Deep Anterior Lamellar Keratoplasty for the Treatment of Stromal Corneal Dystrophies

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Purpose: To report the perioperative complications and clinical outcomes after deep anterior lamellar keratoplasty (DALK) using the big bubble technique in eyes with stromal corneal dystrophies.

Patients and Methods: Seventy-four eyes of 65 patients who underwent DALK for stromal corneal dystrophies were evaluated in this retrospective interventional case series study. Main outcome measures were intraoperative and postoperative complications, postoperative uncorrected visual acuity, best spectacle–corrected visual acuity, spherical equivalent refraction, and topographic astigmatism.

Results: There were 44 eyes with macular corneal dystrophy, 18 eyes with lattice dystrophy, and 12 eyes with granular dystrophy. DALK was completed in 69 cases (94.6%). Descemet membrane microperforations occurred in 6 eyes (8.7%). The mean follow-up period was 43.5 ± 23.9 months, ranging from 12 to 96 months. Postoperative best spectacle–corrected visual acuity of 0.5 or better was present in 52 of 69 eyes (75.4%). There were 3 episodes of stromal graft rejection, which responded to topical therapy. Lattice dystrophy recurred in 6 eyes (35.3%).

Conclusion: DALK using the big bubble technique is an effective procedure in the treatment of patients with corneal stromal dystrophies. Recurrence of lattice dystrophy was relatively high.

Key Words: deep anterior lamellar keratoplasty, big bubble technique, stromal corneal dystrophies

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Corneal dystrophies are a heterogeneous group of hereditary corneal disorders that are generally bilateral, mostly genetically determined noninflammatory conditions resulting in the formation of corneal opacities. Clinically, the corneal dystrophies can be divided into 3 groups based on the predominant anatomical location: anterior corneal dystrophies, stromal corneal dystrophies, and posterior corneal dystrophies.[1] A penetrating or lamellar graft may be eventually required in visually affected individuals with stromal or posterior dystrophy.[2]

Deep anterior lamellar keratoplasty (DALK) has been shown to be effective for the treatment of corneal diseases not affecting the endothelium and Descemet membrane (DM). It involves removal of the diseased anterior layers of the corneal stroma and preserves healthy DM and endothelium of the host. One of the most important advantages over penetrating keratoplasty (PK) is the elimination of endothelial graft rejection. Also, because topical steroids can be discontinued earlier, there is less risk of secondary infection, delayed wound healing, cataract development, or glaucoma after DALK surgery.[3–11]

Corneal dystrophies without endothelial abnormalities are good candidates for DALK surgery.[7–11] We present our long-term results in a large series of eyes with stromal corneal dystrophies. This is the largest series of DALK cases using the big bubble technique in stromal corneal dystrophies.

PATIENTS AND METHODS

In this noncomparative interventional case series study, data were recorded prospectively and then analyzed retrospectively. The charts of all patients with stromal corneal dystrophies undergoing DALK surgery between August 2002 and July 2010 were evaluated. The eyes that were followed up for at least 12 months were included. All surgeries were performed by 2 surgeons (M.Ü. and O.Ş.A.) in 2 different centers. The study followed the tenets of the Declaration of Helsinki. All patients signed a consent form after having received an explanation of the nature and possible consequences of the procedure.

DALK was attempted in 74 eyes of 65 consecutive patients with stromal corneal dystrophies. Surgeries were performed with the patient under general or retrobulbar anesthesia using the big bubble technique as described by Anwar and Teichmann.[12] As first defined by Sarnicola et al[13] and then others,[4–6,8] patients who had complete DM exposure via the big bubble were termed as the Descemetic deep anterior lamellar keratoplasty (dDALK) group.

In cases where a big bubble was not accomplished after more than one attempt, a layer-by-layer manual stromal dissection was performed under direct visualization. The surgeon

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intended to reach the maximal depth by exposing a plane as close as possible to the DM. This group of DALK patients was termed as the predescemetic deep anterior lamellar keratoplasty (pdDALK) group. At the end of the operation, air was injected intracamerally to prevent formation of a double anterior chamber in all cases.

When DM perforations occurred during surgery, air was injected into the anterior chamber to seal microperforations. If DM perforation was large enough to preclude lamellar keratoplasty, then the surgeon converted to PK.

