Original Article

Deep anterior lamellar keratoplasty with a manual spatula: Anatomical and functional results

Mário Henrique Camargos de Lima, Alex Roque Rizzi, Rosângela Aparecida Simoceli, Fernando Betty Cresta, Milton Ruiz Alves

Objective: Evaluate the anatomical, refractive, and functional results of an innovative technique of deep anterior lamellar keratoplasty with a manual spatula. **Materials and Methods:** We evaluated the results and examinations of 16 eyes from 14 patients who underwent deep anterior lamellar keratoplasty using the technique described by Ferrara. Residual bed thickness after keratoplasty was evaluated postoperatively using Visante. The measurement was performed using a technique similar to that used to measure flap thickness after laser *in situ* keratomileusis refractive surgery. The measurements were performed at the center of the cornea in an area comprising the central 3-mm in the 45° and 135° meridians. **Results:** Best-corrected visual acuity was 0.34 ± 0.18 LogMar (0.09 to 0.60 LogMar), the spherical equivalent was -4.31 ± 3.38 D (+0.25 to -9.50 diopters), and keratometry was 45.75 ± 2.77 D (41.11 to 52.48 diopters) postoperatively. Corneal astigmatism was 3.19 ± 2.78 D (0.18 to 11.81 diopters). Residual stromal bed thickness measured by optical coherence tomography showed values of 67.1 ± 24.3 µm (30 to 109 µm). The statistical correlation by Spearman's test between the best-corrected visual acuity and the residual stromal bed thickness was 0.11 (P = 0.67). **Conclusion:** Deep anterior lamellar keratoplasty, in which manual dissection was performed using an instrument similar to that used to implant corneal rings, provided good visual and anatomical results.

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Deep anterior lamellar keratoplasty (DALK) is a technique for partial thickness corneal transplantation that preserves endothelial cells after removing all or part of the stroma, resulting in a less thick but uniform residual bed.[1]

The advantages of using this type of keratoplasty are numerous when compared to penetrating keratoplasty. First, it is conducted on a closed eye, which decreases the risk of complications such as the formation of synechiae, glaucoma, and endophthalmitis.[1,2] DALK may also have increased tectonic strength and superior resistance to rupture of the globe after blunt trauma.[3,4]

Moreover, maintenance of the recipient endothelial cells eliminates complications related to endothelial rejection, which is a major cause of penetrating keratoplasty failure.[5] Corticosteroids have an important role in avoid stromal rejection in these patients. Nevertheless, some studies suggest that there is no need to use prolonged immunosuppressive therapy, particularly corticosteroids, which minimizes the risk of cataract, glaucoma, and postoperative infection.[1,5]

The literature shows similar visual acuity results for DALK compared with penetrating keratoplasty.[6-8]

The use of the big bubble technique has improved the outcome of DALK with respect to residual thickness of the stroma;[1,2] however, there is no consensus on the visual function achieved in eyes in which variable thickness of the posterior stroma is preserved.[9,10]

A steep learning curve is associated with the DALK procedure. The most common intraoperative complication is perforation of Descemet's membrane, which requires conversion to penetrating keratoplasty. To avoid this complication, surgeons seek to carry out techniques that preserve the minimum thickness of the posterior stroma.[11-13] The use of a manual dissection technique for deep stroma with an instrument developed by Ferrara to implant corneal rings requires a shallower learning curve and offers greater regularity of the residual stroma.[14]

This study evaluated the anatomical and functional results of DALK performed using a manual tunneler and correlated the residual stromal bed thickness results with those of best-corrected visual acuity (BCVA).

Materials and Methods

We studied a series of cases with intervention to evaluate the anatomical and functional results of 16 eyes from 14 patients who underwent DALK using the manual dissection technique and the instrument developed by Ferrara.[14] This study was approved by the Ethics Committee of the Faculty of Medicine, University of São Paulo, São Paulo, SP, Brazil.

Patients included in the study were diagnosed with keratoconus, defined by the presence of at least one of the following criteria: Slit lamp changes (Vogt striae or Fleischer ring), central power > 48.7 D, and the difference between corneal power in the lower and upper cornea in the area of 3-mm (IS) >1.9 D. The patients were 21-41 years of age with

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BCVA (glasses or contact lenses) ≤20/80 (0.60 LogMar) and with no deep corneal scarring or previous hydrops episodes. We excluded patients with other ocular co-morbidities such as cataract, glaucoma, retinal disease, high myopia, amblyopia, or previous ocular surgery.

