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Deep lamellar keratoplasty for various corneal lesions

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PURPOSE. *To evaluate the efficacy and safety of deep lamellar keratoplasty (DLK) as a method for treating various diseases of corneal stroma with unaffected endothelium.*

METHODS. *DLK was performed in 31 eyes of 31 patients with corneal stroma opacity without endothelial abnormalities. Surgical procedures included deep removal of corneal stroma 7.5 mm in diameter with the use of viscoelastic or 0.02% trypan blue solution, exposing Descemet membrane in the central area of about 5 mm across including the area of pupil, and grafting a corneal lenticule. In three cases of postinflammatory stromal scars with coexisting limbal stem cell deficiency, limbal stem cell grafting was additionally performed. Main outcome measures were best-corrected visual acuity (BCVA) and postoperative astigmatism.*

RESULTS. *Intraoperative perforation of Descemet membrane with the necessity of converting the procedure into penetrating keratoplasty occurred in five cases (16.1%) and one patient underwent penetrating keratoplasty on the seventh day after DLK due to persistent double anterior chamber. These six patients were excluded from the study. Postoperative BCVA ranged from 0.1 to 1.0 and astigmatism from 1.2 to 4.7 D. Postoperative complications were loose sutures, ocular hypertension, Descemet membrane detachment, and corneal melting.*

CONCLUSIONS. *DLK is an effective procedure for treating various diseases of corneal stroma with unaffected endothelium. This technique as an extraocular procedure seems to be the treatment of choice in mentally retarded patients. (Eur J Ophthalmol 2004; 14: 467-72)*

KEY WORDS. *Deep lamellar keratoplasty, Lamellar keratoplasty*

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INTRODUCTION

Deep lamellar keratoplasty (DLK), introduced in the current form by Sugita and Kondo (1), is a recent surgical procedure that allows removal of all of the opaque corneal tissue to the level of Descemet membrane. It is a promising approach to eradicate the risk of endothelial graft rejection in patients with corneal stromal opacification with preserved endothelial function. We evaluated the effectiveness and complications of DLK.

METHODS

DLK was performed in 31 nonconsecutive eyes with stromal opacity without endothelial abnormalities: 21 keratoconus eyes, 9 with post-inflammatory stromal scarring, and 1 with leucoma in Stevens-Johnson syndrome. There were 20 men and 11 women, with a mean age of 42.2 ±10.3 years (range, 19–58). Mean follow-up was 25.5±7.2 months (range, 6–32). Main outcome measures were best-corrected visual acuity (BCVA) and astigmatism. In three cases limbal stem cell graft-

