Deep Trephination Allows High Rates of Successful Pneumatic Dissection for DALK Independent of Surgical Experience

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Purpose: To evaluate the relationship between surgical experience and the success rate of pneumatic dissection for deep anterior lamellar keratoplasty (DALK) using deep trephination.

Methods: A noncomparative case series evaluating the first 10 consecutive keratoconic eyes without deep stromal scarring, operated by 8 surgeons of 3 different experience levels, was conducted; there were a total of 80 patients. Standardized DALK was performed, including deep trephination 450 to 550 μm in depth and 9 mm in diameter, pneumatic dissection, removal of the stroma, and transplantation of a 9-mm partial-thickness anterior lamellar graft. The success rate of pneumatic dissection correlated with surgical experience.

Results: Pneumatic dissection succeeded in 7, 7, 8, and 9 cases of 10 cases in the first group of 4 inexperienced surgeons (under 10 previous keratoplasties of any kind); in 9 and 10 of 10 cases in the second group of 2 relatively experienced surgeons (under 100 keratoplasties); and in 10 and 8 of 10 cases in the third group of 2 very experienced surgeons (more than 1000 previous keratoplasties). No difference between the groups was found to be statistically significant with the χ^2 test ($P > 0.05$).

Conclusions: The standardized DALK technique using a deep trephination allows high success rates of pneumatic dissection even for surgeons inexperienced in keratoplasty.

Key Words: learning curve, DALK, deep trephination

(*Cornea* 2019;38:645–647)

In 2017, 2541 deep anterior lamellar keratoplasty (DALK) procedures were performed worldwide, representing 3% of the corneal tissue placed for transplantation by Eye Bank Association of America member eye banks. Only 1027 DALK procedures were performed in the United States.[1] Unlike penetrating keratoplasty, or Descemet stripping automated endothelial keratoplasty, the DALK technique has not been standardized. This is particularly true with regard to the performance of dissection (pneumatic or other) used to separate Descemet membrane (or the predescemetic layer) from the overlying corneal stroma.

In a previous report, we have demonstrated that injection of air up to 2 mm inside a deep trephination (intended within 100 μm from the endothelial surface) obtained with a precalibrated, guarded trephine set by means of anterior segment optical coherence tomography (AS-OCT) allows a success rate of 80% in pneumatic dissection during DALK.[2]

The strength of this technique is that it is based on repeatable steps, each of which has objective, quantitative inputs. Specifically, the cannula is inserted at a set, predetermined depth rather than relying on the subjective feedback of cannula depth described in conventional techniques. Accordingly, we hypothesized that pneumatic dissection is achievable independently of surgical experience. To prove this, we performed statistical analysis comparing the success rate of pneumatic dissection among surgeons of differing levels of surgical experience.

PATIENTS AND METHODS

This was a retrospective multicenter study performed during 2016. The study followed the tenets of the 2013 Declaration of Helsinki and was approved by the local ethics committee of "Villa Igea" Hospital (Forlì, Italy) and at the University Hospital of "Magna Graecia," Catanzaro, Italy.

The medical records of the first 10 consecutive keratoconus patients without corneal stromal scarring,

Received for publication October 15, 2018; revision received December 10, 2018; accepted December 15, 2018. Published online ahead of print January 24, 2019.

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M. Busin has received (2006–2016) reimbursement of travel expenses and royalties from Moria (Antony, France). The remaining authors have no conflicts of interest to disclose.

Presented in part as a poster at the Annual Meeting of the American Academy of Ophthalmology; 11–14 November, 2017; New Orleans, LA.

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operated by 8 different surgeons, were noted for the success or failure of pneumatic dissection.

The surgeon groups included 1) 4 inexperienced surgeons, each of whom had performed less than 10 keratoplasties of any kind before learning DALK; 2) 2 relatively experienced surgeons who had completed up to 100 keratoplasties before learning DALK; and 3) 2 very experienced surgeons who had performed more than 1000 keratoplasties each. Surgeries were performed at "Villa Igea" Hospital (Forlì, Italy) and at the University Hospital of "Magna Graecia," Catanzaro, Italy, according to the technique described below.

