Deep Anterior Lamellar Keratoplasty versus Penetrating Keratoplasty for Macular Corneal Dystrophy: A Randomized Trial

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• PURPOSE: To compare outcomes of big-bubble deep anterior lamellar keratoplasty (DALK) and penetrating keratoplasty (PK) for macular corneal dystrophy.

• DESIGN: Prospective, randomized, interventional case series.

• METHODS: SETTING: Single hospital. PATIENTS: Eighty-two eyes of 54 patients requiring keratoplasty for the treatment of macular corneal dystrophy without endothelial involvement were included. MAIN OUTCOME MEASURES: Operative complications, uncorrected visual acuity, best-corrected visual acuity, contrast sensitivity function, higher-order aberrations, and endothelial cell density were evaluated.

• RESULTS: The DALK and PK group consisted of 35 and 41 eyes, respectively. Best-corrected visual acuity after surgery was 20/40 or better 68.5% and 70.7% of the eyes in the DALK and PK groups, respectively ($P > .05$). No statistically significant differences between groups were found in contrast sensitivity function with and without glare for any spatial frequency ($P > .05$). Significantly higher levels of higher-order aberrations were found in the DALK group ($P < .01$). In both groups, a progressive and statistically significant reduction in endothelial cell density was found ($P < .01$). At the last follow-up, the mean endothelial cell loss was 18.1% and 26.9% in DALK and PK groups, respectively ($P = .03$). Graft rejection episodes were seen in 5 eyes (12.1%) in the PK group, and regrafting was necessary in 3 eyes (7.3%). Recurrence of the disease was documented in 5.7% and 4.8% of the eyes in the DALK and PK groups, respectively.

• CONCLUSIONS: Deep anterior lamellar keratoplasty with the big-bubble technique provided comparable visual and optical results as PK and resulted in less endothelial damage, as well as eliminating endothelial rejection in macular corneal dystrophy. Deep anterior lamellar keratoplasty surgery is a viable option for macular corneal dystrophy without endothelial involvement. (Am J Ophthalmol 2013;156:267–274. © 2013 by Elsevier Inc. All rights reserved.)

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MACULAR CORNEAL DYSTROPHY IS A BILATERAL autosomal recessive disorder that may result in significant visual discomfort. It is characterized by multiple grayish-white stromal opacities with indistinct and hazy borders that extend from limbus to limbus. As corneal opacity slowly becomes more dense and involves the visual axis, loss of functional visual acuity occurs. Therefore, keratoplasty eventually becomes necessary for the restoration of vision and the recovery of corneal transparency.[1]

Traditionally, penetrating keratoplasty (PK) has been considered as the definitive treatment option for a variety of corneal pathologic features, including corneal stromal dystrophies.[1,2] However, deep anterior lamellar keratoplasty (DALK) currently is considered to be the first-choice surgical procedure in patients with corneal disease not involving the endothelium, such as keratoconus, stromal scars, and stromal dystrophies.[3–5] The main advantage of DALK is that the patient's own endothelium is retained, which eliminates the risk of endothelial graft rejection and preserves endothelial cell density.[6–9] Although DALK has several advantages over PK, there have been concerns about its role in macular dystrophy because of the involvement of deeper layers of stroma and possibly the Descemet membrane. Some investigators believe that DALK is not suitable for the treatment of macular corneal dystrophy, claiming that the stromal and endothelial involvement as well as the fragility of Descemet membrane in macular corneal dystrophy would lead to interface opacities and higher rates of endothelial cell attrition after DALK.[4,10]

In the peer-reviewed literature to date, there are a few reports comparing therapeutic outcomes of PK and DALK surgery in the context of macular corneal dystrophy.[4,10] In the current study, we prospectively compared big-bubble DALK and PK in terms of optical

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and visual outcomes, complications, and their effect on the endothelial cell density for the management of macular corneal dystrophy.