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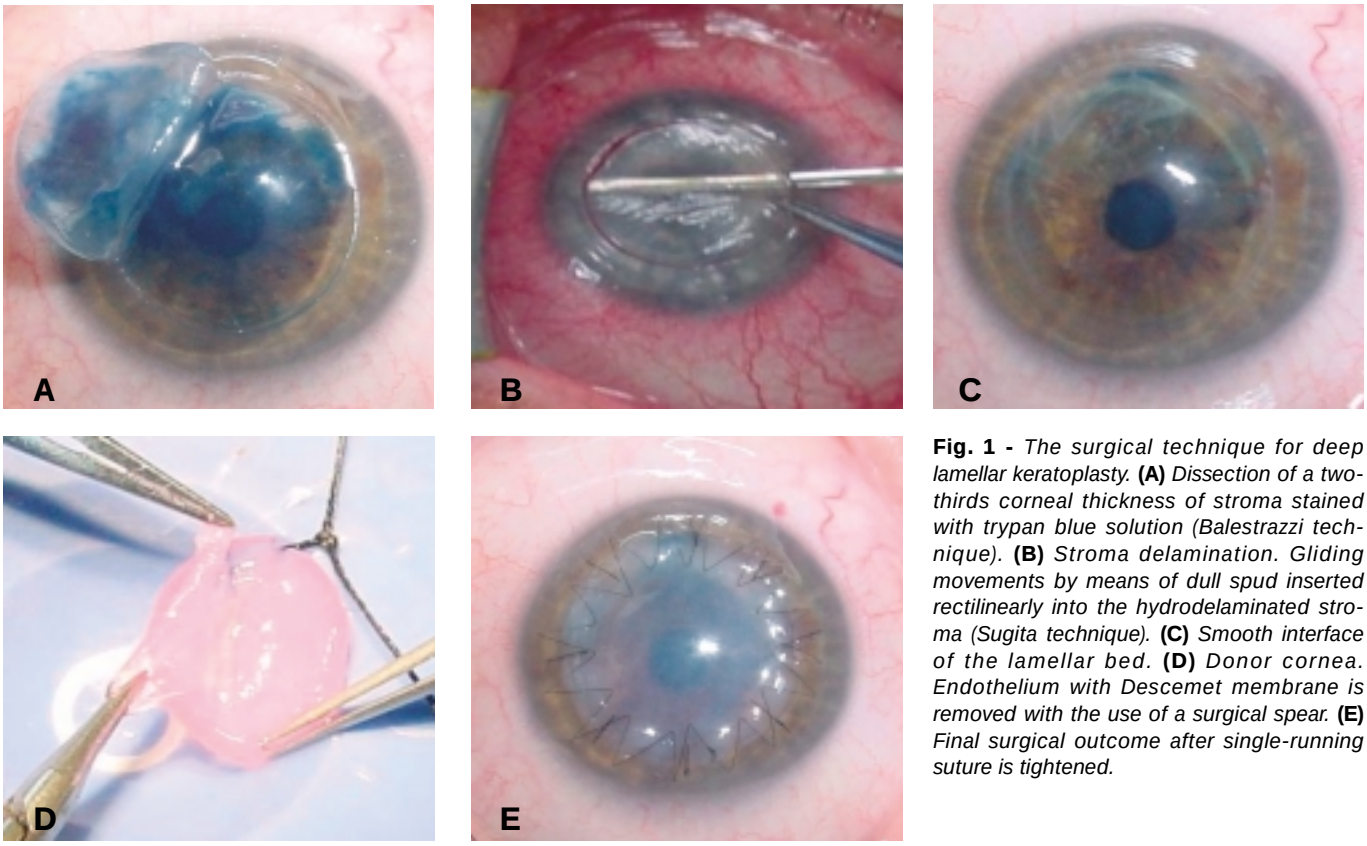

Fig. 1 - *The surgical technique for deep lamellar keratoplasty.* **(A)** *Dissection of a two-thirds corneal thickness of stroma stained with trypan blue solution (Balestrazzi technique).* **(B)** *Stroma delamination. Gliding movements by means of dull spud inserted rectilinearly into the hydrodelaminated stroma (Sugita technique).* **(C)** *Smooth interface of the lamellar bed.* **(D)** *Donor cornea. Endothelium with Descemet membrane is removed with the use of a surgical spear.* **(E)** *Final surgical outcome after single-running suture is tightened.*