Surgical Technique

The main steps are illustrated in Figure 1. Anesthesia and akinesia were obtained in all patients with a peribulbar injection of 7 to 10 mL ropivacaine (0.75%). A suction trephine (Moria, Antony, France) with a predeterminable measurable block of blade advancement was centered on the geometric center of the cornea. The trephination depth was set to aim for 100 μm short of the thinnest AS-OCT (Casia SS-1000; Tomey Corp, Nagoya, Japan) measured corneal thickness at the 9-mm zone. A small air bubble was injected into the anterior chamber via a temporal paracentesis. A blunt Fogla probe (Bausch & Lomb Storz Ophthalmics, Irvine, CA) was inserted at the base of the trephination and advanced 1 mm centripetally while maintaining the depth achieved with the trephination. The probe was then exchanged for a 27-gauge Fogla cannula (Bausch & Lomb Storz Ophthalmics, Irvine, CA), which was advanced along the same track created by the probe, 1 mm further into the cornea. Air was gently injected into the stroma until a bubble was obtained. After pneumatic dissection, the recipient cornea was debulked by anterior keratectomy to approximately 80% depth. A disposable handheld trephine was marked with ink and gently impressed on the central cornea to mark the central 6-mm optical zone. An adhesive viscoelastic substance was placed on the central cornea, and a 15-degree blade was used to open the bubble. Blunt Vannas scissors were used to enlarge the slit, and then, excision of the deep corneal stroma was completed using corneal scissors. The donor cornea was mounted on the anterior chamber of the automated anterior lamellar therapeutic keratoplasty system (Moria, Antony, France) and dissected by means of a 400-μm microkeratome head. The resulting anterior lamella graft was punched to 9 mm diameter and sutured into the recipient corneal bed using a double running 10-0 nylon suture. As previously described,[2] the final corneal architecture comprised a peripheral crown of approximately 1.5 mm width because of the overlap of the donor lamella on the residual deep stroma, with a central 6-mm optical zone slightly thinner than the normal cornea where the donor was laid on the bare predescemetic layer. Figure 2 illustrates how the "step" in the transition between the 9-mm outer zone with the overlapping stroma and the central 6-mm area disappears with time, with normalization of the posterior corneal contour within the first year.

Statistical Analysis

All data collected in the study were entered into an electronic database via Microsoft Excel 2007 (Microsoft Corp, Redmond, WA). Statistical analyses were performed using SPSS Statistics Version 20 (IBM, Armonk, NY). The χ^2 test was used to determine the significance of different success rates for different groups of surgeons ($P < 0.05$ was considered statistically significant). The success rate of achieving pneumatic dissection in this subgroup of keratoconic eyes without deep scarring by the 2 senior surgeons at our institute across our entire institutional database is approximately 95%. Accordingly, assuming a 95% success rate for experienced surgeons, we considered a success rate of less than 60% for inexperienced surgeons to be unacceptable. Therefore, with an alpha level of 0.05 and a power of 0.80 and a sample size ratio of 1:3 between surgeries performed by inexperienced surgeons versus experienced surgeons, we calculated that at least 18 patients would be required in the significantly experienced group and 55 in the relatively inexperienced group.

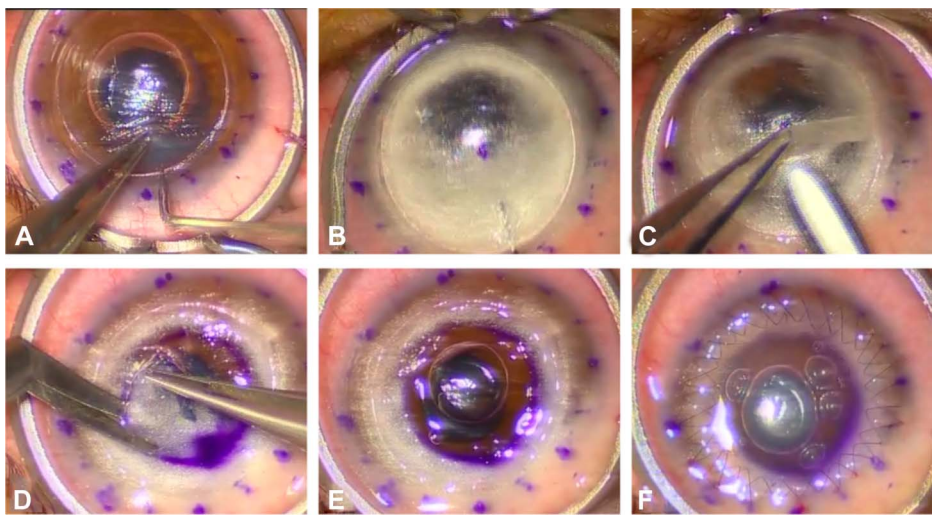

FIGURE 1. Main steps of the surgical technique, including (A) a blunt probe inserted at the base of the deep trephination and advanced 1 mm centripetally; (B) a cannula (27 G) inserted along the same track created by the probe, advanced 1 mm further with subsequent air injection and big bubble formation; (C) debulking of the anterior stroma (removal of approximately 80%); (D) excision of the deep stroma (bubble roof) from the central 6 mm optical zone; (E) a recipient bed consisting of a 6-mm central area of the bare predescemetic layer with a surrounding crown of the deep stroma, 1.5 mm in width; and (F) transplantation of a 9-mm anterior lamella sutured with a double running 10-0 nylon suture.

