

Ferrara Technique of Deep Anterior Lamellar Keratoplasty for Keratoconus Treatment

Paulo Ferrara, Guilherme Ferrara, Leonardo Torquetti

ABSTRACT

Purpose: To report the first clinical results of application Ferrara's technique of deep anterior lamellar keratoplasty (FDALK) in patients with keratoconus.

Materials and methods: Thirty-four eyes of 34 patients with advanced keratoconus were included in the study. All patients were operated by the FDALK technique. Preoperative and postoperative uncorrected distance visual acuity (UDVA), corrected distance visual acuity (CDVA), corneal topography and corneal astigmatism were evaluated. Intra- and postoperative complications are described.

Results: Uncorrected visual acuity improved in from 20/400 to 20/125; corrected visual acuity improved from 20/300 to 20/48. The mean follow-up was 19.3 months (sd: 7.1). Corneal topography (Pentacam®) showed significant corneal flattening in all cases. Microperforations of the Descemet's membrane, requiring conversion to penetrating keratoplasty, occurred in two cases.

Conclusion: The FDALK technique is a safe and effective technique to be applied in patients with keratoconus. Visual outcome is comparable to PK, with advantage of preserving recipient endothelium, which lessens the risk of endothelium rejection.

Keywords: DALK, Keratoconus, Keratoplasty.

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INTRODUCTION

Deep anterior lamellar keratoplasty replaces almost all the corneal stroma but retains the endothelium.¹ Overall, it minimizes the risk for endothelial rejection, increases the life expectancy of the graft, and provides good visual results compared with PKP.²⁻⁵ Keratoconus patients are those who benefit most from a successful DALK procedure, once the endothelium of these patients can be preserved.

Several studies comparing visual outcomes between penetrating keratoplasty (PK) and DALK have shown similar results. Initially, DALK was performed using manual corneal dissection.⁵ The greatest limitation of early DALK techniques was that they left variable amounts of residual stroma. This provided a scaffold for vascular ingrowth or led to variable amounts of postoperative scarring in the

interface due to the remaining vessels. Also, the uneven or irregular dissection plane could impair visual acuity. The main disadvantage of DALK is the significant learning curve to master the technique. Moreover, it is time-consuming procedure, especially when the stroma has to be manually separated from the Descemet's membrane.

Anwar and Teichmann's⁶ big-bubble technique of injecting air into the corneal stroma to isolate Descemet membrane markedly improved DALK outcomes. Removing the overlying stroma completely created a clear graft interface without irregularities. Visual outcomes are excellent, and postoperative interface problems from vascularization of the recipient corneal bed are minimal.

In 2006, Ferrara⁷ has created a technique, which could allow a deep and smooth separation of corneal stroma from Descemet's membrane, by an interlamella cleavage plane created by a nylon wire. The technique has been described as Ferrara's technique of deep anterior lamellar keratoplasty (FDALK).

The present technique allows a deep and smooth separation of corneal stroma from Descemet's membrane, by an interlamella cleavage plane created by a nylon wire.

In this study we describe the FDALK technique and the clinical outcomes of patients with keratoconus operated by this technique.

