A New Surgical Technique of Microkeratome-Assisted Deep Lamellar Keratoplasty With a Hinged Flap

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We describe a new surgical technique of microkeratome-assisted deep lamellar keratoplasty for treating patients with corneal stromal disease and normal endothelium. A microkeratome is used to create a hinged anterior stromal flap in the host cornea, and the diseased stroma is resected or ablated. A complementary donor stromal button, prepared using a microkeratome and an artificial anterior chamber, is transplanted prior to repositioning of the flap. The flap may be lifted at a later date, and an excimer laser used to correct residual refractive errors. Notwithstanding the preliminary and theoretical nature of this report, this technique may improve the outcomes of deep lamellar keratoplasty and may allow for decreased postoperative complications.

Penetrating keratoplasty is currently the surgical method of choice for treating corneal diseases that involve the stroma and endothelium. High astigmatism, endothelial rejection, loss of corneal clarity, and considerable visual impairment may complicate the postoperative course. Endothelial cell loss, pleomorphism, and polymegathism may progress following surgery and result in late graft failure. Lamellar keratoplasty (LK) may avoid many of these problems, but it is limited by delayed epithelialization, persistent epithelial defects, irregular astigmatism, difficult surgical technique, and graft/host interface haze and vascularization.

In selected patients with considerable corneal stromal disease and normal endothelium, deep LK under a hinged host flap may be a viable alternative surgical approach. This surgical technique involves performing LK by using a microkeratome to create a hinged anterior corneal flap, resecting or ablating the host stromal abnormalities, and transplanting a complementary donor stromal button (which is prepared using a microkeratome and an artificial anterior chamber). In theory, this approach may be valuable in corneal stromal dystrophies and scarring secondary to traumatic, inflammatory, or infectious causes. It has 2 potential theoretical advantages: (1) The host epithelium and endothelium are preserved, which may reduce the risk of graft rejection, and (2) the superficial hinged corneal flap may reduce astigmatism and surface irregularities. We describe herein our preferred surgical technique used to perform microkeratome-assisted deep LK.

SURGICAL PROCEDURE

Radial and diagonal alignment marks are placed on the host cornea centered over the pupil with a conical marker inked with a sterile skin marker or gentian violet solution. The corneal marks allow for subsequent repositioning of the anterior stromal flap. A microkeratome (Automated Corneal Shaper or Hansatome; Bausch & Lomb Inc, Rochester, NY) is used to dissect a hinged anterior corneal flap, measuring 8.5 to 9.5 mm in diameter and 130 to 180 µm in thickness (Figure 1, step 1). The following steps are involved in fashioning the desired corneal flap. The suction ring is placed over the patient's cornea, and great care is taken to ensure centralization over the pupil. The suction is activated, and the intraocular pressure is checked to ensure that it is more than 65 mm Hg. The microkeratome head is then placed into position and is allowed...
to course across the suction ring in forward and reverse directions. The hinged anterior corneal flap is temporarily elevated, and the thickness of the residual stroma (host resection bed) is measured using a pachymeter.

The donor stromal button is prepared using a dedicated artificial anterior chamber (Bausch & Lomb Inc). A microkeratome is used to dissect a 110-μm anterior corneal cap (Figure 2, A). The microkeratome is allowed to course across the donor tissue without the stop, thus an 8.5-mm anterior corneal-free cap is created (which is discarded). The donor anterior corneal cap is made thinner than the recipient’s hinged corneal flap so that the remaining donor stroma is of sufficient thickness to allow for a second microkeratome pass (which creates an 8.5-mm donor stromal lenticule) (Figure 1). The thickness of the donor stromal lenticule resected by the second microkeratome pass is determined by choosing a plate similar in depth to the thickness of the host resection bed. Next, a 6-mm trephine is used to punch the donor stromal lenticule to create the donor stromal button.

