

Surgical Technique

Small-Bubble Deep Anterior Lamellar Keratoplasty Technique

A Lamellar Procedure After Penetrating Keratoplasty

Vincenzo Scorcia, MD; Jacqueline Beltz, MD, FRANZCO; Massimo Busin, MD

A novel type of deep anterior lamellar keratoplasty (DALK) using limited pneumatic dissection (small bubble) has been performed for the treatment of stromal corneal opacities or ectasia that occurs after penetrating keratoplasty (PK). The standard procedure included deep trephination (70%-80% of thickness) outside the old PK wound, centripetal advancement of a cannula from the base of the incision across the PK wound, slow pneumatic dissection of the central cornea within the PK wound, removal of the centrally detached stroma and manual dissection of the residual surrounding tissue up to the trephination, and suturing of donor tissue deprived of its endothelium. The small bubble DALK is a viable and effective alternative to additional PK for the replacement of the diseased stroma of a full-thickness graft with healthy endothelium. It shares the optical advantages of PK and the safety of an anterior lamellar keratoplasty, avoiding the risks of open eye surgery.

JAMA Ophthalmol. 2014;132(11):1-5. doi:10.1001/jamaophthalmol.2014.2756
Published online August 7, 2014.

Stromal disease (ectasia, opacities, scars, or melting) that occurs after penetrating keratoplasty (PK) can variously affect visual outcome.^{1,2} To date, even in the presence of healthy endothelium, this type of complication has been treated with subsequent PK.³ Instead, the selective replacement of the diseased stroma by means of deep anterior lamellar keratoplasty (DALK) using pneumatic dissection (big bubble) has not been attempted, mainly because of the extreme likelihood of breaking the descemet scar at the junction between the donor and host cornea. We describe a new surgical technique (small-bubble DALK) that uses pneumatic dissection to bare Descemet membrane (DM) only in a central optical zone and predescemet manual dissection to remove the surrounding peripheral stroma.



Video at
jamaophthalmology.com

Methods

We reviewed the medical records of all patients with post-PK complications who had undergone small-bubble DALK at the Department of Ophthalmology, University of Magna Graecia, Catanzaro, Italy, from July 1, 2010, through January 31, 2012. The study followed the tenets of the Declaration of Helsinki and was approved

by the ethics committee of the University of Magna Graecia; all patients gave written informed consent by signing detailed informed consent forms. Uncorrected visual acuity, best spectacle-corrected visual acuity, endothelial cell density (EM-3000, Tomey Corporation), and corneal topography (anterior segment optical coherence tomography; SS-1000 CASIA, Tomey Corporation) were assessed preoperatively and after complete suture removal. A *t* test was used to evaluate the statistical significance of the changes recorded ($P < .05$ was considered statistically significant).

Surgical Procedure

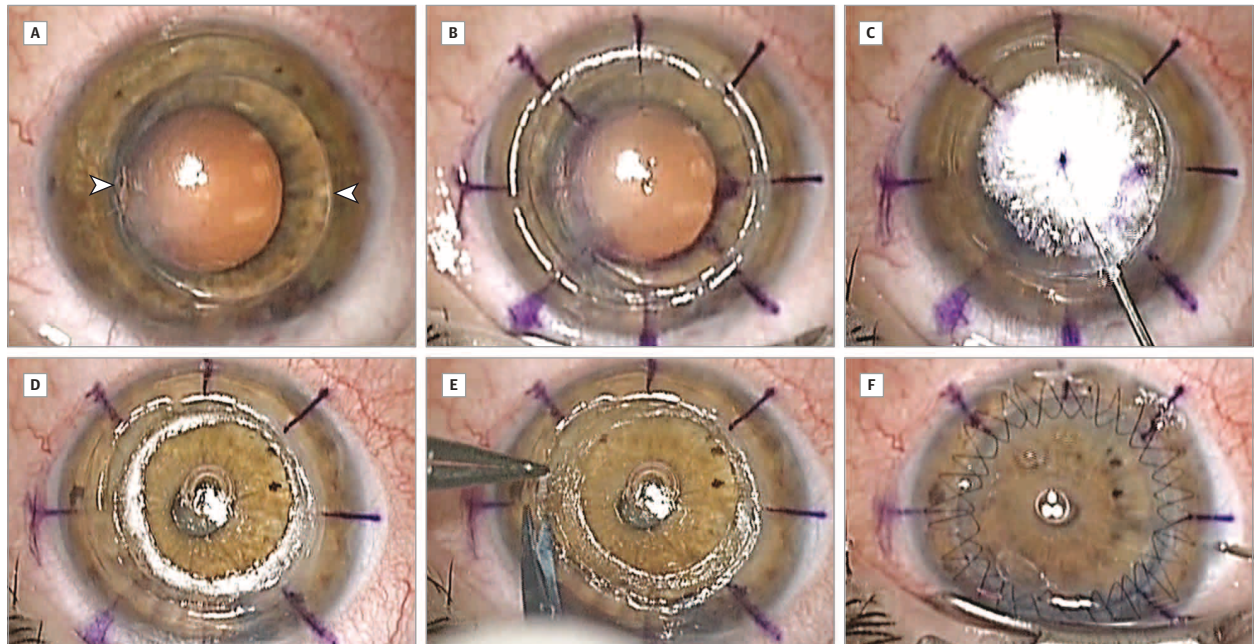
In all patients, anesthesia was administered with peribulbar injection of a mixture of 5 mL each of lidocaine hydrochloride, 2%, and bupivacaine hydrochloride, 0.5% (Video). A Barron suction trephine (Katena Products Inc) was centered on the corneoscleral limbus, and a circular incision 8 to 9 mm in diameter, was made, taking care to include the original PK wound (Figure 1A and B); thus, the graft size was enlarged compared with the original PK in an attempt to minimize postoperative astigmatism. To minimize the risk of perforation, trephination to approximately 70% to 80% of the thickness measured by anterior segment optical coherence tomography was purposely performed outside and not inside the often irregular PK wound. A blunt 27-gauge cannula was inserted at the base of the incision and advanced centripetally across the PK wound; air was injected with minimal pressure to obtain a bubble within the margin of the PK wound (Figure 1C). After manual removal of the superficial stroma, the bubble was entered with a 30° blade, and the deep stroma was excised, baring DM over an optical area 5 to 6 mm in diameter (Figure 1D). Predescemet dissection of the residual peripheral rim was performed manually (Figure 1E).