MATERIALS AND METHODS

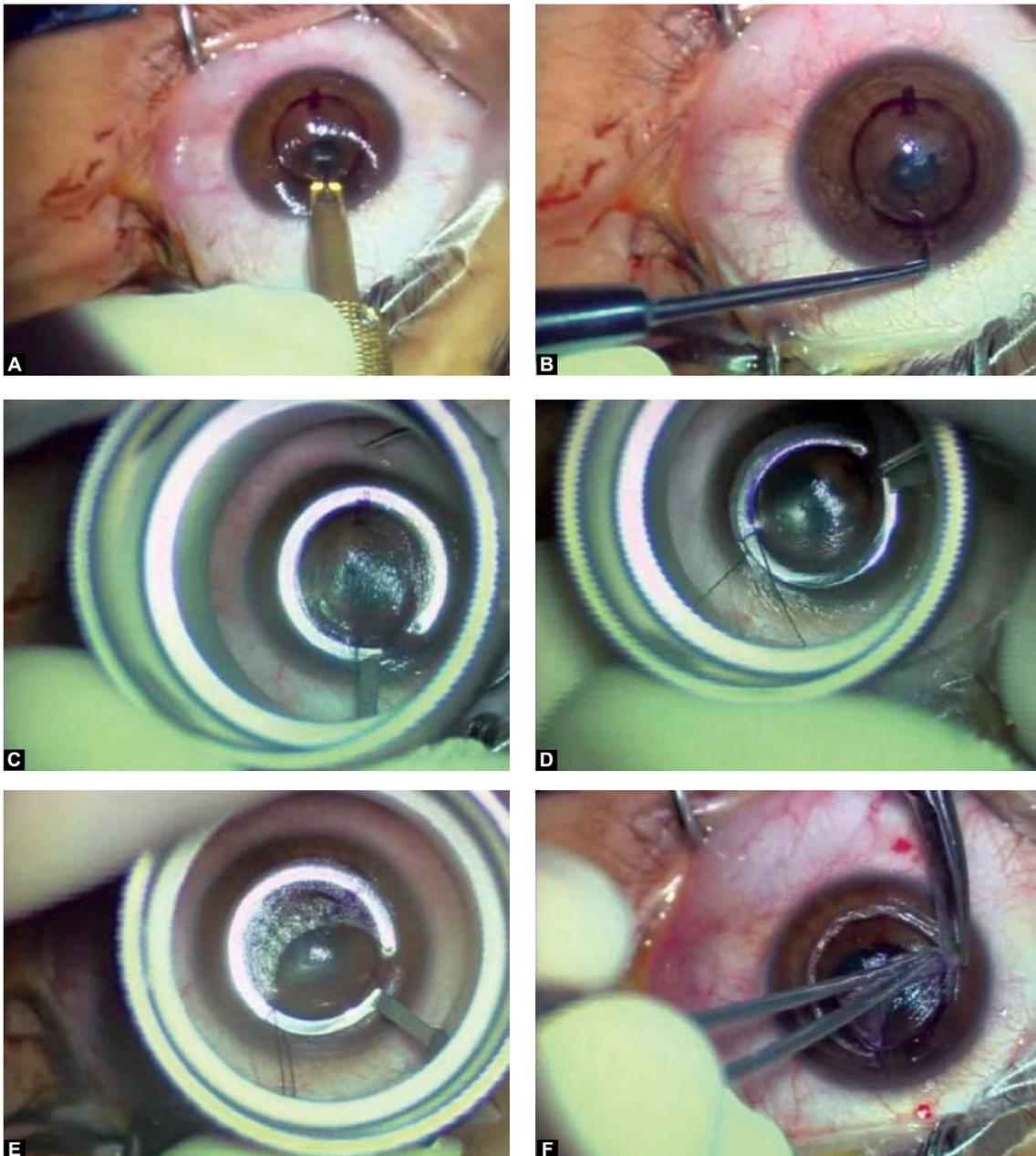
The study was approved by the Institutional Ethics Comitee, and informs consent was obtained of all participants. Thirty-four eyes of 34 patients with advanced keratoconus were included in a prospective clinical study that aimed to describe the technique and clinical outcomes of Ferrara's technique of DALK (FDALK). All patients had complete ophthalmic examination including biomicroscopy, Snellen uncorrected visual acuity (UDVA) and best corrected visual acuity (CDVA), funduscopy, tonometry, corneal topography (Pentacam, Oculus Inc, Lynnwood, USA)) and specular microscopy (Topcon SP-2000, Topcon Corp, Tokyo, Japan). Postoperative evaluation was performed at 1 day, 1 week, 1 month, 3 months and 6 months. All these parameters were evaluated in the pre- and postoperative period. For statistical analysis the paired Students t-test was used, by the Minitab software (2007, Minitab Inc.).