METHODS

ALL PATIENTS WERE INFORMED ABOUT THE STUDY AS WELL as the advantages and disadvantages of the procedure. Informed consent was obtained from all patients to participate in this research study in accordance with the Declaration of Helsinki. The Institutional Review Board of Kartal Training and Research Hospital, Istanbul, Turkey, approved the study before it commenced. This study is registered at http://www.controlled-trials.com with identification number ISRCTN41152132. This study was a prospective, randomized clinical trial. Patients requiring keratoplasty for the treatment of macular corneal dystrophy without endothelial involvement were enrolled between January 1, 2006, and June 1, 2010. Macular corneal dystrophy diagnosis was made based on patient history, family history, and slit-lamp findings, including multiple gray-white stromal opacities extending to the deep stroma. Eighty-two eyes of 54 patients were included. All eyes were assigned a number randomly based on a surgical chart (even number, DALK; odd number, PK). Patients who were lost to follow-up, who had undergone previous eye surgery, or who underwent additional surgery combined with keratoplasty were excluded from the data analysis.

All eyes were operated on by a single experienced surgeon (A.K.). Deep anterior lamellar keratoplasty was performed by using the big-bubble technique previously described by Anwar and Teichman.[11] When a big bubble could not be obtained after repeated attempts, a layer-by-layer manual dissection was performed. If during manual dissection the bare Descemet membrane could not be reached and diseased unclear stromal tissue remained, we converted to PK.

Full-thickness corneoscleral donor buttons stored in Optisol GS (Bausch and Lomb, Rochester, New York, USA) were used for transplantation. Penetrating keratoplasty procedures were performed using the standard technique. The donor buttons in both the DALK and PK groups were sutured with a single continuous suture or interrupted 10-0 nylon sutures.

A complete ophthalmologic examination was performed before the operation and postoperative visit in both groups. The examination included logarithm of the minimal angle of resolution uncorrected visual acuity (UCVA), logarithm of the minimal angle of resolution best-corrected visual acuity (BCVA), manifest refraction, slit-lamp biomicroscopy, and corneal topographic analysis with the CSO topography system (Costruzione Strumenti Oftalmici, Firenze, Italy). Contrast sensitivity measurements and corneal aberrometric analysis also were performed after surgery after all sutures were finally removed. The CSV-1OOOE chart (VectorVision, Greenville, Ohio, USA) was used for the assessment of contrast sensitivity. This test consists of 4 rows of sine-wave gratings (3, 6, 12, 18 cycles/degree) that had to be observed by the patient with full correction in place at a distance of 2.5 m. After an initial demonstration, the contrast threshold was measured for each spatial frequency. All patients were tested under both mesopic and photopic conditions, and the results were expressed in log units of contrast sensitivity. Corneal aberrometry was recorded and analyzed with the CSO topography system, whose software automatically converts the corneal elevation profile into corneal wavefront data using Zernike polynomials with an expansion up to the seventh order. The corneal aberration coefficients and root mean square (RMS) values were calculated for a 6.0-mm pupil.

Endothelial cell density of donor corneas were assessed by a specular microscope before storage in Optisol medium. The endothelium was photographed and evaluated using a Topcon SP 2000p noncontact specular microscope (Topcon Corp, Tokyo, Japan). Images of the central corneal window were reviewed by the same observer (E S.), and manual correction of the cell borders was performed before final analysis of the endothelium. Twenty endothelial cells were marked for each analysis. For each examination, 3 measurements of endothelial cell density were averaged.

Data were described as mean ± standard deviation (range). SPSS statistics software package version 15.0 for Windows (SPSS, Chicago, Illinois, USA) was used for statistical analysis. Normality of all data samples was checked by means of Kolmogorov-Smirrnov test. When parametric analysis was possible, the Student *t* test for unpaired data was used for comparisons between PK and DALK groups. When parametric analysis was not possible, the Mann–Whitney *U* test was applied for between-group comparisons. A *P* value less than .05 was considered statistically significant.

