Deep Anterior Lamellar Keratoplasty in Eyes With Intrastromal Corneal Ring Segments

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Purpose: To evaluate the possibility of using the intrastromal corneal ring segments (ICRSs) previously implanted as a depth reference for performing pneumatic dissection in deep anterior lamellar keratoplasty (DALK).

Methods: The depth of placement of 2 symmetrical ICRSs placed in the superior and inferior midperipheral cornea of 4 eyes of 4 patients with keratoconus was measured by means of anterior segment optical coherence tomography. Because of irregular and/or high astigmatism, DALK using pneumatic dissection was performed in all eyes. The standardized procedure included the following: 1) Deep trephination of the recipient cornea outside the ICRSs (9 mm in diameter), aimed at facilitating the insertion and advancement of a dedicated cannula under the ICRS implant, just within its peripheral margin; 2) air injection for pneumatic dissection; 3) removal of about 80% of the anterior stroma; 4) perforation of the "big bubble" ceiling under viscoelastic protection and removal of its central 6 mm; and 5) suturing of a donor lamella of the anterior stroma obtained by microkeratome dissection using a 450-μm head and punched to a diameter of 9 mm.

Results: In all cases, the site for air injection was selected where the thickness of the stroma underlying the superior ICRS did not exceed 150 μm. Pneumatic dissection succeeded uneventfully in all eyes; postoperative best spectacle-corrected visual acuity was 20/20 in 3 of 4 eyes, whereas refractive astigmatism was less than 3 diopters in all cases.

Conclusions: The presence of ICRSs facilitates gauging the depth of cannula insertion at the time of DALK, to succeed with pneumatic dissection.

Key Words: cornea, keratoconus, deep anterior lamellar keratoplasty, intrastromal corneal ring segments

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Since their introduction in 2000, intrastromal corneal ring segments (ICRSs) have been used to treat patients with mild-to-moderate keratoconus.[1–3] Although successful results with stable correction have been reported in most cases, some patients have experienced progression of ectasia or other complications, necessitating further surgery.[3–5] If corneal transplantation is necessary, although ICRSs do not affect the recipient endothelium, deep anterior lamellar keratoplasty (DALK) has been seldom reported, mainly because ICRSs are considered a physical obstacle to the surgical maneuvers required by this procedure.[6,7]

However, because they are placed in the deep stroma and air should be injected as deep as possible to maximize the success rate of pneumatic dissection,[8] ICRSs can be used as a reference to guide the depth of insertion of the cannula/needle used for DALK.

We report herein the technical details and the successful outcomes in 4 eyes of 4 patients that underwent a modified DALK technique based on this concept.

PATIENTS AND METHODS

The study followed the tenets of the Declaration of Helsinki and was approved by the local Ethics Committee (Comitato Etico "Ospedali Privati Forlì"). This series includes all keratoconic eyes with irregular and/or high astigmatism present after implantation of ICRSs of the Intacs (Addition Technology, Sunnyvale, CA) type that underwent a standardized DALK at our institution. Slit-lamp examination, best spectacle-corrected visual acuity (BSCVA), refraction, anterior segment optical coherence tomography (AS-OCT) (SS-CASIA; Tomey, Tokyo, Japan), and an endothelial cell count were obtained preoperatively, at 6 and 12 months postoperatively.

Surgical Technique

The procedure (see Supplemental Video 1, Supplemental Digital Content 1, http://links.lww.com/ICO/A763) was

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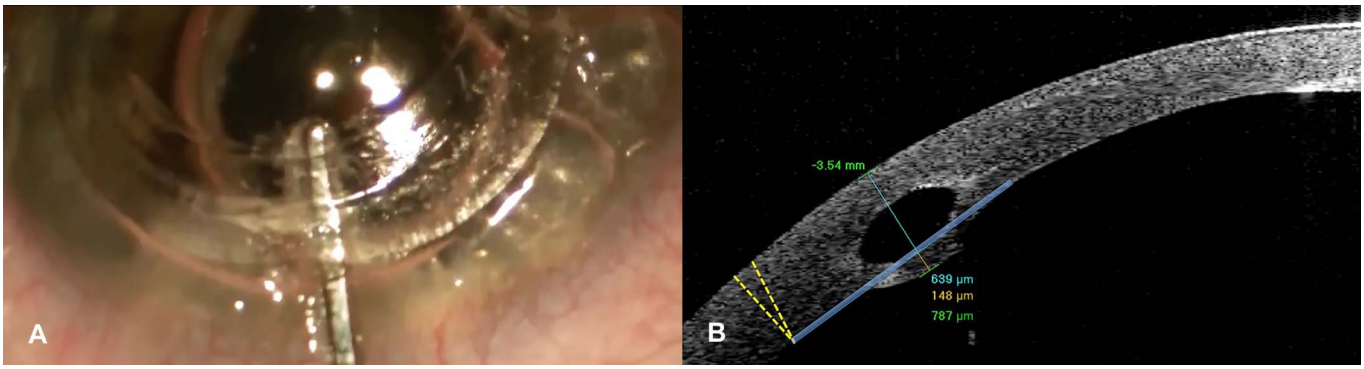