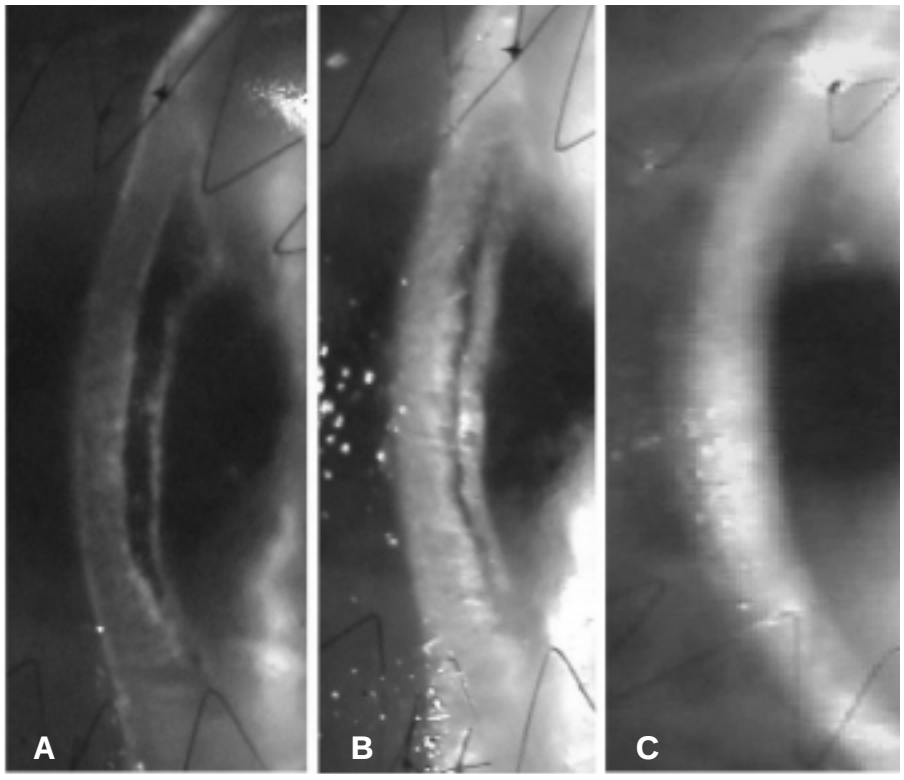

Fig. 2 - *A spontaneous attachment of pseudoanterior chamber.* **(A)** *Supernumerary anterior chamber visible on first postoperative day.* **(B)** *One week postoperatively.* **(C)** *Loss of supernumerary anterior chamber 5 weeks postoperatively.*

ing was additionally performed. Five patients with keratoconus were mentally retarded.

The surgery was performed under general anesthesia. The surgical technique was similar in all cases and all procedures were performed by one surgeon (E.W.). In the recipient eye, the cornea was trephined to a depth of 70% with 7.5 mm diameter Hessburg-Barron vacuum trephine. After the lamellar hydrodissection, stroma was dissected entirely (Fig. 1A) or divided into four quadrants with the use of bevel knife according to Tsubota, who applied Gimbel's nucleofractics divide-and-conquer technique to DLK. Next it was dissected layer by layer in the central area of about 5 mm across including the area of pupil, to the level of Descemet membrane with the crescent knife (2, 3). Then the tunnel for deep stromal dissection was bored using spatula (Fig. 1B). In the first 18 corneas, dissection of the deepest stromal lamellae was performed by injecting a viscoelastic substance (Healon, Pharmacia & Upjohn) through the tunnel into the stromal fibers. The recent 13 recipient corneas were delaminated with the use of 0.02% trypan blue solution (Balestrazzi technique) (4) The latter technique was introduced to facilitate discerning and removal of the deep stromal layers, so as to decrease the risk of Descemet membrane perforation. Lamellar dissection was performed until smooth interface of lamellar bed appeared (Fig. 1C). If there was any microperforation of Descemet membrane but no significant aqueous humor leakage, the procedure was continued. However, if there was a large Descemet membrane tear with shallow anterior chamber, the surgery was shifted to penetrating keratoplasty.

The donor lenticule was trephined in the artificial chamber with the 0.5 mm oversized manual trephine to a depth of 100%. After removing the endothelium together with Descemet membrane using forceps (Fig. 1D), the button was placed onto the recipient bed and sutured in with eight interrupted sutures and then with 10/0 nylon single or double-running antitorque suture (Fig. 1E).

In three cases of post-inflammatory stromal scars, where the cornea surface was vascularized and conjunctivalized, limbal stem cell grafting was additionally performed after DLK procedure was finished. In all these eyes limbal stem cell deficiency (LSCD) was preoperatively confirmed by impression cytologic analysis, based on presentation of goblet cells in the corneal area. In one case conjunctival-limbal autograft (CLAU) was obtained from contralateral undamaged eye and two patients underwent living-related HLA-matched conjunctival limbal allografting (lr-CLAL).

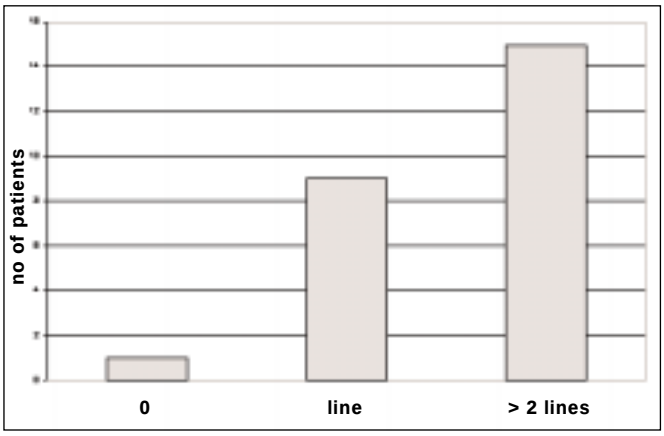

Fig. 3 - *Postoperative improvement of best-corrected visual acuity (BCVA) in relation with preoperative BCVA.*