RESULTS

A TOTAL OF 82 EYES OF 54 PATIENTS WITH MACULAR corneal dystrophy were included. An equal number of eyes (41 eyes) underwent DALK and PK surgery. No intraoperative complication occurred in the PK group. Conversion to PK was needed in 6 eyes (14.6%) in the DALK group because of macroperforation. Therefore, the data analysis included 41 eyes in the PK group and 35 eyes in the DALK group. Complete Descemet membrane exposure was achieved in 27 eyes (77.1%; desmetic DALK [dDALK]) via the big-bubble technique; however, layer-by-layer manual stromal dissection was needed in 8 eyes (22.8%; predesmetic DALK [pdDALK]). Table 1

TABLE 1. Comparative Table Showing the Preoperative Data of Patients Included in Deep Anterior Lamellar Keratoplasty and Penetrating Keratoplasty Groups of Eyes Analyzed in the Study

	DALK Group	PK Group	*P* Value
Age (y)			
Mean (SD)	29.7 (11.3)	33.0 (13.0)	.40
Median (range)	28.0 (16 to 61)	31.0 (17 to 67)	
Sex (male/female)	9/12	16/13	.61
UCVA (logMAR)			
Mean (SD)	1.34 (0.44)	1.40 (0.46)	.51
Median (range)	1.30 (0.69 to 3.00)	1.30 (0.69 to 3.00)	
BCVA (logMAR)			
Mean (SD)	1.30 (0.46)	1.36 (0.48)	.53
Median (range)	1.30 (0.69 to 3.00)	1.30 (0.69 to 3.00)	

BCVA = best-corrected visual acuity; DALK = deep anterior lamellar keratoplasty; logMAR = logarithm of the minimal angle of resolution; PK = penetrating keratoplasty; SD = standard deviation; UCVA = uncorrected visual acuity.

The corresponding *P* values for the comparison between groups are shown for each parameter evaluated.

TABLE 2. Comparative Table Showing the Postoperative Data Conditions of Patients Included in the Deep Anterior Lamellar Keratoplasty and Penetrating Keratoplasty Groups of Eyes Analyzed at the Last Visit of the Follow-up

	DALK Group	PK Group	*P* Value
UCVA (logMAR)			
Mean (SD)	0.62 (0.27)	0.47 (0.21)	.02
Median (range)	0.69 (0.15 to 1.60)	0.52 (0.00 to 1.00)	
BCVA (logMAR)			
Mean (SD)	0.35 (0.30)	0.23 (0.11)	.13
Median (range)	0.30 (0.09 to 1.60)	0.22 (0.09 to 0.40)	

BCVA = best-corrected distance visual acuity; DALK = deep anterior lamellar keratoplasty; logMAR = logarithm of the minimal angle of resolution; PK = penetrating keratoplasty; SD = standard deviation; UCVA = uncorrected visual acuity.

The corresponding *P* values for the comparison between groups are shown for each parameter evaluated.

summarizes the preoperative conditions in the 2 groups of eyes analyzed. As shown, no statistically significant differences were found between the 2 groups in terms of age, sex, or preoperative visual acuity.

The mean period between surgery and complete suture removal was 14.0 ± 3.4 months and 16.4 ± 3.8 months in DALK and PK groups, respectively ($P = .07$). Mean complete follow-up time was 30.5 ± 8.75 months and 31.2 ± 9.78 months in the DALK and PK groups, respectively ($P = .53$).

• **VISUAL OUTCOMES:** After surgery, UCVA and BCVA improved significantly in both groups ($P < .01$). Table 2 summarizes the comparative outcomes at the last visit. Logarithm of the minimal angle of resolution UCVA was significantly better in the PK group ($P = .02$).