All surgeries were performed by one surgeon (RA Simoceli) under peribulbar anesthesia and sedation. The surgical technique shared some steps with intrastromal corneal ring implantation. A corneal incision was made at 12 pm with a diamond knife at a 90% depth in the 8-mm optical zone [Fig. 1]. Ultrasonic pachymetry was performed intraoperatively in the 90° axis to calculate the depth of the incision [Fig. 1]. The incision was enlarged with a blunt instrument [Fig. 2], and a manual spatula was inserted to make a tunnel similar to that made for intrastromal corneal ring implantation [Fig. 2]. The spatula was equipped with a 6-0 nylon thread at its end and was inserted into the tunnel [Fig. 3]. After tunneling, the spatula was removed and the nylon thread was pulled from both sides of the radial incision to obtain a deep dissection of the corneal stroma leaving the least possible residual stroma [Fig. 4]. Trephine and scissors were used to remove the corneal flap and to regularize the bed for suturing. The size of excised corneal button has the same size of the spatula, 8 mm in all eyes. The donor cornea button was trepanned, 0, 5-mm larger than the recipient site, and without removing Descemet's membrane and the endothelium, was sutured with 16 equidistant nylon 10-0 sutures [Fig. 5].

Results were obtained by ophthalmologic examination performed on all 14 patients (16 eyes) at 6-8 months postoperatively when the sutures had been removed. For each participant, we recorded measurement values of BCVA in LogMar, refractive error expressed by the spherical equivalent, spherical diopters of the central corneal curvature using the Eye Sys topographer, and thickness of the residual bed measured with optical coherence tomography (OCT) of the anterior segment (Visante, Carl Zeiss Meditec, Dublin, CA, USA) using standard procedures similar to those validated for measurement of flap thickness after LASIK refractive surgery.[15] Measurements of the residual thickness of the stroma were performed in the center of the cornea in a zone comprising the central 3-mm of the 45th meridian (including the 225th) and the

Figure 1: A corneal incision was made at 12 pm with a diamond knife at a 90% depth in the 8-mm optical zone

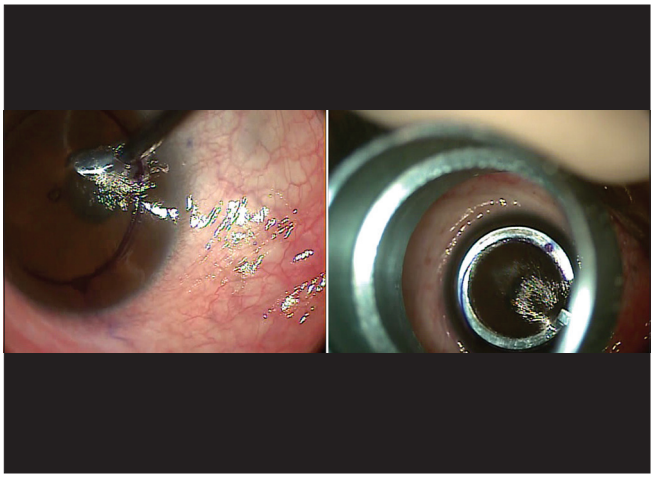

Figure 2: The incision was enlarged with a blunt instrument, and a manual spatula was inserted to make a tunnel similar to that made for intrastromal corneal ring implantation

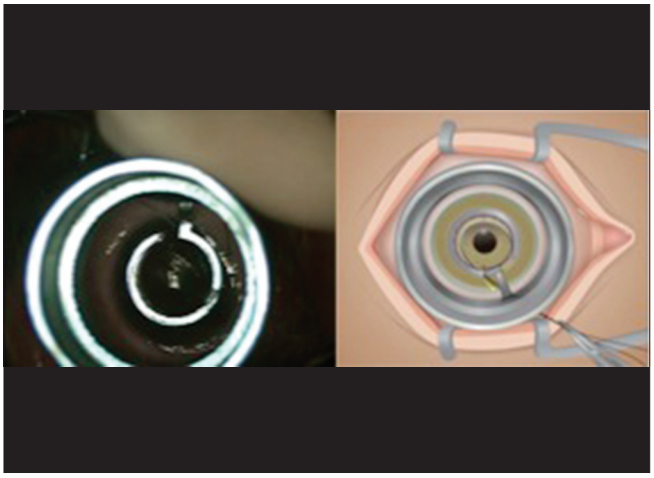

Figure 3: A manual spatula was inserted to make a tunnel similar to that made for intrastromal corneal ring implantation. The spatula was equipped with a 6-0 nylon thread at its end and was inserted into the tunnel

