Deep Anterior Lamellar Keratoplasty by Big-Bubble Technique for Treatment Corneal Stromal Opacities

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• PURPOSE: **To evaluate the efficacy of using the big-bubble technique of deep anterior lamellar keratoplasty (DALK) for newer indications.**

• DESIGN: **Prospective, noncomparative, interventional case series.**

• METHODS: **Ten eyes of eight patients with pathologies involving the corneal stroma and sparing the Descemet membrane (DM) were included in this study conducted at a tertiary care hospital. The indications for DALK included corneal clouding attributable to mucopolysaccharidoses (n = 2), macular corneal dystrophy (n = 5), lattice corneal dystrophy (n = 1), granular corneal dystrophy (n = 1), and stromal scar attributable to infectious keratitis (n = 1). DALK was performed using the big-bubble technique in order to achieve the complete separation of DM from the corneal stromal tissue in the recipient's eye. Subsequently, the corneal stromal tissue was excised completely, and a full-thickness donor corneal lenticule without its DM was secured over the bared DM of the host. The main outcome measures of the study were the ability to successfully bare DM, the gain in visual acuity, and the presence of any complications.**

• RESULTS: **Using the big-bubble technique, DM was bared, and DALK could be performed successfully in all eyes. No intraoperative or postoperative complications were observed. All patients achieved a best-corrected visual acuity (BCVA) of 20/40 or better at the end of six months.**

• CONCLUSIONS: **DALK using the big-bubble technique can be useful in treating corneal stromal dystrophies, corneal clouding attributable to mucopolysaccharidoses, and stromal scar attributable to infectious keratitis. (Am J Ophthalmol 2007;143:954–957. © 2007 by Elsevier Inc. All rights reserved.)**

BOTH PENETRATING AND LAMELLAR KERATOPLASTY have been recommended for treating various diseases of corneal stroma with unaffected endothelium.[1–3] Deep anterior lamellar keratoplasty (DALK) is a relatively newer technique of lamellar corneal transplantation surgery and is used to treat corneal diseases that do not involve the Descemet membrane (DM).[4] The technique allows the placement of a nearly full-thickness corneal donor button onto the host bed containing minimal or no stromal tissue on DM and is preferred over performing penetrating keratoplasty (PK) for treating corneal stromal pathologies, as it avoids the replacement of host endothelium with donor endothelium and thus precludes graft rejection.[5]

One of the many techniques to achieve lamellar dissection down to DM in corneal opacities is the big-bubble technique, which uses air to create a plane of dissection between DM and corneal stroma.[5] The technique of DALK has been largely used in treating cases of keratoconus, as it provides a safer and successful alternative to PK.[6–9] Recently, the procedure has been used to treat stromal corneal dystrophies using the viscodissection technique.[10] In the present study, we evaluated the use of DALK using the big-bubble technique[5] for new indications including cases of stromal corneal dystrophy and corneal clouding attributable to mucopolysaccharidosis.

METHODS

WE PERFORMED DALK IN 10 EYES OF EIGHT PATIENTS, INcluding those with Hurler-Scheie syndrome (n = 2), macular corneal dystrophy (n = 5), lattice corneal dystrophy (n = 1), granular corneal dystrophy (n = 1), and stromal scar attributable to infectious keratitis (n = 1) (Table). Informed consent from the subjects and Institutional Review Board approval was obtained. A single experienced surgeon performed all surgeries (R.B.V.). Preoperative evaluation included recording of uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA) using the Snellen acuity chart, keratometry, slit-lamp examination, nine-point ultrasonic pachymetry (Sonogage, Inc, Cleveland, Ohio, USA) and vitreoretinal evaluation including B-scan ultrasonography. The surgeries were performed using the big-bubble technique.[6]

• **SURGICAL TECHNIQUE:** DALK was performed in all cases under general anesthesia using the big-bubble technique. A Hessburg Barron (JedMed Instrument Co, St Louis, Missouri, USA) suction trephine (7.00 mm to 7.5 mm)

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TABLE. Indications for Deep Anterior Lamellar Keratoplasty Using the Big-Bubble Technique