SURGICAL TECHNIQUE

The surgical procedure has been described.⁷ The surgery shares some steps of Ferrara intrastromal ring segments implantation. Initially, using a diamond knife, set at 90% of corneal thickness at 90° meridian, at 8 mm optic zone (Fig. 1A), a 0.9 mm radial incision was formed and corneal pockets were created using the Ferrara spreader (Fig. 1B). A 6.0 nylon preloaded spatula was then inserted into the corneal pocket and in a counterclockwise direction rotated in 360° to create a deep stromal tunnel (Figs 1C and D). A partial-thickness 8.0 mm trephination was formed. After

the tunnelization the spatula was removed from the tunnel and the nylon wire was pulled from both sides of the radial incision to dissect deep to corneal stroma leaving only the Descemet's membrane (Fig. 1E). The trephine was used to cut until it touches the spatula beneath the corneal stromal tunnel. Blunt-tipped Vannas scissors are used to remove anterior stromal tissue along the edge of partial thickness trephination (Fig. 1F).

The donor cornea was punched out from the endothelial side, oversized by 0.5 mm, comparing to recipient trephination. The donor button is sutured into place using a continuous or 16 interrupted 10-0 nylon sutures.



Figs 1A to F: (A) Radial incision, (B) corneal pockets are created using the Ferrara spreader, (C and D) a 6.0 nylon preloaded spatula is inserted into the corneal pocket and in a counterclockwise direction rotated in 360° to create a deep stromal tunnel, (E) after the tunnelization, the spatula was removed from the tunnel and the nylon wire was pulled from both sides of the radial incision to dissect deep to corneal stroma leaving only the Descemet's membrane, (F) blunt-tipped Vannas scissors are used to remove anterior stromal tissue along the edge of partial thickness trephination

Postoperative medication included moxifloxacin and prednisolone four times a day for a week and tapered for a period of 6 weeks. Lubricants were prescribed to be used several times a day. The sutures were removed 3 months after the surgery (Fig. 2).

RESULTS

The mean follow-up period was 19.3 months (sd: 7.1 months). Average corneal pachymetry at the apex of the conus was 313 μ in the preoperative period and 493 μ

postoperatively (p = 0.000). Preoperative UDVA was 20/400 and CDVA was 20/300. The final UDVA was 20/125 and CDVA was 20/48.

Corneal topography (Pentacam®) showed significant corneal flattening in all eyes (Fig. 3). The K1 (average) decreased from 57.75 D to 44.45 D (p = 0.032), the K2 (average) decreased from 65.99 D to 49.91 D (p = 0.002) and the Km (average) decreased from 61.49 D to 46.96 D (p = 0.001) (Graph 1).

Conversion to penetrating keratoplasty was needed in two patients due to inadvertent perforation of Descemet’s membrane.

DISCUSSION

The main advantages of DALK over PK are:

- Less risk of rejection⁸ – the lack of endothelial cells with the potential for immune rejection, theoretically could decrease the incidence of rejection, comparing with PK;
- Larger availability of tissue – as the endothelium is not used in the procedure many grafts that would be unsuitable for PK due to a poor endothelium, could be used for DALK. Thus, an elderly donor or a donor with unhealthy endothelium but healthy stroma can still be used effectively for full-bed DALK grafting.