At the last follow-up, UCVA was 20/40 or better in 11 eyes (31.4%) in the DALK group and in 14 eyes (34.1%) in the PK group ($P > .05$). Best-corrected visual acuity was 20/40 or better in 24 eyes (68.5%) in the DALK group and in 29 eyes (70.7%) in the PK group ($P > .05$). Uncorrected visual acuity was significantly better in the dDALK group than in the pdDALK group ($P = .04$). Although not significant, BCVA also was better in dDALK group (Table 3).

• **CONTRAST SENSITIVITY OUTCOMES:** Figure 1 shows the mean contrast sensitivity function under mesopic conditions measured with and without a glare source. As shown, no statistically significant differences between groups were found in contrast sensitivity measured without glare for any spatial frequency (3 cycles/degree, $P = .39$; 6 cycles/degree, $P = .77$; 12 cycles/degree, $P = .72$; and 18 cycles/degree, $P = .94$). The same trend was observed for contrast sensitivity measured with glare (3 cycles/degree, $P = .48$; 6 cycles/degree, $P = .60$; 12 cycles/degree, $P = .88$; and 18 cycles/degree, $P = .80$). Comparing the subgroups, the mean contrast sensitivity function under photopic and mesopic conditions were not different between the dDALK and pdDALK groups for each of the spatial frequencies ($P > .05$).

• **CORNEAL ABERROMETRIC OUTCOMES:** Aberrometric analyses were obtained in 27 eyes (77.1%) in the DALK group and in 30 eyes (73.2%) in the PK group (Figure 2). Significantly higher levels of higher-order aberrations (HOAs), primary coma aberrations, spherical aberrations, and residual aberrations were found in the DALK group (HOA RMS, $P < .01$; coma aberration RMS, $P < .01$; spherical aberration RMS, $P < .01$; residual aberration RMS, $P = .03$). No significant differences between groups were detected in the total RMS ($P = .17$). Significant correlations between contrast sensitivity and HOA RMS were observed only in the DALK group (no glare: 3 cycles/degree, $r = -0.48$, $P = .02$; 6 cycles/degree: $r = -0.43$, $P = .04$; 12 cycles/degree, $r = 0.46$ and $P = .03$; 18 cycles/degree, $r = -0.40$, $P = .05$; glare: 3 cycles/degree, $r = -0.41$, $P = .05$; 6 cycles/degree, $r = -0.47$, $P = .02$; 12 cycles/degree, $r = -0.44$, $P = .04$; 18 cycles/degree, $r = -0.44$, $P = .04$). We could not make a comparison between the dDALK and pdDALK groups because only 1 pdDALK patient had corneal aberrometric analysis.

• **CORNEAL ENDOTHELIAL DENSITY CHANGES:** Figure 3 shows the endothelial cell density during the postoperative follow-up. Before surgery, endothelial cell density was

TABLE 3. Comparative Table Showing the Postoperative Visual Outcomes of Patients Included in the Predesmetic Deep Anterior Lamellar Keratoplasty and Desmetic Deep Anterior Lamellar Keratoplasty Groups of Eyes Analyzed at the Last Visit of the Follow-up

	pdDALK (n = 8)	dDALK (n = 27)	*P* Value (Mann–Whitney *U* Test)
UCVA (logMAR)			
Mean (SD)	0.72 (0.39)	0.58 (0.21)	.04
Median (range)	(0.52 to 1.60)	0.52 (0.15 to 1.00)	
BCVA (logMAR)			
Mean (SD)	0.44 (0.12)	0.32 (0.30)	.05
Median (range)	(0.15 to 1.60)	0.22 (0.09 to 0.40)	

BCVA = best-corrected distance visual acuity; dDALK = desmetic deep anterior lamellar keratoplasty; logMAR = logarithm of the minimal angle of resolution; pdDALK = predesmetic deep anterior lamellar keratoplasty; SD = standard deviation; UCVA = uncorrected distance visual acuity.