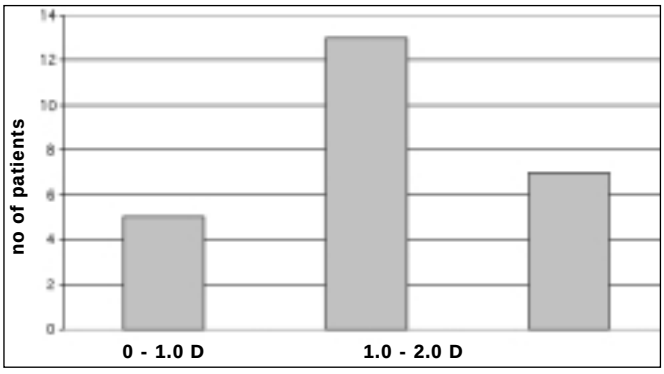

Fig. 4 - *Postoperative astigmatism.*

Data were expressed as mean ± standard deviation (SD). Changes in BCVA and postoperative astigmatism are shown in the Figures.

RESULTS

The surgical procedure was completed in 25 eyes. In five cases in the viscoelastic group during deep stromal peeling a large Descemet membrane tear with anterior chamber shallowing occurred, so we converted the procedure into penetrating keratoplasty. In two eyes the intrastromal pseudoanterior chamber developed. In one case because the intrastromal pseudoanteri-

or chamber continuously deepened, on the seventh day following surgery penetrating keratoplasty was performed. In the other case a spontaneous attachment was observed after 5 weeks (Fig. 2). These six patients who finally underwent penetrating keratoplasty were excluded from the study.

There were no observed episodes of rejection in any of the 25 eyes in an average 25.5 months of follow-up (range, 6–32). Postoperative BCVA ranged from 0.1 to 1.0 (Fig. 3) and astigmatism from 1.2 to 4.7 D (mean 2.3±1.04 D) (Fig. 4). Postoperative complications were delayed epithelial healing (5 cases), loose sutures in early postoperative period (4), ocular hypertension (3, all successfully treated by medication), corneal melting (1), supernumerary anterior chamber (1), and inflammatory infiltrates (1).

In mentally retarded patients we observed no serious postoperative complications.

In eyes that additionally underwent limbal grafting, complete corneal epithelial healing occurred within the first week after surgery in two eyes (66%), and after 12 days in all three eyes. Impression cytology analysis of the central area taken 2 months after surgery demonstrated normal corneal epithelium in all three cases. Peripheral conjunctival ingrowths with tendency to regress were present until 4 months after surgery.

Specular microscopy 6 weeks postoperatively revealed a high level of average endothelial cell density 2,320/mm^2 (range, 1,920–3,115).

DISCUSSION

Our results confirmed that DLK could be applied instead of penetrating keratoplasty in cases with no damage of endothelium. In our group the most common indication was keratoconus (68%), which is considered to have the minimal risk of rejection. But even in this condition the risk of endothelial rejection is reported as 7–13% (4, 5). There was no rejection episode among 25 eyes. Visual improvement was at least as good as we could predict after penetrating keratoplasty.

Sugita and Kondo reported no significant difference in VA in eyes with small amount of stroma left (1). This opinion is inconsistent with our observation. Exposing Descemet membrane at least in the region of the pupil seems to be crucial to gain marked visual improvement. In eyes with small amount of deep stroma left, the BCVA was worse than in eyes where stroma was excised completely. Leaving a small portion of stroma occurred only in a few eyes from the viscoelastic group, and never in trypan blue eyes. Postoperative BCVA (with spectacle correction) in our group ranged from 0.1 to 1.0. Often it was possible to achieve even better visual results with a contact lens. Such a correction did not pose a problem since our patients (mainly with keratoconus) were accustomed to wearing contact lenses.

Keratometric astigmatism was lower than usually gained after penetrating keratoplasty. Delayed epithelial healing concerned all three eyes that underwent limbal grafting and also two eyes after sole DLK.

