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Results of Deep Anterior Lamellar Keratoplasty (DALK) in Keratoconus: A Retrospective Analysis

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Abstract

Introduction: DALK is a surgical treatment used for many stromal pathologies such as keratoconus, corneal scars, stromal dystrophy and stromal degeneration that do not affect the endothelium The aim of this study was to present the clinical results of keratoconus patients who underwent deep anterior lamellar keratoplasty (DALK) surgery.

Materials and Methods: Data from 30 eyes of 30 patients who underwent deep anterior lamellar keratoplasty were retrospectively reviewed. Preoperative examinations, operative data, intraoperative and postoperative complications, additional interventions, and visual outcomes were evaluated. Descriptive statistical methods (mean, standard deviation) were used for data evaluation. The results were assessed at a 95% confidence interval, with a significance level of $p < 0.05$.

Results: Out of the 35 keratoconus patients scheduled for DALK surgery, 30 eyes were included in the study. Five patients who developed macroperforation of Descemet's membrane (DM) during DALK surgery were excluded from the study. The patients were followed up for an average of 26.6±8.4 months (range: 6-48) after keratoplasty surgery. Preoperatively, visual acuity level ≤1/10 was present in 22 patients (73.3%), and between 1/10-2/10 in 8 patients (26.7%). Postoperatively, best-corrected visual acuity (BCVA) was ≤1/10 in 1 eye (3.3%); BCVA was ≥1/10 in 29 eyes (96.6%), and ≥5/10 in 23 eyes (%76.6). Stromal rejection developed in 1 of 30 patients (3.3%) who underwent DALK surgery.

Conclusion: DALK surgery performed on patients with keratoconus significantly reduces the risk of immunological reactions and graft rejection. Therefore, it is the first surgical method to be considered especially in patients with keratoconus who require keratoplasty.

Key words: Deep anterior lamellar keratoplasty; keratoconus; keratoplasty.

Introduction

Penetrating keratoplasty (PK) is a frequently performed surgical procedure for various corneal pathologies such as keratoconus, corneal degeneration, corneal scars, and corneal dystrophies. However, one of the major disadvantages is the compromised structural integrity of the eye, which leads to reduced resistance to trauma and an increased risk of endothelial rejection. Currently, deep anterior lamellar keratoplasty (DALK) has established itself as an alternative to PK when the endothelium is healthy. DALK is a surgical treatment used for many stromal pathologies such as keratoconus, corneal scars, stromal dystrophy and stromal degeneration that do not affect the endothelium (1). Since the endothelium is preserved in DALK, the risk of intraocular complications such as endophthalmitis, expulsive hemorrhage, glaucoma or cataract, which frequently occur in penetrating keratoplasty, is lower. The major advantage of DALK over PK is its ability to preserve the endothelium and reduce the risk of immunological reactions and graft failure (1,2,3). In addition, because the endothelium is preserved during DALK surgery, less postoperative use of topical corticosteroids is required, reducing the risk of potential secondary infections that could develop with prolonged use of steroids after surgery, as well as the risk of cataracts and glaucoma(4,5). The aim of this retrospective study is to present the results of patients with keratoconus who underwent DALK surgery.

Materials and Methods

A retrospective evaluation of 35 keratoconus patients presenting with visual impairment who required keratoplasty between September 2020 and March 2024 was performed. Written informed consent was obtained from the patients who participated in the study. The surgical procedures were performed by the same physician. A detailed medical history was obtained from the patients with information on age, gender, systemic diseases and previous eye surgeries. Visual acuity, autorefractometer values (KR-890; Topcon, Japan), best-corrected visual acuity, intraocular