The corresponding *P* values for the comparison between groups are shown for each parameter evaluated.

measured in all donor corneas in the PK group; however, endothelial cell density was obtained in 27 eyes (65.8%) in the DALK group. The mean preoperative endothelial cell density was 2881 ± 449 cells/mm^2 and 2734 ± 549 cells/mm^2 in the DALK and PK groups, respectively ($P = .27$). In both groups, a progressive and statistically significant reduction in endothelial cell density was found during the follow-up ($P < .01$). Endothelial cell loss was 13.25 ± 11.21% at 6 months, 15.44 ± 12.31% at 12 months, 16.32 ± 14.76% at 24 months, and 18.12 ± 16.43% at the last follow-up in the DALK group. In the PK group, the mean endothelial cell loss was 12.17 ± 10.92%, 15.04 ± 13.21%, 22.12 ± 18.93%, and 26.98 ± 21.76% at 6 months, 12 months, 24 months, and the last visit, respectively. Significantly higher endothelial cell density loss was observed in the PK group compared with the DALK group at 24 months after surgery ($P = .03$) as well as at the last postoperative follow-up visit ($P < .01$). Comparing the subgroups, the mean endothelial cell losses were not different between the dDALK and pdDALK groups ($P > .05$).

• **COMPLICATIONS:** Microperforation occurred in 5 eyes (14.2%) in the DALK group, and a double anterior chamber was seen in 1 eye (2.8%) that resolved completely after an intracameral air injection. Stromal graft rejection episodes were seen in 3 eyes (8.5%) from the DALK group that were treated successfully and resolved with topical corticosteroids. In the PK group, endothelial graft rejection episodes were seen in 5 eyes (12.1%). Two of these cases (4.8%) resolved successfully with medical treatment, whereas regrafting was necessary in 3 eyes (7.3%), which was performed at 26, 33, and 35 months after the first graft. Furthermore, regrafting was performed in 1 eye (2.8%) in the DALK group at 28 months because of endothelial decompensation. In addition, 1 eye (2.4%) underwent resuturing in the PK group because of the traumatic graft dehiscence. Recurrence of the disease was documented in 2 eyes (5.7%) from the DALK group and also in 2 eyes (4.8%) from the PK group. Complications are documented in Table 4.

DISCUSSION

ALTHOUGH SUCCESSFUL OUTCOMES WITH DALK AND PK procedures have been reported previously, histologic analysis of corneal deposits make lamellar surgery questionable because of possible involvement of posterior corneal tissues.[1,4,10,12] The Descemet membrane-baring techniques such as the Anwar big-bubble technique provide comparable visual results with or even better than PK as confirmed in a case-control study.[11,13] This suggests that the visual outcomes of PK remain superior to those of DALK unless baring of the Descemet membrane is complete. Tan and associates also reported that techniques such as the Anwar big-bubble technique yielded visual results that were equivalent or superior to those of PK.[13] Regarding macular corneal dystrophy, in which the use of lamellar keratoplasty is a cause of concern, no appropriate comparison between DALK and PK has been carried out to this date. In this prospective and randomized clinical study, we compared visual and optical quality, effect on corneal endothelium, and surgical complications of big-bubble DALK and PK for macular corneal dystrophy.

After surgery, UCVA and BCVA improved significantly in both groups. This is consistent with the results of previous studies. Vajpayee and associates performed big-bubble DALK in 5 cases of macular corneal dystrophy, and BCVA improved in all cases.[14] Another DALK study with stromal dystrophies reported a postoperative BCVA of 20/40 or better in 75.4% of the eyes.[15] In the present study, BCVA was 20/40 or better in 68.5% and 70.7% of the eyes in the DALK and PK groups, respectively. This visual outcome was found in 55% of eyes from a large series of macular corneal dystrophy cases treated with PK.[16] Patel and associates compared DALK and PK performed in the