FIGURE 1. Intraoperative image showing the dedicated cannula used for pneumatic dissection advanced centripetally under the ICRS and just within its peripheral margin (A); Preoperative AS-OCT measurement of the peripheral corneal thickness including the tissue beneath the superior ICRS: the dashed lines show the site of deep trephination, 9 mm in diameter; the light blue line represents the cannula used for pneumatic dissection (B).

modified from the DALK performed routinely at our institution, the outcomes of which have been reported recently.[9,10]

A deep trephination was performed using a suction trephine with adjustable blade advancement (Moria, Antony, France) set to stop at approximately 100 µm from the thinnest pachymetric value obtained with AS-OCT at the site of trephination (9 mm in diameter). A small air bubble was injected into the anterior chamber using a temporal paracentesis. This bubble moved peripherally if pneumatic dissection succeeded in creating the big bubble. A blunt probe was then inserted, followed by a dedicated cannula, which was advanced centripetally under the ICRS, just within its peripheral margin (Fig. 1A). The site of entry was determined by selecting an area where the residual corneal thickness beneath the ICRS (Fig. 1B) was between 100 and 150 µm. Air was injected at this point and succeeded in creating a big bubble in all cases, even in the presence of hemorrhage. The recipient cornea was then debulked by performing an anterior keratectomy with the intention of removing about 80% of the stroma. The ICRSs were explanted within the anterior stromal cap or, once exposed, removed from the recipient bed. The central 6-mm optical zone of the residual bubble ceiling was marked with a handheld trephine, and a 15-degree blade was used to enter the bubble. The deep stroma within the 6-mm mark was excised with corneal scissors, thus exposing the bubble floor in this area. As the big bubble rarely extends beyond 8 mm, limiting the clearance of deep stroma to just the central 6-mm optical zone eliminates the need for peripheral dissection, which would be almost certainly necessary with a 9-mm trephination. This modification of the conventional technique may also reduce the risk of perforation when pneumatic dissection fails because subsequent hand dissection has to be carried out over a much smaller area, 6 mm in diameter. Finally, a donor lamella was obtained by means of microkeratome-assisted dissection (450 µm head), punched to 9 mm, and sutured in place with a double running or 16 interrupted 10-0 nylon sutures. With our modified DALK technique, a normal thickness was restored in the peripheral

TABLE 1. Demographic Data and Preoperative and Postoperative Parameters of Patients Undergoing DALK

	Case 1	Case 2	Case 3	Case 4
Age (yr)	61	62	43	39
Follow-up (mo)	18	12	12	12
Indication for surgery	High-degree astigmatism	Irregular astigmatism	Irregular astigmatism	Irregular astigmatism
Preoperative risk factors for PK	ICRSs Decentration	Neovessels; lipidic deposition	ICRSs decentration; neovessels; lipidic deposition	Neovessels; lipidic deposition
Preoperative BSCVA	20/25	20/100	20/100	20/200
Preoperative refraction	−2.50 sph	−8.00 sph	–4.00 sph	−5.50 sph
	−8.00 cyl@80 degrees	−3.00cyl@25 degrees	−2.50 cyl@90 degrees	−4 cyl@30 degrees
Postoperative BSCVA	20/20	20/30	20/20	20/20
Postoperative refraction	+0.25 sph	−6.00 sph	−1.50 sph	−3.50 sph
	−2.75 cyl@70 degrees	−1.25 cyl@170 degrees	−1.75 cyl@100 degrees	−1.00 cyl@40 degrees
Endothelial cell loss (%) 1 yr after DALK	4.8	2.5	8.0	6.3

cyl, cylinder; PK, penetrating keratoplasty; sph, sphere.

