membrane remained intact. An 8.25-mm full-thickness donor button was cut with a trephine, and the endothelium was removed with a methylcellulose sponge. The donor button was sutured to the recipient corneal bed. The remaining viscoelastic material was then irrigated from the interface with a balanced salt solution using a 23-gauge cannula. The postoperative course was uneventful, with complete clearing of the graft occurring within 2 weeks. The interface between the graft and Descemet membrane remained clear. The patient underwent selective suture removal 3 months postoperatively. Uncorrected visual acuity was 20/70 OS, and best spectacle-corrected visual acuity was 20/25 OS with 3.5 diopters (D) of residual astigmatism.

#### CASE 2

A 63-year-old man had a best-corrected visual acuity of 20/400 OD, attributable to corneal thinning and scarring from a previously treated bacterial ulcer that extended approximately 60% to 70% into the anterior corneal stroma without involvement of the Descemet membrane. Deep lamellar keratoplasty was performed for visual rehabilitation. Using a 7.5-mm suction trephine, the same technique used in case 1 was then employed to successfully dissect down to an intact Descemet membrane. A 7.75-mm full-thickness donor button was sutured to the recipient corneal bed. The postoperative course was uneventful, with complete clearing of the graft occurring within 3 weeks. The junction between the graft and Descemet membrane remained clear. The patient underwent selective suture removal 3 months postoperatively and had an uncorrected visual acuity of 20/70 OD and a best spectacle-corrected visual acuity of 20/30 OD with 2.5 D of residual astigmatism.

#### CASE 3

An 8-year-old boy sustained a forceful blow to the right eye with a blunt object 9 months prior to our examination. The trauma was complicated by total hyphema, glaucoma, and subsequent dense blood staining of the entire cornea. Intraocular pressure could not be controlled with topical medications, and he underwent cyclocryotherapy on 2 occasions. He was referred to us for additional care that included penetrating keratoplasty and surgery for glaucoma. Visual acuity was light perception OD with good color discrimination and entoptic phenomenon. Findings from ultrasound biomicroscopy indicated extensive disruption of the anterior segment with anterior synechiae and displacement of the lens into the anterior chamber. Because evidence of iris adhesion to the endothelial surface could not be seen directly, deep lamellar dissection was performed to remove blood-stained stroma, thereby allowing visualization of the iris through the Descemet membrane prior to entering the anterior chamber during penetrating keratoplasty. Using an 8-mm trephine, a partial-thickness groove was made in the recipient corneal bed. The wound was separated in the 10-o’clock position using Colibri forceps, and a rounded blade was then used to make a deep incision that ran parallel to the stromal lamellae. Sodium hyaluronate was slowly injected into this pocket. It was forced through the posterior stromal lamellae along the path of least resistance, causing the Descemet membrane to separate from the posterior stromal tissue. Corneal scissors were used to separate blood-stained stromal tissue of the host by cutting along the groove with one blade between the stroma and Descemet membrane. Central stromal tissue was lifted from the eye. The Descemet membrane remained intact. A retrocorneal inflammatory membrane could be seen clearly through the Descemet membrane. The iris tissue was adherent to the endothelial surface, and a preexisting rent in the anterior lens capsule, attributable to the patient’s previous trauma, with release of cortical material into the anterior chamber, could be seen. The Descemet membrane was carefully incised in the 9-o’clock position, and a potential space was identified between the Descemet
membrane and underlying tissues. The Descemet membrane was gently separated from these underlying tissues as it was incised along the trephination wound. Using these maneuvers, no inadvertent incisions were made in the iris tissue as it was dissected from the endothelial surface. Cataract removal, penetrating keratoplasty, and Ahmed valve placement were completed without difficulty.

CASE 4

A 79-year-old man had previously undergone repair of a complicated retinal detachment in the right eye using vitrectomy and silicone oil tamponade. He was left aphakic and eventually developed corneal decompensation, attributable to silicone oil toxicity. He was referred to us for penetrating keratoplasty along with silicone oil removal from the vitreous cavity to provide better visualization of the posterior segment and for possible visual rehabilitation. Prior to surgery, it was known that the iris was adherent to the posterior surface of the cornea in several areas, although anterior segment structures could not be seen at the time of surgery because of corneal clouding. A stab incision was made into the cornea at the limbus in the 9-o’clock position, and viscoelastic material (Healon) was instilled through deep corneal lamellae to separate the Descemet membrane from overlying stromal tissue over the entire area of the cornea. An 8-mm trephine was then used to cut a central groove into the recipient corneal bed. A gush of viscoelastic material (Healon) indicated that the lamellar dissection plane had been reached. The stromal tissue was excised using corneal scissors along the trephination groove. The Descemet membrane remained intact. It was then possible to see anterior segment structures through the Descemet membrane. Several areas of anterior synechiae were present. The Descemet membrane was incised with a supersharpe blade in an area without iris adhesions, and the incision was continued along the trephination wound using corneal scissors. During this process the iris was separated from the Descemet membrane ahead of the scissors by blunt dissection using a cyclodialysis spatula. Following these maneuvers the anterior chamber was reformed. Silicone oil removal and penetrating keratoplasty were completed without complications.