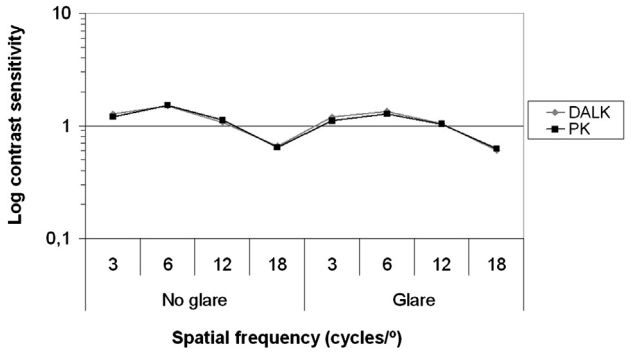

FIGURE 1. Graph showing the mean contrast sensitivity function under mesopic conditions measured with and without a glare source at the last visit of the follow-up for the 2 the groups analyzed in the study: deep anterior lamellar keratoplasty (DALK; grey line) and penetrating keratoplasty (PK; black line).

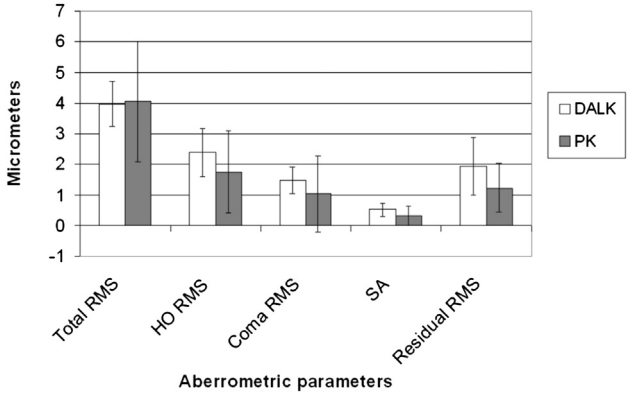

FIGURE 2. Bar graph showing the mean values and standard deviations of the ocular aberrometric parameters measured with the Zywave system in the 2 groups analyzed in the current study: penetrating keratoplasty (PK; grey bars) and deep anterior lamellar keratoplasty (DALK; white bars). The following parameters were obatined with the aberrometer and were analyzed for a 5-mm pupil: total root mean square (total RMS), higher-order root mean square (HOA RMS), coma root mean square (Coma RMS), primary spherical aberration (SA), and residual root mean square (RMS).

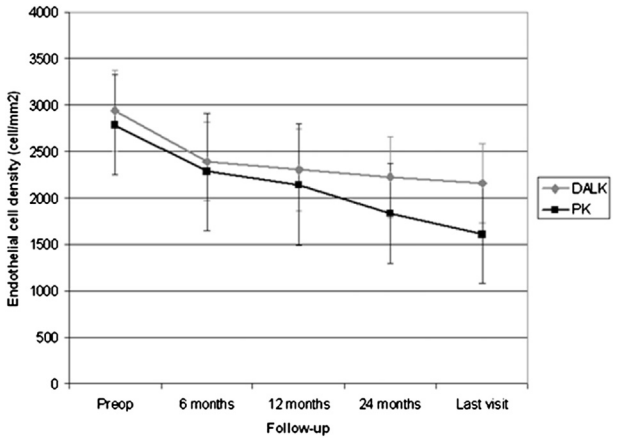

FIGURE 3. Graph showing changes in corneal endothelial cell density during the follow-up in the 2 groups analyzed in the study: deep anterior lamellar keratoplasty (DALK; grey line), and penetrating keratoplasty (PK; black line).

right and left eye, respectively, of a subject with macular corneal dystrophy.[10] These authors achieved an acceptable bed clarity with the big-bubble technique, and controversially obtained better visual outcomes with it compared with PK in the other eye. In the current study, we also performed subgroup analyses between dDALK and pdDALK groups and we observed superior visual outcomes with dDALK patients. It seems to be related to interface problems, which is of critical importance in achieving comparable visual outcomes to PK after DALK surgery. Interface haze may interfere with BCVA and contrast sensitivity because of increase in HOAs and scattering, leading to a decrease in visual quality. Interface irregularity was seen in 11.4% of the eyes in our DALK patients and all of them in pdDALK group. This rate was higher than that reported for keratoconus, whereas it was comparable with those reported for stromal corneal dystrophies and corneal scars undergoing DALK surgery with the big-bubble technique.[6,9,14] Therefore, corneal surgeons must keep in mind that DALK surgery using layer-by-layer manual dissection may result in poorer visual outcomes than Descemet membrane-baring techniques in macular corneal dystrophy patients; however, larger series are needed to evaluate this further.