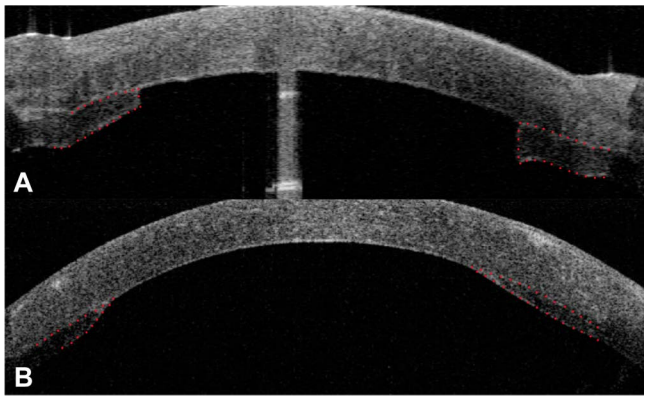

FIGURE 2. AS-OCT showing the transition between the central 6-mm zone and the 9-mm outer zone with the residual recipient stroma. One week postoperatively a "step" is clearly visible (A), but 1 year later, it has disappeared (B) through spontaneous stromal thinning and remodeling of posterior corneal curvature. Recipient stromal layer highlighted by red dots.

RESULTS

Pneumatic dissection succeeded in 7, 7, 8, and 9 cases of 10 cases in the first group of 4 inexperienced surgeons (under 10 previous keratoplasties of any kind); in 9 and 10 of 10 cases in the second group of 2 relatively experienced surgeons (up to 100 keratoplasties); and in 10 and 8 of 10 cases in the third group of 2 very experienced surgeons (more than 1000 previous keratoplasties). The mean success rate was 85%.

When the data were analyzed, there was no statistically significant difference between the success rates in each group stratified by surgical experience ($P = 0.13$). Furthermore, the 3 groups were reallocated to create just 2 groups of either relative surgical inexperience (<100 previous keratoplasties) or significant experience (>1000 keratoplasties). In this second comparison, there was still no statistically significant difference between the 2 groups with an 83.3% versus 90% success rate of pneumatic dissection ($P = 0.45$).

Assuming that the difference in success rates (90% vs. 83%) was real, we calculated at a power of 0.80 that 277 patients would be required in the experienced group and 831 in the inexperienced group to reach the 0.05 significance level. This would be unrealistic in view of the very little clinical difference between the 2 groups.

DISCUSSION

DALK has undisputed advantages over penetrating keratoplasty in terms of endothelial survival and complication rates.[3–12] However, surgeon uptake rates of DALK have been stunted in part because pneumatic dissection is technically challenging. As previously published,[13] the deep trephination used for our technique optimizes the success rate of pneumatic dissection, while being complicated by accidental perforation in a very low percentage of cases (1.2%), which can still be completed without the need for conversion to conventional PK.[2] The block of the suction trephine with measurable blade advancement can be predetermined accurately on the basis of the pachymetric map obtained by means of AS-OCT and is instrumental for the success of this technique, rather than relying on the subjective feedback of cannula depth with variable success.

Our trephination at 9 mm is advantageous because the corneal depth tends to be more homogenous at this diameter when compared with that at 8 mm, where it is more likely to be within ectatic corneal tissue. If the pachymetric map demonstrates that the cornea is particularly thin in some areas even at the 9 mm diameter, we thicken the cornea by means of stromal hydration to minimize the chance of perforation during trephination.

The learning curve in DALK surgery has been detailed in the literature[13] with reports of reduced complications after an initial learning curve of 10 cases. By contrast, our technique performs favorably in the hands of less experienced surgeons even during their first 10 cases, during which complication rates are comparable with those of an experienced surgeon.

In conclusion, with our standardized technique, surgeons are equally successful in achieving pneumatic dissection independent of their surgical experience.

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