COMMENT

Detachment of the Descemet membrane following inadvertent injection of viscoelastic material anterior to the membrane has been described during intraocular surgery. These detachments have been successfully repaired using a variety of techniques including placement of sulfur hexafluoride gas (SF6), air, viscoelastic substances, and perfluoropropane gas into the anterior chamber. Spontaneous reattachment can also occur. Based on these observations, we postulated that we could create a controlled separation of the Descemet membrane from overlying stromal tissue using viscoelastic material to facilitate deep lamellar dissection.

One of the reasons why traditional lamellar keratoplasty may yield a suboptimal visual result is that with current technologies, some of the stroma left behind during the lamellar dissection becomes opaque or contains residual diseased tissue. A variety of surgical techniques have been developed over the years to facilitate deep lamellar keratoplasty and improve optical outcomes. Deep lamellar dissection with intrastromal air was originally described by Archila. Using this technique, he was able to perform deep lamellar dissection successfully in 10 eyes with no inadvertent entry into the anterior chamber. In another study, deep lamellar dissection with intrastromal air was attempted in 10 eyes. Air dissection was performed successfully in 6 of 10 eyes in that study. Conversion to full-thickness penetrating keratoplasty was required in 4 of 10 eyes because of inadvertent perforation into the Descemet membrane at the time of surgery. In only 1 of 6 eyes that underwent successful air dissection was the separation at the Descemet membrane.

Deep lamellar keratoplasties using Barraquer microkeratomes have also been attempted by several authors, with mixed results. There are a number of technical difficulties in performing microkeratome-assisted lamellar keratoplasty. In addition, the procedure results in only a partial-thickness dissection, leaving residual corneal stroma down to the Descemet membrane; this residual stromal tissue may opacify, necessitating eventual performance of a full-thickness penetrating keratoplasty.

Deep lamellar keratoplasties using hydrodelineation have also been attempted with some success. Using this technique, saline solution is injected through a partial-thickness lamellar incision using a blunt 27-gauge cannula. The saline penetrates the stromal collagen fibers, causing them to whiten and swell. This in turn makes tissue removal using blunt dissection easier to perform. Using this technique, Sugita and Kondo performed deep lamellar keratoplasty on 120 eyes with corneal stromal opacification. They were able to successfully dissect down to the Descemet membrane in 75% of eyes using this technique. However, they also reported a 39.2% rate of puncture of the Descemet membrane in this series of eyes. The authors stated that none of the eyes with punctures in the Descemet membrane required conversion to penetrating keratoplasty, and all had similar outcomes to eyes without puncture 6 months postoperatively.

Full-thickness keratoplasty using viscoedelamination has been previously described in the treatment of painful bullous keratopathy. Sun and coauthors used this technique to facilitate dissection of corneal tissue in 21 eyes in patients with painful bullous keratopathy. Using this technique, Sun et al successfully dissected the diseased edematous corneal tissue in all of the eyes without cases of inadvertent penetration of the Descemet membrane. They did not dissect all the way down to the Descemet membrane but attempted to remove as much of the edematous corneal tissue as possible. Six months postoperatively, the painful symptoms were
relieved in all of the cases, and a modest improvement in vision was achieved in 73% of the eyes. However, since the underlying cause of the bullous keratopathy is presumed to be a poorly or nonfunctioning endothelial pumping mechanism, one would assume that the donor lamellar graft would eventually become edematous as well.

All 4 patients in our study had successful surgical outcomes; specifically, there were no cases of inadvertent puncture of the Descemet membrane during the viscoelastic dissection. In the 2 patients who underwent lamellar keratoplasty, the donor grafts remained clear postoperatively with no evidence of interface opacification, host endothelial decompensation, pseudoanterior chamber formation, or complications from retained viscoelastic substance. In the 2 patients who underwent penetrating keratoplasty, the iris-endothelial adhesions, inflammatory membranes, and disrupted anterior segment structures were successfully visualized prior to incision of the Descemet membrane, allowing us to avoid inadvertent surgical trauma to normal tissues.

The surgical technique we have described offers all of the advantages of traditional lamellar keratoplasty with the added advantage of leaving a clear interface. It should enable surgeons to remove all of the stroma from the underlying Descemet membrane safely and reliably, thereby eliminating the potential disadvantage of leaving residual tissue that could compromise vision. This technique has the advantage over the other full-thickness techniques, including air dissection and hydrodelineation, in that there is a low risk of inadvertent puncture of the Descemet membrane, and it is technically easy to perform. The simplification of the technique should allow surgeons to offer lamellar keratoplasty to those patients who have their disease process confined to the stroma with normal endothelium. The technique is also a useful means for seeing anterior segment structures prior to incising the Descemet membrane in patients with suspected iridocorneal adhesions or other disruption of normal anterior segment architecture. By visualizing the tissue, inadvertent incision of the iris can be avoided.

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