Descemet membrane rupture is a common complication, reported between 0 and 39.2% (1, 2, 6). Intrastromal trypan blue staining decreased the risk of Descemet membrane perforation in our study. This procedure secures a possibility of intraoperative conversion into penetrating keratoplasty when necessary.

The viability of endothelial cells, critical for graft success, in lamellar keratoplasty remains almost undisturbed. Graft failure resulting mainly from graft rejection in high risk cases in this method is also diminished, thus systemic immunosuppression is not necessary. Unquestionable advantages of DLK over penetrating keratoplasty and continuous surgical refinements allow this procedure to be applied in all eyes needing corneal grafting, where endothelium is not involved. According to our experience, DLK performed according to Tsubota, in Trimarchi modification with additional use of Balestrazzi technique for stroma staining, offers an opportunity to obtain a good visual outcome, and should be recommended as a first choice keratoplasty in all cases where endothelium and Descemet membrane remain healthy (4, 7, 8).

To date, there have been no reports on corneal melting after DLK. In one keratoconus eye in this report corneal melting developed 3 weeks after surgery. This patient had normal preoperative Schirmer I score in both eyes; however, postoperative Schirmer I and II scores in the operated eye were 12 and 5 mm, respectively. Dogru et al recently reported disturbed tear film in keratoconus (9), which could be the cause of upset epithelial growth. When combining these observations, disturbances of tear film should be considered as a reason for sterile corneal melting, es-

pecially as intensive lubrication with 1 hour intervals resulted in successful healing after 5 weeks.

There are various methods of dealing with pseudoanterior chamber (aqueous tracking into the lamellar graft bed). One of them is to observe and wait for a spontaneous attachment. However, some surgeons propose injecting a mixture of air and sulfurhexafluoride (SF_6) in the anterior chamber and performing penetrating keratoplasty if the reposition of Descemet membrane was not achieved (10). In our study, intrastromal pseudoanterior chamber developed in two eyes. In the former case, since pseudochamber was deepening continuously during the first week, on the seventh day following surgery we decided to perform penetrating keratoplasty. The microperforation of Descemet membrane in this eye occurred near the site of trephination, while in the latter eye centrally localized Descemet membrane puncture allowed spontaneous attachment after 5 weeks (Fig. 2). The only medications were locally administered fluorometholone drops and 5% NaCl drops and ointment.

DLK with simultaneous limbal stem cell grafting is a rarely performed procedure. Until now only Tsubota and Shimazki and Yao et al reported such a combined surgery (11, 12). Their and our experiences confirmed the necessity of creating the surface as smooth as possible, to enable the stem cells to produce the properly placed epithelial layers. This is especially important in eyes with burns or pemphigoid, where the normal epithelium substitutes for the rough, fibrous tissue.

In eyes that underwent additional limbal stem cell grafting, complete corneal epithelial healing occurred in two eyes (66%) within the first week after surgery, and after 12 days in all three eyes. Impression cytology analysis of the central area taken 2 months after surgery demonstrated normal corneal epithelium in all three cases. Conjunctival ingrowths in peripheral cornea were present until 4 months after surgery and then faded. When combined with limbal stem cell transplantation in eyes with LSCD, DLK seems to be a promising approach in reconstruction of the ocular surface and recovering the corneal clarity without immunologic rejection.

No serious postoperative complications were observed in five mentally retarded patients with keratoconus. Because prognosis of penetrating keratoplasty in patients with Down syndrome is worse than in other patients with keratoconus (lid anomalies, lack of patient cooperation, advanced stages of keratoconus that require larger grafts often leading to immunologic reactions, suture loosening and secondary glaucoma), this technique may significantly decrease the risk of graft failure (13, 14). According to our observation the most frequent complication after penetrating keratoplasty for keratoconus in mentally retarded patients is suture loosening, which was almost completely eliminated after DLK, occurring in only one patient with advanced keratoconus. The other important advantage of performing DLK in mentally retarded patients was milder and shorter postoperative treatment regime (with reduction in postoperative steroid treatment) than required after penetrating keratoplasty, and the possibility of earlier suture removal (in our group after 6 to 8 months). The aforementioned factors seemed to support DLK, an extraocular procedure, as the treatment of choice in such cases.

CONCLUSIONS

DLK may be an effective keratoplasty in various diseases of corneal stroma with unaffected endothelium. This extraocular procedure seems to be the treatment of choice in mentally retarded patients.

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