The recipient hinged anterior corneal flap is elevated with a flat spatula, exposing the underlying stroma. A 6-mm trephine is used to perform a partial-thickness trephination. The depth of the trephination is set at approximately 90% of the previously performed pachymetry. Next, lamellar keratectomy is performed. Air, isotonic sodium chloride solution, or viscoelastic material may be injected into the corneal stroma prior to trephination to facilitate lamellar keratectomy. Lamellar dissection is initiated from the partial-thickness trephine incision using a spatulated dissector blade. Once the plane of dissection is established at the depth of trephine incision, further dissection is performed with to-and-fro movements of the spatula to split the corneal stroma delimited by the trephine mark. This lamellar dissection removes a layer of deep stromal corneal tissue (Figure 2, C). The remaining stromal lamellae covering the Descemet membrane are removed using microscissors (Figure 2, D). If the corneal abnormalities are limited to the mid stroma, excimer laser ablation can be used to remove diseased cornea, avoiding the posterior stromal manipulations and the associated risk of perforating the Descemet membrane.

The donor stromal button is then transplanted onto the host bed (Figure 1). The hinged anterior corneal flap is laid back over the donor stromal button; its margins are approximated to previously applied corneal marks (Figure 2, E) and allowed to seal into place. Sutures are placed to secure the corneal flap (Figure 2, F). Alternatively, a bandage contact lens may be used.

Lamellar keratoplasty is an attractive alternative to penetrating keratoplasty for the treatment of stromal disorders associated with intact endothelial function. Despite the preliminary and theoretical nature of this report, we believe that this is the first published report of a surgical technique of deep LK using a microkeratome to create a hinged anterior stromal flap and a dedicated artificial anterior chamber to create a complementary donor button.

Our technique of microkeratome-assisted LK differs from other LK surgical techniques. We believe that there are potential advantages to creating a hinged anterior stromal corneal flap. Since the corneal flap is lined with the patient’s own epithelium, the occurrence of postoperative epithelial defects, or epithelial rejection, would be theoretically reduced. The hinged corneal flap and preplaced alignment marks may allow for improved postoperative reapposition. This may potentially create an optically smoother corneal surface with reduced incidence of high astigmatism. The flap may be lifted at a later date, and an excimer laser used to correct residual refractive errors. In addition, there is a theoretical benefit in dealing with vision-threatening complications, such as expulsive hemorrhage, as the hinged corneal flap can quickly secure the wound with less suturing. Despite these putative advantages, our technique may be quite complex. Clinical studies

Figure 1. Microkeratome-assisted deep lamellar keratoplasty technique. Schematic diagram showing recipient bed preparation (steps 1 and 2), donor preparation (steps 3 and 4), and transplantation (steps 5 and 6). Step 1, a hinged anterior stromal flap is created in the host cornea using a microkeratome and lifted; step 2, partial-thickness trephination (90% depth) is followed by lamellar dissection to remove the diseased host stromal tissue overlying the Descemet membrane; step 3, a donor lenticule is created using a microkeratome and a dedicated artificial anterior chamber; step 4, a trephine is used to punch the donor stromal lenticule to create a donor stromal button (red); step 5, the donor stromal button (red) is transplanted onto the host bed; and step 6, the hinged anterior stromal flap is repositioned and sutured.

Figure 2.
are needed to determine whether this technique indeed reduces graft/host interface problems, improves visual outcomes, or is potentially a practical alternative for traditional LK techniques.

The concept of deep LK is not new. Previous published reports have confirmed the advantages and limitations of LK. In a retrospective review, Soong et al reported postoperative visual acuity of 20/50 or better in 38% of eyes that underwent LK for corneal diseases such as dystrophies (Granular, Reis-Buckler), aniridic keratopathy, corneal scars, and keratoconus. Major causes of poor postoperative visual acuity were (1) graft/host interface haze and/or vascularization in 44% of cases, (2) graft surface irregularities and/or astigmatism in 42% of cases, and (3) persistent epithelial defects in 21% of cases.