Age (yrs)	Follow-Up (mos)		Indication for Surgery	Preoperative BCVA	Postoperative BCVA
14/F	9	OD	Hurler-Scheie syndrome (mucopolysaccharidoses 1S)	20/200	20/40
14/F	10	OS	Hurler-Scheie syndrome (mucopolysaccharidoses 1S)	20/120	20/40
32/M	8	OS	Lattice corneal dystrophy	20/200	20/40
50/M	6	OS	Granular corneal dystrophy	20/200	20/40
28/M	11	OS	Stromal scar due to resolved infectious keratitis	20/80	20/30
30/F	6	OD	Macular corneal dystrophy	20/200	20/40
35/M	6	OD	Macular corneal dystrophy	CFCF	20/40
35/M	9	OS	Macular corneal dystrophy	CFCF	20/40
27/M	8	OS	Macular corneal dystrophy	20/120	20/40
47/M	7	OD	Macular corneal dystrophy	20/200	20/40

BCVA = best-corrected visual acuity; CFCF = counting fingers close to face; OD = right eye; OS = left eye; F = female; M = male.

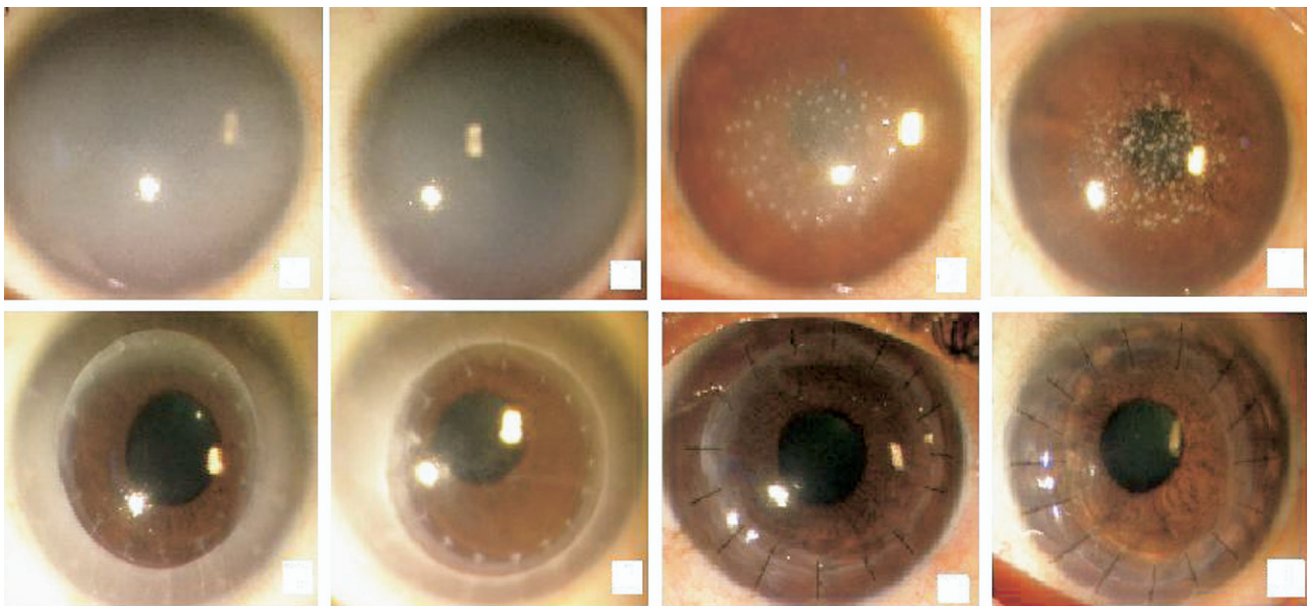

FIGURE. Various corneal pathologic conditions in which deep anterior lamellar keratoplasty (DALK) was performed. Corneal clouding in Hurler-Scheie syndrome (right eye) (Top left). Post-keratoplasty clear corneal graft in Hurler-Scheie syndrome (right eye, nine months postoperatively) (Bottom left). Hurler-Scheie syndrome (left eye) (Top second from left). Post-keratoplasty corneal graft in Hurler-Scheie syndrome (left eye, 10 months postoperatively) (Bottom, second from left). Stromal corneal opacities in an early case of macular corneal dystrophy (Top, second from right). Post-keratoplasty corneal graft in macular corneal dystrophy (one month postoperatively) (Bottom, second from right). Granular corneal dystrophy with stromal corneal opacities (Top right). Post-keratoplasty corneal graft in granular corneal dystrophy (two weeks postoperatively) (Bottom right).