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pressure values (Canon TX-20 tonometer, USA), anterior and posterior segment examinations and topographic records (Pentacam-70700, Germany) were obtained for each patient. 12 patients who underwent DALK had a history of previous cross-linking (CXL) treatment. These patients were treated with hard contact lenses after the procedure, but they were not satisfied. Exclusion criteria for the study included subjects with a history of intraocular surgery, additional ocular pathologies such as retinal vascular disease, patients with hydrops and patients with scarred Descemet's membrane (DM). All patients were operated on under general anesthesia. In all cases, the deep anterior lamellar keratoplasty (DALK) technique with large air bubbles described by Anwar and Teichmann was used. The recipient bed was trephined with an adjustable 7.50-mm vacuum trephine (Moria Trephine, France) to a depth of approximately 300 micrometers. The graft tissue was prepared with a 7.75 mm corneal punch (Moria Cornea Vacuum Punch, France). A 30-gage needle was attached to a 5-ml syringe filled with air. The needle tip was bent at an angle of approximately 45° and advanced approximately 4-5 mm from the incision site toward the center of the corneal stroma with the bent tip pointing downward. Intrastromal air injection was performed to create a big bubble. If a big bubble did not form on the first attempt, the entry site was adjusted and another attempt was made to create a big bubble. The formation of a white, opaque bubble, indicating sufficient spread of air in the corneal stroma, confirmed the successful formation of a big bubble. In cases where the intraocular pressure increased during this process, paracentesis was performed with a 23-gauge blade to lower the pressure in the anterior chamber. The crescent-shaped blade was used to remove the anterior corneal stroma. The remaining stromal tissue was carefully punctured with a 45° blade and the big bubble was evacuated. Viscoelastic (2% Crownvisc) was applied under the stromal hole and the remaining stroma tissue was removed from the incision. The stroma tissue was cut and removed by passing the tip of the scissors through the hole. In this way, only the descement membrane remained. The surface was washed with physiological saline solution to ensure that no foreign bodies remained on the Descemet membrane. The 7.75 mm donor tissue with stripped endothelium was sutured onto the recipient bed using monofilament 10/0 nylon suture (Ethicon, USA). Suturing was performed using 16 single or 8 single and 16 continuous sutures. At the end of the surgery, patients received a subconjunctival dexamethasone injection (Dekort 2ml 8mg ampoule) and the surgery was terminated. Patients were examined postoperatively on the first day, the first week, the first, third and sixth month and then at six-month intervals. A routine ocular examination was performed at each examination. In case of loosening of single sutures, the loose sutures were removed and routine suture removal was performed after 12 months. In patients with high astigmatism, selective suture removal was performed in the early postoperative period Suture adjustment for astigmatism was performed using corneal topography.

Ethical approval: Ethical approval was obtained for the study from the local ethics committee. (approvalnumber:B.30.2.ATA.01.00/373,07.06.2024).

Statistical analysis: Statistical analyses were performed using the programme SPSS for Windows 18.0 (Statistical Product and Service Solutions, Inc., Chicago, IL, USA). Descriptive statistical methods (mean, standard deviation) were used to analyse the data. Independent samples t test was used to compare the means of a quantitative variable with two groups. The results were evaluated with a confidence interval of 95. The P-value was assumed to be 0.05.

Results

Of the 35 keratoconus patients who were scheduled for DALK surgery, 30 eyes were included in the study. Five cases that experienced macroperforation of Descemet's membrane (DM) during DALK surgery and subsequently underwent penetrating keratoplasty were excluded from the study. Preoperative, intraoperative and postoperative data were evaluated. A total of 20 male and 10 female patients aged between 11 and 48 years (mean age: 22.4 ± 6.8) were included in the study. The demographic characteristics of the patients are listed in Table 1.

Table 1: Demographic characteristics

Demographic Characteristics	Number of Patients(n=30)
Age (years)[a]	22.4 ± 6.8(11-48)
Gender (Male/Female)	20/10 (%66.6/ %33.3)
Right/Left eye	18/12(%60/%40)
Follow-up period (months)[a]	26.6±8.4(6-48)

a: Mean and standard deviation.

Of the 30 eyes that underwent keratoplasty, microperforation of Descemet's membrane (DM) was observed in eyes. Surgical DALK was

performed in the 2 eyes with microperforation. Postoperatively, corneal surface irregularity was observed in 3 eyes (10%). Wrinkling in DM was observed in 2 patients (6.6%). Postoperative 1st, 3rd and 6th month controls were performed. During the controls, 1(3.3%) patient started taking antiglaucomatous medication (brimonidine tartrate, İstanbul, Türkiye) due to increased intraocular pressure in the 3rd month. In 1(3.3%) patient, the loose sutures were removed and the sutures were renewed due to loosening of the sutures in the 1st month. In 1 patient, cataracts developed in the 14th month and the sutures were removed and cataract surgery was performed. During this process, the grafts of 29 patients were seen as transparent. 1(3.3%) patient developed stromal rejection at postoperative month 10 and despite the administration of topical dexamethasone, graft failure occurred. Vision level was measured at final check-ups after all sutures were removed. Intraoperative and postoperative complications are listed in Table 2.

Table 2: Intraoperative and postoperative complications

Intraoperative Complications	**Number of eyes(n=30)**
DM microperforation	2(%6.6)
DM residual stroma	1(%3.3)
Postoperative complications	
Corneal interface irregularity	3(%10)
DM wrinkling	2(%6.6)
Suture breakage	1(%3.3)
Glaucoma due to steroid use	1(%3.3)
Cataract development	1(%3.3)
Graft rejection	1(%3.3)

DM: Descement membrane.