A Barron donor punch (Katena Products Inc) was used to prepare a full-thickness graft (same size as the trephination in the recipient cornea) from which DM and endothelium were stripped off using a dry Weck-Cel sponge. The donor tissue was fixated with 4 cardinal sutures that were removed after completing the procedure with a double running 10-0 nylon suture (Figure 1F). These sutures were removed in all cases within 12 months.

Results

Nine eyes from 9 patients with a history of PK who had undergone small-bubble DALK were identified. The indications for subsequent surgery were corneal ectasia ($n = 4$), scarring after stromal melt ($n = 2$), post-photorefractive keratectomy haze ($n = 2$), and recurrence of dystrophy ($n = 1$) (Figure 2). In all cases, the pathologic findings did not extend outside the PK wound.

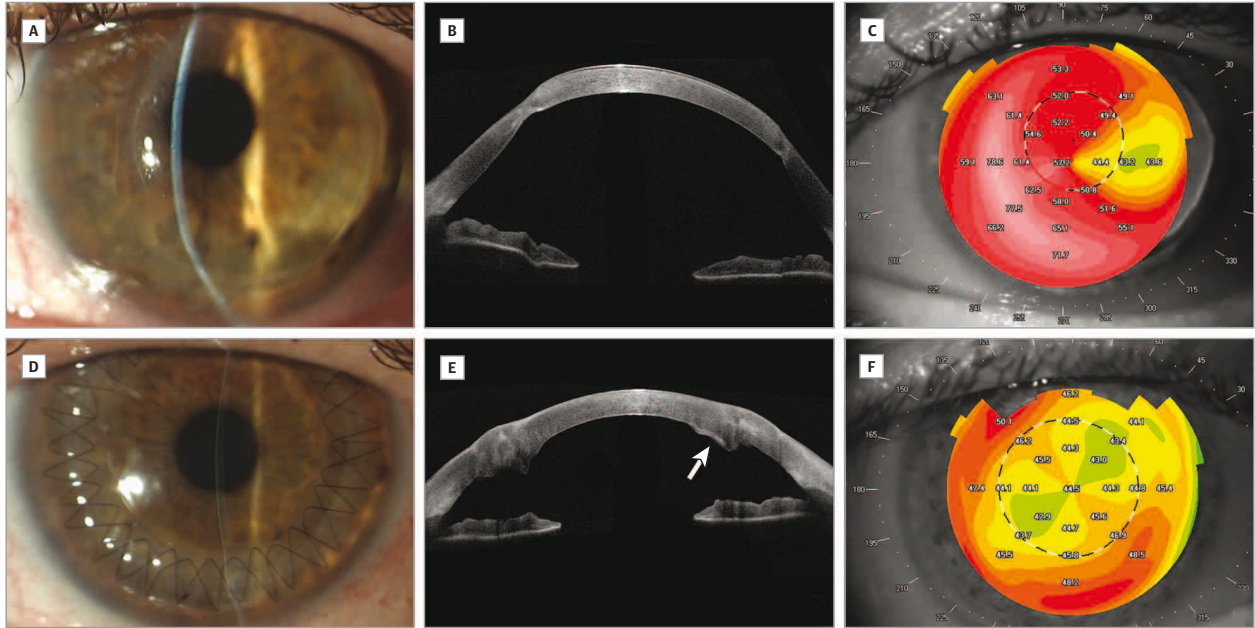
Figure 1. Surgical Steps of Small-Bubble Deep Anterior Lamellar Keratoplasty



A, Recurrent ectasia in an eye with a decentered penetrating keratoplasty (arrowheads). B, Trephination 8.5 mm in diameter, up to 70% to 80% of peripheral corneal thickness. C, Air injection into deep stroma by means of a blunt 27-gauge cannula to achieve a bubble 5 to 6 mm in diameter. D, After

removal of the superficial stroma, baring of the Descemet membrane with blunt corneal scissors. E, Manual predescemetic dissection and removal of the residual peripheral deep stroma. F, Fixation of donor tissue with 2 running 10-0 nylon sutures.