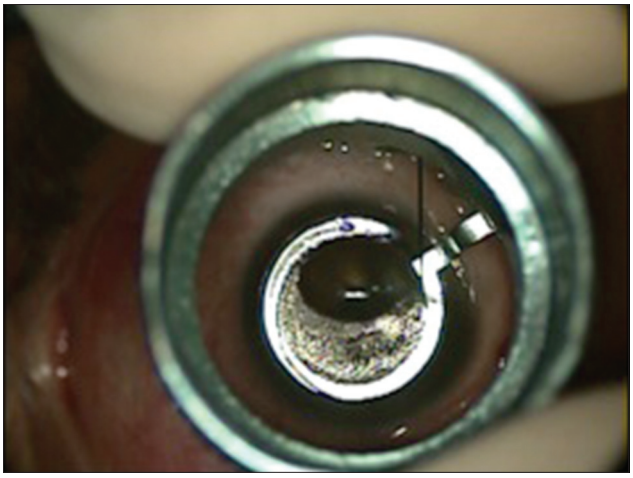

Figure 4: After tunneling, the spatula was removed and the nylon thread was pulled from both sides of the radial incision to obtain a deep dissection of the corneal stroma leaving the least possible residual stroma

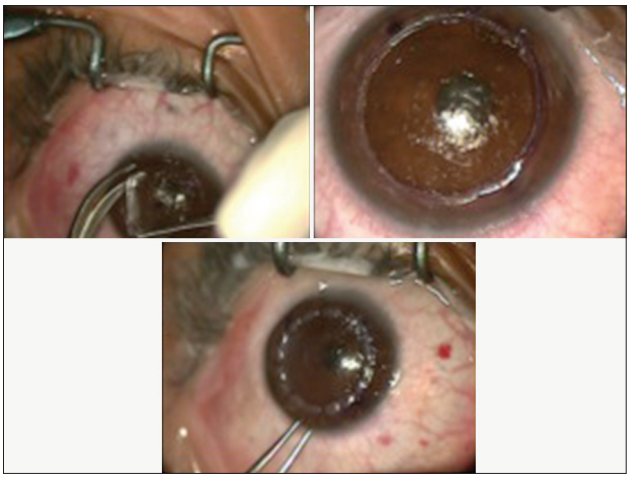

Figure 5: Trephine and scissors were used to remove the corneal flap and to regularize the bed for suturing. The donor cornea button was trepanned, 0, 5-mm larger than the recipient site, and without removing Descemet's membrane and the endothelium, was sutured with 16 nylon 10-0 equidistant sutures

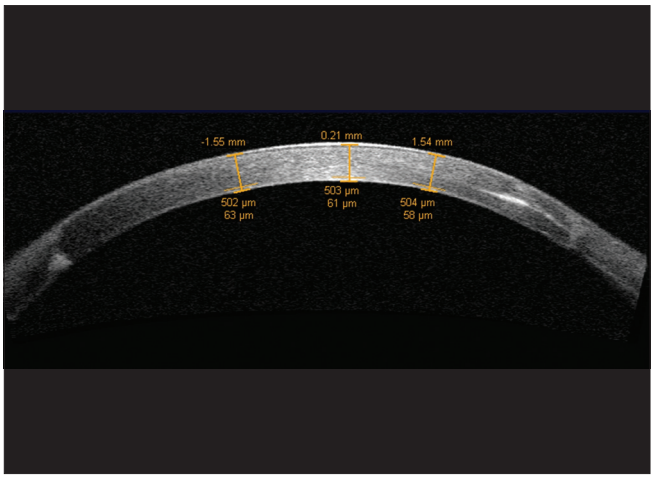

Figure 6: The measurement was performed using a technique similar to that used to measure flap thickness after laser in situ keratomileusis refractive surgery. The measurements were performed at the center of the cornea in an area comprising the central 3-mm in the 45° and 135° meridians

135th meridian (including the 315th). A total of 10 measurements were made (five in each meridian), and the results were expressed as the mean of the measurements in microns [Fig 6].

We used SPSS ver. 17.0 for statistical analysis (SSPSS Inc., Chicago, IL, USA). Quantitative data are presented as means and standard deviation. We evaluated the correlation between the quantitative variables (thickness of the stroma and residual better AVCC) by calculating Spearman's r coefficient and the *P* value. The significance level for the tests was 5%.

Results

We had a predominance of male patients (78.5%) compared to females (21.5%). The preoperative BCVA was 1.21 ± 0.44 (0.18-2.1) LogMar. No micro or macro perforations occurred during the surgeries.

Mean values, standard deviations, and variations in BCVA were 0.34 ± 0.18 LogMar (LogMar 0.09 to 0.60), spherical equivalent of the refractive error -4.31± -3.38 D (+0 25 to -9.50 D), astigmatism 3.19 ± 2.78 D (0.18 to 11.81 D). The keratometry was 45.75 ± 2.77 D (41.11 to 52.48 diopters) postoperatively. The thickness of the residual central stroma showed values of 67.1 ± 24.3 µm [Table 1]. The thinnest total thickness measured by Visante in the 0-2 mm zone was 534.25 ± 55 µm (407 to 608 µm). Residual stromal bed thickness was < 80 µm in 11 eyes (68.75%).