was used for partial-thickness trephination of the host cornea up to an approximate depth of 300 μm. A 27-gauge disposable needle bent at 90 degrees was advanced in the paracentral stroma, and air was injected into the corneal stromal tissue, which formed a large air bubble between DM and the host's corneal stroma. Subsequently, debulking the anterior two-thirds of the superficial corneal stroma was performed using a crescent blade (Alcon Surgical, Fort Worth, Texas, USA) and left a very thin layer of corneal stromal tissue over the large air bubble. A paracentesis was created using a 15-degree blade (Alcon Surgical) at the 10-o'clock position to lower the intraocular pressure of the eye. A small opening was then created in the stromal tissue overlying the air bubble using a 15-degree blade (Alcon Surgical), and after the egress of the air bubble from the incision site, 2% hydroxypropyl methylcellulose (Visilon, Shah & Shah, Mumbai, India) was injected through the opening to maintain the space between the remaining corneal stromal tissue and DM. A curved Vannas scissors (Appasamy Associates, Chennai, India) was used to divide

the stromal tissue into four quadrants, and each quadrant was excised baring the DM completely.

• **DONOR PREPARATION:** Full-thickness donor corneal tissues stored in McCarey-Kaufman medium were used for transplantation. Circular trephine blades (Storz Ophthalmics, St Louis, Missouri, USA) ranging from 7.5 mm to 8.00 mm in diameter were used to punch the donor lenticule from the endothelial side of the corneoscleral button. The Descemet membrane of the donor corneal button was scraped off after staining it with 0.06% trypan blue dye (Visiblue, Shah & Shah) using a Descemet stripper. The host graft disparity was kept at 0.5 mm with donor graft being larger than the host. The donor lenticule was secured over the recipient bed with 16 10-0 monofilament nylon interrupted sutures.

Postoperatively, the patients received 0.3% ciprofloxacin hydrochloride (Ciplox, Cipla, Mumbai, India) eye drops three times a day, 1% prednisolone acetate (Predacetate, Allergan, Mumbai, India) eye drops four times day, and preservative-free artificial tears every two hours for the first month, which were subsequently tapered over the next six months. Selective suture removal was performed for any suture-related problems and for control of astigmatism from one month onward. The main outcome measures of the study were the ability of the big-bubble technique to bare the DM, gain in visual acuity, and the presence of any complications.

RESULTS

DALK WAS PERFORMED SUCCESSFULLY USING THE BIG-bubble technique in all eyes, and there were no intraoperative or postoperative complications. A complete baring of the DM in the area of trephination was achieved in all eyes. Reinjection of the air bubble was required in one eye attributable to the formation of an incomplete air bubble. In two cases of macular corneal dystrophy, some adhesions were encountered intraoperatively between deeper stromal opacities and DM. These adhesions were successfully separated by gentle blunt dissection. The mean age of the patients was 31.5 ± 11.5 years (range, 14 to 50 years). The mean follow-up period was 8 ± 1.76 months (range, six to 11 months) (Table). Selective suture removal was done in three eyes to control astigmatism. At six months, a BCVA of 20/40 or better was achieved in all eyes. None of the eyes demonstrated any interface haze on slit-lamp biomicroscopy, and there were no instances of stromal graft rejection or graft infection (Figure).