Despite minimal spherocylindrical errors and excellent uncorrected distance visual acuity after surgery, many patients were disappointed with their vision, leading us to believe that visual acuity measurements were not predictive of visual performance in our series. For this reason, we investigated contrast sensitivity function and corneal HOA outcomes in each group to obtain more information for comparing the postoperative visual performance after both keratoplasty techniques. No significant differences between DALK and PK groups were obtained in mesopic contrast sensitivity for any of the spatial frequencies evaluated. This finding is consistent with those obtained in other studies comparing the contrast sensitivity function after PK and DALK for the management of other corneal conditions.[17–19] However, the results of this series contrast with those of a previous study from our research group comparing contrast sensitivity outcomes after DALK and PK in keratoconus eyes, in which a significantly better contrast sensitivity value was obtained after DALK for a spatial frequency of 3 cycles/degree.[20] This finding was suggested to be in relation to the potentially smoother interface in the periphery of DALK patients.[20] The absence

TABLE 4. Complications after Deep Anterior Lamellar Keratoplasty and Penetrating Keratoplasty in Macular Corneal Dystrophy

Complications	DALK (n/%)	PK (n/%)
Microperforation	5 (10.7)	0
Conversion to PK	6 (14.6)	0
Double anterior chamber	1 (2.8)	0
Interface irregularity	4 (11.4)	0
Elevation of IOP	1 (2.8)	2 (4.8)
Stromal graft rejection	4 (11.4)	0
Endothelial graft rejection	0	5 (12.1)
Recurrence of the disease	2 (8.5)	2 (4.8)
Secondary surgeries		
Phacoemulsification	1 (2.8)	1 (2.4)
Trabeculectomy	0	1 (2.4)
Regrafting	1 (2.8)	3 (7.3)
Resuturing because of traumatic wound dehiscence	0	1 (2.4)

DALK = deep anterior lamellar keratoplasty; IOP = intraocular pressure; PK = penetrating keratoplasty.

of statistical significance in the difference between our DALK and PK groups may have been influenced by the limited sample size or the higher variability in the contrast sensitivity outcomes observed in the DALK group. In contrast to the contrast sensitivity outcomes of the current series, significant differences were observed in corneal HOAs between PK and DALK groups. Specifically, HOA, primary coma aberration, and residual aberration RMS as well as the coefficient corresponding to the primary spherical aberration were significantly higher in the DALK group. This suggests that the air–cornea interface, which is the first and most important refractive medium and constitutes most of the total refractive power of the eye, is more aberrated after surgery in eyes with macular corneal dystrophy undergoing DALK surgery compared with those undergoing PK. According to this, contrast sensitivity outcomes also should have been poorer in the DALK group, but this was not the case. One explanation for this may be the relevant contribution of the posterior corneal surface in these cases. Indeed, Yamaguchi and associates found in a comparative study of anterior and posterior corneal aberrations after PK and DALK that posterior surfaces compensated significantly for anterior aberrations.[21] In any case, significant inverse correlations between HOA RMS and mesopic contrast sensitivity were found only in our DALK group, which confirms that this group of patients was more susceptible to having contrast sensitivity affected by corneal aberrations, especially in those cases with postoperative levels of HOA.