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cornea because its final architecture resulted from the overlapping of the microkeratome-dissected donor lamella over a residual crown, about 1.5 mm in width, of deep recipient stroma, which had been left in place. Transplantation of a whole cornea may have resulted into an increased peripheral thickness that may have compromised fitting of the donor tissue into the recipient bed. AS-OCT examinations performed postoperatively did not detect irregularities in the thickness of the final architecture and/or dissected surface of the donor lamellae.

The postoperative treatment did not differ from that described previously in our report, and all eyes were sutureless within 12 months from surgery.[10]

RESULTS

The demographic data as well as preoperative and postoperative parameters evaluated in all eyes of this series are summarized in Table 1.

Risk factors for eventual penetrating keratoplasty (PK) were present in all 4 eyes (ICRSs decentration n = 2; corneal neovascularization and lipid deposition n = 3). Preoperatively, BSCVA was 20/100 or worse in 3 eyes and 20/25 in the remaining eye; however, this eye could not tolerate the required severe astigmatic correction of 8 diopters. Astigmatism was irregular in the other 3 eyes. Pneumatic dissection succeeded in all 4 cases, and all corneas were clear at the last follow-up examination. After complete suture removal (ie, within 1 year from DALK), BSCVA had improved to 20/20 in 3 of 4 eyes, with the remaining eye, which was amblyopic, seeing 20/30. Furthermore, refractive astigmatism was below 3D and endothelial cell loss less than 10% in all cases.

DISCUSSION

Complications requiring further surgery after ICRS implantation have been dealt with in various ways. Implant removal can address part of the problem, but these eyes usually require sequential surgery to restore vision. PK removes both ICRSs and ectatic tissue simultaneously, thus also treating the underlying disease, but exposes the patient to the risk of endothelial rejection. Because the patients' endothelium is unaffected by ICRS implantation, DALK is theoretically a better surgical option, but to date, only scant reports on its use have been published.[6,7] This is probably because of the difficulty in dealing with the presence of intracorneal implants while performing pneumatic dissection. For this reason, ICRSs were either removed before attempting pneumatic dissection,[6] or the needle/cannula required for air injection was inserted in the gap between the 2 implants.[7]

Instead, our approach uses the implants as a guide for the depth of cannula insertion. It is known that the success rate of pneumatic dissection can be maximized if air is injected as close as possible to the endothelial surface.[8] Therefore, by obtaining a pachymetric map of the corneal tissue beneath the ICRSs and inserting the cannula under the implant, the surgeon knows exactly at what depth the air is injected, that is, within the thickness value measured with the AS-OCT. In our series, for cannula insertion and air injection, we chose a site where the residual stromal thickness was between 100 and 150 μm. This was based on the consideration that, whilst insertion of the cannula had to be at least 50 μm deeper than the posterior Intacs surface for minimal resistance when advancing the cannula centripetally, we also wanted sufficient residual thickness to minimize risk of perforation.

In all cases in this series, we employed our standardized DALK procedure, including implantation of a 9-mm anterior lamellar graft after baring of a 6 mm diameter central zone of the predescemetic layer.[10] With this technique, because only the central 6 mm of deep stroma is removed, it was sufficient to create a bubble of this size, remaining within the diameter of the ICRSs and eliminating possible interference from them. In addition, the 9-mm size is instrumental in allowing centration of the lamellar graft relative to the limbus while comprising the entire ICRSs in the excised tissue. Pneumatic dissection was also possible even in the presence of extensive corneal vascularization (3 of 4 eyes) and consequent intraoperative bleeding. In fact, the reference offered by the implants can be easily perceived while advancing the cannula, even if blood may obscure some details of the surgical field.

As a final consideration, PK should be avoided when dealing with conditions that pose a high risk for immunologic rejection, such as implant decentration requiring decentered or larger grafting or corneal vascularization. For these eyes, DALK offers the advantage of sparing the recipient endothelium, thus adding substantially to the long-term safety of surgery, eliminating the risk of irreversible endothelial rejection. Stromal rejection may still occur; however, in such cases, medical treatment alone usually succeeds in recovering prerejection vision.

In conclusion, ICRSs do not hinder but rather may help surgeons perform DALK as they can be used as a reference to determine the corneal depth at which pneumatic dissection is attempted.

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