Full-thickness donor corneoscleral buttons stored in Optisol GS (Bausch & Lomb) were used for transplantation. The Barron Donor Cornea Punch (Barron Precision Instruments, LLC, Grand Blanc, MI) was 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 trypan blue dye. The host–graft disparity was kept at 0.25 to 0.5 mm with the donor graft being larger than the host graft. The donor lenticule was secured over the recipient bed with 16 interrupted or a combination of 8 interrupted and 1 continuous 16-bite 10-0 monofilament nylon sutures. Keratoscopy was performed intraoperatively to adjust suture tension.

After the surgery, all patients received topical ciprofloxacin 0.3%, prednisolone acetate 1%, and preservative-free artificial tear eye drops 6 times per day for 1 month. Artificial tears and prednisolone acetate 1% eye drops were tapered off over 3 to 6 months. Additionally, in patients with interface irregularities, steroids with low potency such as fluorometholone or loteprednol were used in low doses after cessation of prednisolone therapy for 3 to 6 months.

A complete ophthalmic examination was performed preoperatively and postoperatively, including slit-lamp examination, uncorrected visual acuity, best spectacle–corrected visual acuity (BSCVA), refractive error, and corneal topographic keratometry. Follow-up examinations were scheduled 1 and 7 days and 1, 3, 6, and 12 months postoperatively and every 6 months thereafter. At each follow-up visit, a routine ocular examination was repeated. Selective suture removal was performed for any suture-related problems and for control of astigmatism from 6 weeks onward in eyes with more than 5 diopters of topographic astigmatism.

The main outcome measures of the study were the ability to successfully complete DALK, intraoperative and postoperative complications, uncorrected visual acuity and BSCVA, spherical equivalent, astigmatism, and graft clarity. Data are expressed as mean ± SD. Student *t* test or χ^2 analysis was used for data comparison between study groups. Results were considered significant at the 0.05 level. Snellen visual acuity measurements were converted to a logarithm of the minimum angle of resolution score to simplify analysis.

RESULTS

During the time covered by this study, 74 eyes of 65 patients with stromal corneal dystrophy underwent DALK surgery with the big bubble technique. Data for 5 eyes of 3 patients in whom the procedure was converted to PK intraoperatively because of DM macroperforations were excluded from the analysis. Therefore, 69 eyes of 62 patients were included in the study.

There were 35 male and 27 female patients. There were 43 eyes of 39 patients with macular corneal dystrophy, 17 eyes of 15 patients with lattice dystrophy, and 9 eyes of 8 patients with granular dystrophy. The mean follow-up period was 43.5 ± 23.9 months, ranging from 12 to 96 months. At the time of surgery, the mean patient age was 46.9 ± 16.7 years, ranging from 17 to 87 years.

OPERATIVE DATA AND COMPLICATIONS

Intraoperative rate of conversion to PK was 6.8% (5 eyes). Table 1 shows the intraoperative characteristics of 69 DALK eyes, including the numbers of dDALK and pdDALK, intraoperative complications, trephine sizes, graft host disparity, and suturing technique. Complete DM exposure could be achieved in 56 cases (81%) in the dDALK group via the big bubble. Thirteen eyes (19%) required layer-by-layer manual dissection in the pdDALK group because of the lack of a big bubble after several attempts.

Table 2 shows preoperative complications. Microperforation of DM was observed in 6 eyes (8.7%) during the stromal dissection phase, but this did not affect the subsequent surgical steps, leading to the uneventful completion of the DALK procedure. A double anterior chamber was noted in the immediate postoperative period in 4 eyes (5.8%) with intraoperative DM microperforation. DM reattached to graft stroma with conservative management in 3 eyes. The other eye required C3F8 gas injection into the anterior chamber.

Postoperative interface irregularity was developed in 5 patients (7.3%); of them, 3 were in the pdDALK group. Irregularity was most prominent during the first 6 months and then decreased slowly in all cases.