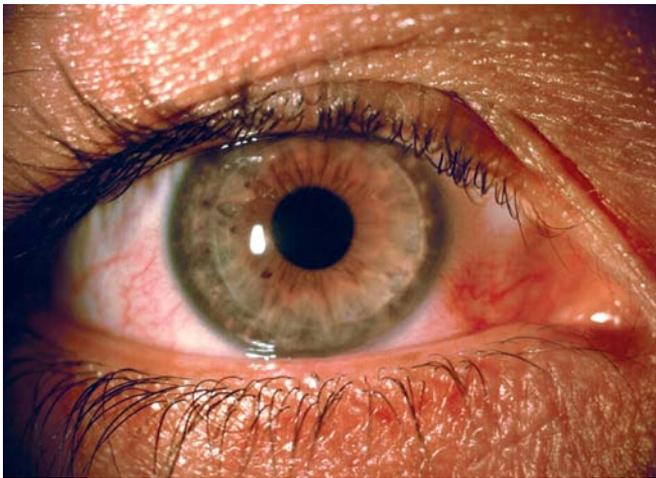


Fig. 2: Cornea after suture removal

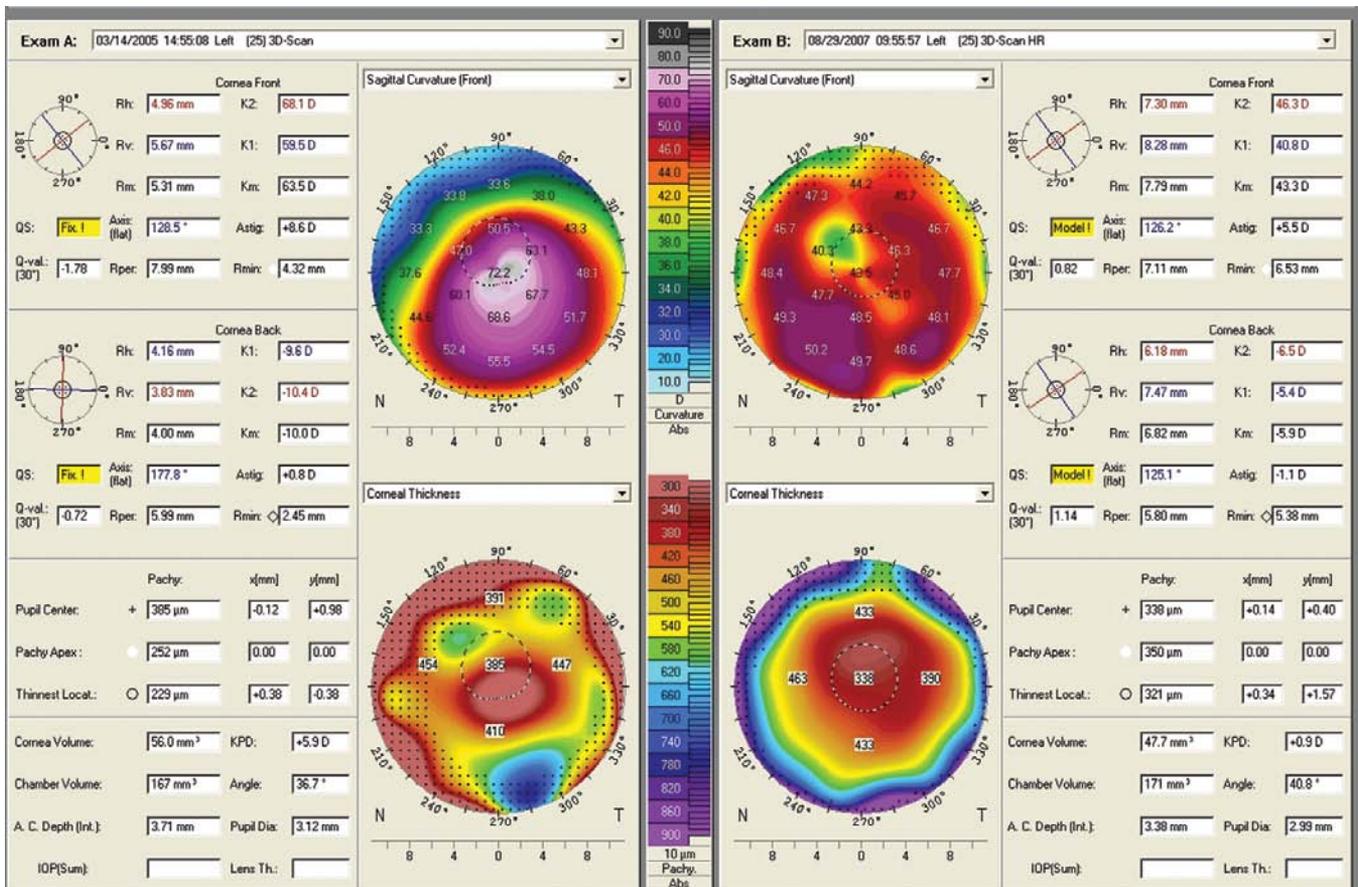
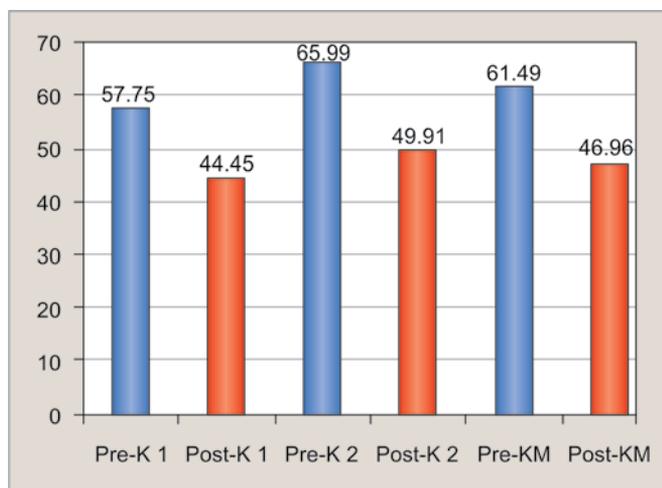