Long-term survival of graft tissue has been linked strongly to a sufficiently high endothelial cell density. Studies have shown that PK leads to a precipitated rate of endothelial cell loss and a chronic loss in the endothelial cells that has been found to contribute to graft failure in a portion of PK procedures.[22] The median endothelial cell density loss per year after PK was shown to be between 12% and 17%.[23,24] However in DALK, the host Descemet membrane and endothelium are intact while only the anterior cornea is replaced, and this results in less damage to the endothelium with fewer immunologic reactions and a subsequent high endothelial cell density rate after surgery. A recent study found a 5-year postoperative endothelial cell density loss of 22.3% after DALK and of 50.1% after PK in eyes with different corneal pathologic features.[25] In a similar study, Shimazaki and associates prospectively compared DALK and PK over a 2-year period and demonstrated an accelerated decrease of endothelial cell density in the PK group.[19] In the current study with macular corneal dystrophy, mean endothelial cell loss was calculated as 13.2% at 6 months, 15.4% at 12 months, 16.3% at 24 months, and 18.1% at the last follow-up visit in the DALK group. In the PK group, the percentages were 12.1%, 15.0%, 22.1%, and 26.9% for the respective postoperative visits. It seems that cell loss after DALK surgery was prominent at 12 months and continues to increase slowly during the follow-up, but this rate was significantly lower than that for PK grafts at 24 months and at the last follow-up visit. It should be noted that we performed DALK for macular corneal dystrophy excluding endothelial opacity in our study. Endothelial decompensation needing regraft surgery developed in only 1 eye (2.8%) in our DALK group. Similarly, Kawashima and associates reported that 2 of 10 eyes with macular corneal dystrophy demonstrated endothelial decompensation after anterior lamellar surgery.[4] Despite progressive endothelial cell loss noted in our DALK group, this rate was significantly lower than that of PK group. However, the risk of endothelial decompensation should be kept in mind when evaluating a patient with macular corneal dystrophy before surgery. The use of optical coherence tomography to determine a lack of endothelial involvement may be more informative for surgeons.

Today, the success of corneal transplantation is still dependent to a large extent on corneal graft rejection. In a large case series of patients who underwent PK surgery for macular corneal dystrophy, Al-Swailem and associates demonstrated that endothelial rejection episodes occurred in 20.5% of eyes, with irreversible endothelial failure in 3.5% of them.[16] Furthermore, 40% of the unsuccessful corneal transplantations in this series were the result of irreversible endothelial rejection episodes. In accordance with these results, because of graft failure after endothelial rejection, regrafting surgery was needed in 3 of the 5 eyes (7.3%) from our PK group. Although DALK surgery minimizes the risk of endothelial rejection, the risk of subepithelial and stromal graft rejection remains.[4,9,12–15]

Stromal dystrophies are known to recur with in the donor material and are expected for both the DALK and PK procedure. Although the recurrence of macular corneal dystrophy

in patients who underwent PK has been reported to be up to 50% in a larger follow-up period (18 years), no adequate comparable results for DALK exist yet.[26] Unal and associates recently documented a 2.3% recurrence rate after big-bubble DALK for macular corneal dystrophy.[15] In the present study, recurrence of the disease was documented in 2 eyes (5.7%) from the DALK group and in 2 eyes (4.8%) from the PK group after 30 months of follow-up. Previous studies have shown that the recurrence rate increased in direct proportion with the follow-up period and that there was a subsequent need for regrafting.[26,27] We believe that recurrence of stromal dystrophies would be comparatively easier to manage with lamellar keratoplasty.

In conclusion, DALK with the big-bubble technique is an alternative treatment option in eyes with macular corneal dystrophy, providing results comparable with those of PK. When selecting macular corneal dystrophy patients for DALK surgery, it is important to evaluate the possibility of endothelial decompensation after surgery. Deep anterior lamellar keratoplasty surgery eliminates the risk for endothelial rejection with subsequent graft failure, maintains structural integrity of the globe, and provides increased resistance against graft trauma dehiscence. Therefore, DALK surgery is a viable surgical option for macular corneal dystrophy patients with no accompanying endothelial involvement.

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Biosketch

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