The correlation between the bed thickness of the central stroma and the BSCVA was 0.11 (Spearman's r, $P \geq 0.67$).

Table 1: The chart shows the patient's ages (years), best corrected visual acuity

Patients	Ago	BCVA	SE	Km	TRCS	CTT
1	41	0.30	0.25	44.17	112.00	541
2	32	0.18	−9.37	44.40	46.75	445
3	30	0.18	2.12	45.38	85.75	568
4	21	0.30	−0.50	43.02	93.50	482
5	39	0.60	9.50	44.91	112.00	407
6	39	0.60	−8.00	43.33	96.25	608
7	37	0.60	8.87	48.03	29.60	541
8	24	0.48	−1.62	47.54	58.00	493
9	34	0.60	3.50	45.85	63.00	516
10	14	0.10	−1.50	42.58	61.00	562
11	22	0.0	−4.12	45.70	75.60	523
12	18	0.18	−1.75	52.48	51.25	571
13	28	0.39	−3.50	47.80	70.75	564
14	24	0.18	−8.50	41.11	76.00	601
15	40	0.30	−7.25	47.21	30.20	536
16	36	0.09	−1.25	48.10	73.75	590

BCVA (LogMar), spherical equivalent of the refractive error SE (diopters), mean keratometry Km (diopters), thickness of the residual central stroma TRCS (µm), and total thickness average in the central córnea CTT (µm), BCVA: Best-corrected visual acuity, TRCS: Thickness of the residual central stroma, SE: spherical equivalent of the refractive error, CTT: Total thickness average in the central córnea

Discussion

DALK presents many advantages over penetrating keratoplasty (*e.g.* preservation of corneal endothelial cells with decreased rates of rejection) possibility due to the low corneal endothelial cell counts and closed-eye surgery, which reduces perioperative complications.[16,17] The main disadvantage is that the learning curve is longer.[18]

No micro or macro-perforations were observed in the present study. The Descemet's perforation is a complication that occurs in ISCR implantation, especially during the incision with the diamond knife. Nevertheless, this small Descemet's perforation does not require the conversion to PK, and the technique can be performed without major problems.

Bahar *et al*. 13 compared the results of 17 patients who underwent DALK with 27 patients who underwent penetrating keratoplasty and did not obtain a significant difference in BCVA. They reported that the average BCVA was 20/40 for DALK and 20/30 for penetrating keratoplasty during the first 12 months. Despite these differences not being significant, most studies show a slight trend toward better vision following penetrating keratoplasty compared to DALK.[8,19]

The Anwar and Melles techniques of DALK have comparable visual acuity and refractive outcomes.[20] The BCVA values obtained were considered good, as 12 eyes (75%) obtained a BCVA ≥ 0.5 logMAR (20/63), which is considered acceptable even after penetrating keratoplasty.[1,7,8] Our technique showed comparable CDVA with Anwar and Melles techniques. Further controlled studies comparing the techniques are necessary to clarify the difference between them.

The postoperative values of the spherical equivalent of the refractive error and topographic astigmatism in the present study were considered acceptable when compared with postoperative values for penetrating keratoplasty.[7,8]

Deep stromal dissection performed using a wire facilitated removal of the posterior stromal tissue, which was corroborated by the finding that the residual stromal beds in 11 eyes (68.75%) were ≤80 μm. The wire dissection provided a regular stromal bed, and the thickness measures showed a slight tendency to be thicker in the periphery. Nonetheless, the central bed thickness measures were lower than 80 μm, providing a good visual result. Ardjomand *et al*. evaluated the residual stromal bed after lamellar keratoplasty in 14 patients and found that most patients with values < 80 μm achieved acceptable vision postoperatively.[21]

Despite the procedure does not create a bare Descemet's membrane, the interface haze was not an issue in any evaluated case. The amount of residual bed thickness (67.1 ± 24.3 μm) provided a BCVA similar to other techniques. The regularity of the stromal bed thickness produced by the nylon thread traction may explain that result.

We found no correlation between postsurgical BCVA and the thickness of the residual stromal bed ($P \geq 0.67$). This finding may be explained by other variables, such as keratometry, final spherical equivalent, and irregular astigmatism, which may have influenced postoperative BCVA.

Conclusion

DALK using the manual tunneling technique provided good visual and anatomical results. DALK using this technique can be considered an alternative procedure due to its simplicity and low incidence of complications.

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