DISCUSSION

DALK IS INDICATED FOR CASES OF CORNEAL STROMAL diseases that have a normal DM and corneal endothelium.[2] The advantages of DALK over PK as a treatment for corneal stromal disease are well known,[11] the most important of which is that there is no risk for endothelial graft rejection. In addition, compared to PK, the technique has all the advantages of a lamellar procedure: avoiding most complications associated with "open-sky" surgery, lesser chances of postoperative complications such as anterior synechiae of iris or secondary glaucoma, and easier postoperative management. DALK retains all the advantages of lamellar keratoplasty over PK while providing a clear interface compared with that of conventional lamellar keratoplasty.[8]

Traditionally, DALK has been used successfully to treat cases of keratoconus.[6] We have routinely used this procedure for treating keratoconic eyes intolerant of contact lenses. Considering the obvious advantages of the procedure, we evaluated its efficacy for newer indications. The corneal endothelium is spared in cases of granular, lattice, and in early cases of macular corneal dystrophy, thereby rationalizing the use of DALK in these cases.[3,12] There is also evidence that DM is spared in corneal clouding caused by mucopolysachharidoses.[13] The eye with the corneal scar attributable to resolved infectious keratitis demonstrated involvement of only two-thirds of the corneal stromal tissue with a thin layer of transparent stromal tissue present anterior to DM. Considering these factors, we planned to perform and evaluate performing DALK in these patients. An unsuccessful DALK procedure in these cases would not have precluded or increased the risk of failure of a subsequent PK. Because DM was observed to be transparent after it was exposed after excising the recipient's corneal stroma, we decided to perform DALK in all these eyes as per our surgical plan.

Deep lamellar keratoplasty (DLK) has been recommended as a surgical alternative to PK in hereditary stromal dystrophies.[2,12] It is an effective procedure for treating various diseases of corneal stroma with unaffected endothelium.[2] Lyons and associates compared the visual outcome, rate, and pattern of recurrence after lamellar and PKs for granular corneal dystrophy.[12] Although a good visual outcome was achieved after lamellar keratoplasty, the visual acuities were marginally inferior to those after PK. The investigators suggested that this might be attributable to the residual dystrophy noted in the deeper corneal layers or attributable to late interface opacification.

In a randomized controlled trial, Shimazaki and associates compared the visual outcomes of PK with DLK, using intrastromal air or balanced saline, in eyes with stromal opacities. The mean postoperative BCVA at the end of six months was comparable in the two groups, but the recovery period was longer in the DLK group.[11] In an age-matched controlled study, Kawashima and associates compared the outcomes of PK with DLK in eyes with lattice and macular corneal dystrophies. DLK was performed by either removing stromal tissue gradually or by viscodissection of DM. All eyes showed a postoperative

improvement in visual acuity. However, macroperforations occurred in 14.6% of the cases requiring conversion to PK.[10] In our study, there were no instances of Descemet perforations necessitating a conversion to PK. In contrast to the other described techniques of DLK, the big-bubble technique creates a perfect cleavage plane between DM and the rest of the corneal tissue and appears to be much safer than the manual technique of achieving deep stromal dissection regarding the instances of macroperforations. The big-bubble technique also ensures a maximum possible depth dissection achieving a complete baring of DM so that no stromal tissue is left to cause interface haze in the future. Attributable to this lack of a graft-host stromal interface, visual recovery may be faster and better as compared with the other techniques of DLK achieving incomplete stromal dissection.[5]

The stromal dystrophies are known to recur within the donor material after corneal transplantation and therefore may require multiple grafts. Several studies have reported the recurrence of stromal corneal dystrophies after PK,[14,15] and a repeat corneal transplantation surgery is required to treat these recurrences. Performing DALK may be a better option in these cases, as repeat procedures may be necessary over a lifetime.

Corneal clouding in mucopolysaccharide storage disorder is the result of abnormal storage in the stromal keratocytes, but DM is not affected in these cases.[16] Patients with mucopolysaccharide storage disorder are predisposed to the risk of glaucoma, and the long-term use of steroids after a PK may further aggravate this problem.[17] Because there is no involvement of DM and the endothelium, performing DALK may be a better option in these patients.[13]

Our study highlights the successful use of DALK with the big-bubble technique to treat corneal opacification caused by stromal corneal dystrophies, mucopolysaccharidosis, and superficial corneal scars attributable to infectious keratitis. In addition to eliminating the risk of endothelial rejection, low-quality donor corneal tissue can be used, therefore easing the shortage of good-quality donor tissue prevalent in developing countries.

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Biosketch

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Biosketch

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