Figure 1 and Figure 2. Postoperatif DALK images

Transparent graft samples of patients who underwent DALK are shown in Figure-1 and Figure-2. The patients were followed up for an average of 26.6±8.4 months (range: 6-40) after keratoplasty surgery. Preoperatively, visual acuity level ≤1/10 in 22 patients (73.3%) and between 1/10-2/10 in 8 patients (26.7%). Postoperatively, best corrected visual acuity (BCVA) was ≤1/10 in 1 eye (3.3%); BCVA was ≥1/10 in 29 eyes (96.6%) and ≥5/10 in 23 eyes (%76.6). The patient with visual acuity ≤1/10 was the patient who developed stromal graft rejection. The refractive results are summarized in Table 3. The preoperative spherical values of the patients in the eyes where measurement was possible ranged from –13.75 to +1.75 (mean -8.75±3.25), and the keratometric astigmatism values ranged from –8.50 to +2.75 (mean –6.75±3.75). The postoperative spherical values were between –7.75 and +3.75 (mean –2.75±2.50), and the keratometric astigmatism values were between –7.25 and +4.50 (mean –2.75±2.25). Refractive results were found to be significant postoperatively (p<0,001).

Discussion

Penetrating keratoplasty is the most important treatment method in the treatment of corneal diseases or in the rehabilitation of subsequently developing visual loss. In particular, innovations in the surgical instruments used, surgical technique and corneal graft technology have extended the life of the graft. Despite these developments, immune-mediated endothelial graft rejection remains one of the main causes of graft failure. Since the corneal endothelium is protected in the recipient bed during DALK, immune-mediated endothelial graft rejection is not observed. The large air bubble technique reported by Anwar and Teichmann was used in DALK surgery. Similar to the data reported in the literature (40-100%), air bubbles could be generated in all patients (100%) (2,3,6). In patients in whom the first application was unsuccessful, air injection was performed a second and third time and air bubbles were produced. DM perforation occurred in 7 patients (20%) during bubble formation or other phases of the procedure. In the literature, DM perforation rates between 8% and 20% have been reported in keratoconus patients (7,8,9). 5 patients (14.2%) who developed Descemet membrane macroperforation were converted to PK. In similar studies, the rate of conversion to PK due to DM macroperforation was reported to be 4% to 39.2%(10,11,12). On the other hand, DALK surgery was completed without any problems in 2 patients (6.6%) who developed DM microperforation at any stage of the surgery. A double anterior chamber between the recipient DM bed and the donor is a relatively common postoperative complication. A double anterior chamber was not observed in any patient.

Table 3: Visual and refractive results

Visual acuity	Preoperative	Postoperative	p
BCVA under 1/10	22	1	
BCVA over 1/10	8	29	
BCVA over 5/10	0	23	
Refraction			
Spherical[a]	-8.75±3.25	–2.75±2.50	p<0.001*
Keratometric Astigmatism[a]	-6.75±3.75	–2.75±2.25	p<0.001*

BCVA: Best corrected visual acuity. **a:** Mean and standard deviation.
***** Independent samples t test.

In this sense, the result was similar to that reported in the literature (0-16%) (13). Double anterior chamber formation between the recipient bed DM and the donor is a relatively common postoperative complication. Studies have reported that the rate of double anterior chamber formation is between 0% and 16% (13). Postoperative double anterior chamber was not observed in this study. The postoperative best corrected visual acuity was 76.6% at 5/10 and above. This rate, which is considered low compared to visual acuity rates in the literature, may be due to the short follow-up period and the inclusion of DALK results from the learning phase in the study (3,12,14,15,16). When the postoperative spherical values and keratometric astigmatism data were compared with the PK series and data from previous studies, the results were similar (17,18,19). In the literature, the superiority of suture techniques over each other in postoperative refractive values has not been shown (20). In this study, we generally used 16 single sutures or 8 single 16 continuous sutures as the suturing technique. Continuous sutures were removed at the end of one year, and single sutures were removed under the guidance of corneal topography for astigmatism adjustment.

Study limitations: One of the main limitations of our study is the short follow-up period. Another limitation is the small number of patients. Therefore, research should be supported by studies with more cases and longer follow-up periods.

Conclusion

DALK surgery in keratoconus patients significantly reduces the immunological response and the risk of graft rejection. This surgery has important advantages such as faster wound healing, earlier suture removal, fewer intraocular complications, lower risk of postoperative infection, the use of donors with insufficient endothelial number or those that have waited longer, and fewer complications such as cataracts and glaucoma due to local steroid treatment in the postoperative period. Considering all these advantages over PK, DALK surgery should be performed especially in patients with keratoconus.

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