TABLE 1. Preoperative and Operative Patient Data

Characteristic	n = 69 (%)
Preoperative diagnosis	
Macular dystrophy	43 (62)
Granular dystrophy	9 (13)
Lattice dystrophy	17 (25)
DALK	
dDALK via big bubble	56 (81)
pdDALK via manual dissection	13 (19)
Recipient trephine size, mm	
7.00	4 (6)
7.50	27 (39)
7.75	25 (36)
8.00	11 (16)
8.50	2 (3)
Host/donor disparity, mm	
0.25	63 (91)
0.50	6 (9)
Suturing technique	
Interrupted	12 (17)
Combined	51 (74)
Single running	6 (9)

TABLE 2. Intraoperative and Postoperative Complications

Preoperative Complications	n = 69 (%)
Intraoperative	
DM microperforation	6 (8.7)
Failure to form big bubble	13 (18.8)
Postoperative	
Double anterior chamber	4 (5.8)
Interface irregularity	5 (7.3)
DM folds	1 (1.5)
Epithelial healing problems	2 (2.9)
Loose/broken sutures	2 (2.9)
Stromal graft rejection episode	3 (4.3)
Steroid-responsive glaucoma	1 (1.5)
Steroid-related cataract development	1 (1.5)
Recurrence of dsytrophy	9 (13)

Recurrence of the disease occurred in 1 eye with macular dystrophy (2.3%), 6 eyes with lattice dystrophy (35.3%), and 2 eyes with granular dystrophy (22%). Significant reduction of visual acuity necessitated a new DALK procedure in 4 patients with lattice dystrophy and 1 patient with granular dystrophy. The earliest recurrence was in an eye with granular dystrophy 14 months after surgery. Mean time from surgery to recurrence was 33.0 ± 7.7 months (range 14–82 months).

There was no graft failure associated with graft rejection. There were 3 instances of stromal graft rejection (between 4 and 9 months after surgery) in 3 eyes (4.3%). There was a complete reversal of stromal edema after initiation of intensive topical corticosteroid therapy.

REFRACTIVE AND VISUAL OUTCOMES

Visual and refractive outcomes are summarized in Table 3. Measurements recorded at the last examination were used for the analysis. All eyes had better visual acuity at 6 months postoperatively than they had preoperatively. A BSCVA of 0.5 or better was present in 3 eyes (4.4%) preoperatively and 52 eyes (75.4%) postoperatively. Comparing the BSCVAs of dDALK and pdDALK groups, the difference was not statistically significant ($P > 0.05$).

Seventeen eyes had a postoperative BSCVA worse than 0.5. Recurrence of original disease was responsible in 5 eyes. Age-related macular changes and nuclear sclerosis were noted in 2 and 5 eyes, respectively. The remaining 5 eyes seemed to have a poor BSCVA because of high postoperative astigmatism.

Selective suture removal was performed in 19 patients for control of astigmatism from 6 weeks onward. All the study eyes had removal of all sutures at the last examination.

DISCUSSION

Immune-mediated corneal graft rejection remains the leading cause of graft failure in corneal transplantation. DALK, which offers the advantages of preservation of the recipient endothelium and elimination of immune-mediated endothelial rejection, has been introduced as an alternative to PK in eyes with keratoconus and stromal opacities attributable to dystrophies, trauma, and postinfectious keratitis.[3–11] Despite the potential advantages of anterior lamellar surgery over PK, there have been some concerns regarding the visual function achieved by patients with lamellar grafts. This has been attributed mainly to host–donor interface opacities or irregularity, especially in cases performed with manual techniques leading to remaining corneal stroma on the recipient bed.[3]

Recently, DALK has gained popularity again because of improvements in surgical techniques and the availability of new surgical instruments and devices that have helped to improve surgical success and reduce surgery time.[4–7,12] Interface haze is rarely a problem with DM-baring procedures. As a DM-baring technique, the big bubble technique involves air injection into the deep stroma with the aim of inducing separation by cleavage between posterior stroma and the DM, allowing the surgeon to gain safe and direct access to this plane. It has the advantage of exposing a smooth surface of excellent optical quality. In a study comparing 3 techniques used for removing the recipient stroma during anterior lamellar keratoplasty, the best visual outcomes were obtained using the big bubble technique.[14] Many studies have reported the safety and efficacy of big bubble DALK surgery and concluded that visual and refractive outcomes were comparable with those of PK.[3,8,10,12,15]

TABLE 3. Preoperative and Postoperative Visual Acuity (logMAR), Spherical Equivalent, and Topographic Astigmatism

Variable	Preoperative	Postoperative
Visual acuity		
UCVA, mean ± SD (range)	1.28 ± 0.42 (3.0–0.2)	0.56 ± 0.22 (1.7–0)
BSCVA, mean ± SD (range)	1.21 ± 0.68 (3.0–0.2)	0.28 ± 0. 17 (1.7–0)
BSCVA 0.3 or better, n (%)	3 (4.4)	52 (75.4)
BSCVA 0.3–1.0, n (%)	24 (34.8)	11 (16)
BSCVA worse than 1.0, n (%)	42 (60.9)	6 (8.7)
Refraction		
Topographic astigmatism	1.25 ± 0.87 (0–3.37)	3.17 ± 2.43 (0.5–6.50)
Spherical equivalent	0.25 ± 0.97 (−1.75 to 1.37)	−2.15 ± 2.69 (−7.0 to 1.75)

logMAR, logarithm of the minimum angle of resolution; UCVA, uncorrected visual acuity.