Fig. 3: Preoperative (left) and postoperative (right) Pentacam showing corneal flattening



Graph 1: Pre- and postoperative keratometry (D)

- Early suture removal and faster visual rehabilitation – the early suture removal provides a faster improvement of UDVA and CDVA;
- Preservation of the endothelium of the recipient;
- Anterior chamber remains untouched – there is significant less risk of intraocular complications, such as choroidal effusion, iris prolapse, positive vitreous pressure, endophthalmitis, cataract and glaucoma due to anterior synechia.⁸

Several techniques of lamellar keratoplasty have been described for keratoconus treatment. Anwar and Teichmann described the big-bubble technique to achieve separation of the Descemet's membrane from stroma after intrastromal air injection.⁶ This technique has been widely used as a technique which provides rapid and satisfactory outcome that is comparable to PK.⁵ The technique allows a safe and direct access to Descemet's plane, with the advantages of shortening the surgical time, reducing the risk for perforation, and exposing a smooth, even surface of excellent optical quality. However, a big bubble is not formed in all cases^{5,6,9} and sometimes more than one injection of air into the deep stroma is required before cleavage between Descemet's membrane and the stroma is achieved. In these cases, repeated injections of air infiltrating the corneal stroma may cause complete whitening of the central cornea within the area of trephination, making it difficult to recognize the line of separation between Descemet's membrane and the stroma.

Fontana et al¹⁰ and Ardjomand et al¹¹ stated that recipient stromal thickness was important in visual acuity and quality results. Ardjomand et al emphasized that DALK surgeries with a recipient tissue more than 80 μm resulted in reduction in photopic contrast sensitivity, even the results were not statistically significant. It seems that bare Descemet's membrane formation is important for the success of DALK

surgery with the results of these studies. In our study we did not measure the residual stroma, however, the 90% thickness incision and the nylon wire provides a smooth surface with a very small amount of residual stroma.

The increased safety of DALK and the potential for better visual outcomes in expertly performed procedures justifies the effort required for corneal surgeons to master the procedure and the additional operating room time. Another potential advantage is the utility of using tissue that is less optimal for PKP with lower endothelial cell counts or longer duration of death to preservation and time in preservation to expand the donor pool for optical keratoplasty.

Bahar et al¹² stated that DALK and PK which were done for keratoconus had similar results comparing visual acuity, refractive results and complications. In their study the median CDVA at 12 months was 20/40 in DALK group and 20/30 in PK group. Finally, they conclude that complications were comparable. In another study Kim et al¹³ noted that there was no significant difference between the DALK and PK groups in terms of postoperative UDVA, CDVA and astigmatism. Moreover, Cohen et al¹⁴ also found that treatment of keratoconus with PK or DALK had similar visual outcomes, graft survival and prevalence of sight threatening complications. Similar results of different studies caused that most of the ophthalmologists accepted DALK as an alternative to PK in treating keratoconus.⁴ Our visual acuity results were similar and compatible with these studies.

The Ferrara technique of DALK (FDALK) eliminates any potential difficulties in recognizing formation of the big bubble during the surgery, which used to be the main difficulty in the most widely used technique nowadays (big-bubble). Moreover, FDALK has a shorter learning curve for the surgeon, which is important, as it can be a reliable technique when compared to other DALK techniques or even the PK.

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