Panda et al reported less suture-induced astigmatism following deep LK using a Paufique knife compared with penetrating keratoplasty using a standard technique. Sugita and Kondo reported dramatic improvement of average visual acuity after deep stromal LK in 106 patients (20/200 OU preoperatively and 20/30 OU postoperatively) but noted that the Descemet membrane was punctured in 39% of eyes. Their technique involved an initial trephination of the cornea to three quarters of its depth, followed by lamellar keratectomy aided by hydrodelamination. Melles et al performed deep stromal LK in 7 patients and observed astigmatism ranging from 1.0 diopter (D) to 3.5 D. Their technique involved filling...
the anterior chamber with air and lamellar dissection to create a stromal pocket across the cornea just superficial to the Descemet membrane using a custom-made dissection blade. Melles et al\(^6\) have also performed posterior corneal transplantation in a patient with pseudophakic bullous keratopathy and reported “suture-in” astigmatism of 3.5 D with a clear posterior corneal transplant at 3 months postoperatively. A mid stromal pocket was dissected across the cornea through a scleral tunnel incision, and a posterior lamellar disk was excised. A similarly shaped donor posterior disk was transplanted without sutures fixation.

Perhaps the most important limitations of deep LK are the presence of residual irregular edges at the outer dissection border close to the Descemet membrane and the risk of Descemet membrane microperforation. Several techniques have been used to overcome these limitations. Archila\(^7\) used an injection of 1 mL of air into the corneal stroma to facilitate the dissection of lamellae close to the Descemet membrane. Tsubota et al\(^8\) used intrastromal air and water injection coupled with a divide-and-conquer technique to obtain better lamellar dissection. Sugita and Kondo\(^4\) injected saline solution in the deep stroma using a blunt 27-gauge needle, which produced whitening and swelling of collagen fibers and facilitated deeper stromal dissection. Melles et al\(^9\) used a viscoelastic injection into a posterior stromal pocket to create a pseudo-anterior chamber to protect the posterior corneal tissues during trephination and to facilitate stromal dissection. Manche et al\(^10\) have used a similar technique of deep lamellar dissection using a viscoelastic substance.

One obvious limitation of our technique is the inability to treat stromal opacities in the anterior quarter of the host cornea, since that layer of the host stroma is not re-placed by this surgery. Such patients may benefit from phototherapeutic keratectomy.\(^{10}\) Another disadvantage of our technique is the limited availability of a dedicated artificial anterior chamber.

The recent success of laser in situ keratomileusis surgery has made it possible to combine our technique with excimer laser ablation, especially if the stromal abnormalities are not close to the Descemet membrane. The use of excimer ablation instead of manual dissection may have potential advantages. Since the host stroma is ablated in a controlled fashion, inadvertent perforations of the Descemet membrane that can occur during manual dissection may be avoided. Furthermore, if an artificial anterior chamber is not readily available, the surgeon may be able to use the excimer laser to prepare the donor button.

As our procedure is relatively new, clinical studies are needed to clarify several parameters such as the thickness of the host and graft corneal flaps, the disparity between the donor button and the host bed, and the timing of relifting the flap to correct postoperative refractive errors. For instance, anterior corneal surface flattening may occur if deturgescence of the donor tissue results in a thinner lenticule than intended. We believe that several parameters may allow for better visual outcomes in our procedure. These include (1) flap thickness greater than 180 µm, whenever possible, to avoid postoperative wrinkles and surface irregularity, (2) temporary sutures and a bandage contact lens to secure the corneal flap in the immediate postoperative period, (3) donor tissue deturgescence prior to preparing the donor button to precisely match the donor button thickness with the depth of the host bed, (4) oversizing the donor button diameter by 0.25 mm to compensate for the trephine angle, and (5) using a tongue-and-groove approach to prevent sideways slippage of the donor button. Since we have not yet critically evaluated our preferences, their potential for improving outcomes remains strictly speculative.

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