Postoperative BSCVA of 0.5 or better was present in 75.4% of the patients in our series, which compares well with that reported after PK and anterior lamellar keratoplasty in patients with keratoconus and other diseases including stromal corneal dystrophies. Percentages of patients having a BSCVA of 0.5 have been reported as ranging between 53% and 91% after PK.[8,16–18] Similar results were also reported after DALK surgery, ranging between 57% and 92%.[4–6,8–11] The relatively low rates in the present study may be associated with recurrence of the original disease in 9 cases because of long-term follow-up. Also, visual acuities were detected only by spectacle correction, and there were no additional refractive procedures.

DALK can be complicated by DM perforation, which can present as microperforation or macroperforation. Although macroperforations usually result in conversion to PK, DALK can almost always be completed successfully in the cases where microperforations occur. Macroperforations that necessitated conversion to PK occurred in 5 eyes (6.8%) in our series. In the literature review, the rate of DM macroperforation has been reported as ranging between 0% and 9% in patients with keratoconus and various corneal diseases.[4,9] We used the big bubble technique to bare the DM in the present study, and we achieved it in 56 eyes (81%). The rates of successful big bubble procedures have been reported to range between 100% and 40%.[4,9]

Endothelial rejection is an important cause of graft failure after PK. Patel et al[19] found that irreversible rejection accounted for 25% of all failed grafts. Although other types of graft rejection (subepithelial or stromal) may still develop after DALK, preservation of host endothelium in DALK eliminates the risk of endothelial rejection, which is the most common type of rejection. Immunologic rejection episodes have been reported to range between 0% and 14.3% after DALK surgery, being reversible in most cases with appropriate therapy.[3–11] But irreversible loss of vision after lamellar keratoplasty because of presumed stromal graft rejection has been also reported.[20,21] In our series, 3 eyes (4.3%) developed immune-mediated stromal rejection with complete reversal of stromal edema after initiation of intensive topical corticosteroid therapy.

Recurrence of the corneal stromal dystrophies in the corneal graft is another important problem and expected for PK or DALK. Recurrence seems to be closely associated with the time interval after the procedure. No recurrence was reported in DALK series with a short-term follow-up period.[7,9] In a large study performed by Pandrowala et al,[22] the recurrence rate of corneal dystrophies was 2.8% in 181 eyes after PK over a period of 6 years. In the study of Marcon et al,[23] the recurrence rate was highest in eyes with lattice dystrophy (60%) after PK and there was a clinically significant recurrence after 5 years of follow-up.

It is suspected that recurrence of a stromal dystrophy occurs because of retained host stroma and would be less likely with the DM-baring techniques.[3] Salouti et al[11] reported that 5 of 7 eyes (71%) had recurrence of granular corneal dystrophy after DALK surgery was performed with the Melles technique. The high recurrence rate may be associated with the technique used in that study, which is not a DM-baring technique, and leads to incomplete removal of stroma on the recipient bed. Lyons et al[24] reported that recurrence of granular corneal dystrophy within the graft was almost universal within 4 years after PK and lamellar keratoplasty, independent of type of graft performed. In the present series, recurrence of the disease occurred in 1 eye with macular dystrophy (2.3%), 6 eyes with lattice dystrophy (35.3%), and 2 eyes with granular dystrophy (22%) and 5 of them needed a new DALK procedure because of clinically significant reduction of visual acuity. The mean follow-up period was relatively long, ranging from 12 to 96 months.

Although graft rejection is a rare cause for a new graft after DALK surgery, clinically significant recurrence may require multiple grafts in eyes that underwent the DALK procedure for corneal dystrophy. Regrafting is a relatively simple procedure after anterior lamellar surgery. Therefore, performing DALK may be a better option in these cases, as repeat procedures may be necessary over a lifetime.

In conclusion, our study highlights the successful use of DALK with the big bubble technique to treat corneal opacification caused by stromal corneal dystrophies.

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