Figure 2. Results of Small-Bubble Deep Anterior Lamellar Keratoplasty Performed in Eyes With Recurrent Ectasia After Penetrating Keratoplasty



A, Preoperative slitlamp appearance. B, Anterior segment optical coherence tomography (AS-OCT). C, Corneal topography of an eye with recurrence of ectasia 6 years after penetrating keratoplasty. D, Three months after small-bubble deep anterior lamellar keratoplasty, the cornea is perfectly clear

with no sign of ectasia. E, Area of peripheral manual dissection as seen with AS-OCT (arrow). F, Fifteen months after surgery, corneal topography reveals the presence of low-degree regular astigmatism.

Table. Preoperative and Postoperative Data for Patients Undergoing Small-Bubble Deep Anterior Lamellar Keratoplasty

Patient No./Sex/Age, y	Indication for Surgery	BSCVA		ECD, Cells/mm ²		Mean Topographic Keratometric Reading, D		Refractive Cylinder, D	
		Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative
1/M/42	Post-PRK scar	20/200	20/20	1024	980	40.1	44.5	6.3	3.1
2/M/51	Granular dystrophy recurrence	20/80	20/25	1345	1360	46.3	45.3	3.2	4.7
3/F/62	Ectasia	20/400	20/30	1540	1487	54.8	46.7	10.5	4.1
4/F/53	Ectasia	20/200	20/20	1124	1086	52.5	44.9	9.6	1.7
5/M/42	Poststromal melt scar	20/100	20/25	NA	1460	39.2	43.7	5.3	2.5
6/F/31	Post-PRK scar	20/400	20/25	NA	1356	44.5	42.7	2.1	3.9
7/M/42	Poststromal melt scar	20/200	20/20	1380	1410	38.2	44.3	6.2	0.8
8/F/39	Ectasia	20/400	20/30	1685	1590	62.0	48.1	13.7	6.2
9/M/42	Ectasia	20/200	20/40	1246	1210	57.6	46.3	7.8	3.8

Abbreviations: BSCVA, best spectacle-corrected visual acuity; D, diopters; ECD, endothelial cell density; NA, not available; PRK, photorefractive keratectomy.

Intraoperative complications included failure to form the bubble ($n = 1$) and microperforation that occurred during manual dissection of the peripheral stroma ($n = 1$). In both cases, the procedure was completed by means of manual dissection, even in the former case obtaining a final central thickness of the recipient bed of approximately 30 μm as measured postoperatively by anterior segment optical coherence tomography.

Demographic data and results are summarized in the **Table**. At the latest follow-up examination (14 months after surgery), all sutures had been removed in all 9 eyes, and best spectacle-corrected visual acuity had improved by at least 4 Snellen lines; refractive astigmatism had improved in all 4 patients with corneal ectasia and in 3 of the 5 eyes with stromal opacities. Endothelial cell density was not significantly affected by surgery. No postoperative complications were recorded.

Discussion

Anterior lamellar keratoplasty (ALK) is becoming increasingly popular because of its main intrinsic advantage of replacing diseased stroma while sparing healthy endothelium.⁴ Although microkeratome-assisted ALK in post-PK eyes is relatively simple and quick to perform, it is not recommended for stromal lesions that extend beyond a depth of 200 μm or for advanced corneal ectasia because of the risk of perforation.⁵ Instead, manual dissection is a painstaking maneuver, often yielding disappointing visual results and requiring conversion to PK in a relatively high number of cases.⁶

The small-bubble DALK technique uses an approach similar to that of the big-bubble technique described originally by Anwar and Teichmann.⁷ However, pneumatic dissection with small-bubble DALK is limited only to the central 5 to 6 mm, thus eliminating the risk of

bursting the bubble when the scar between donor and recipient DM is reached. The size of the optical zone with bare DM was sufficiently large to allow excellent visual results in all cases. Irregularities in the peripheral residual stroma that result from manual dissection are visually irrelevant when located outside the optical zone and may instead lead to a stronger wound profile, as has been reported for mushroom keratoplasty.^{8,9}

As with any procedure that uses pneumatic dissection, creation of the bubble may fail but can be handled more easily, as was done in one eye of this series, because the critical maneuver of baring DM by hand is required over a much smaller area than with conventional big-bubble procedures. In addition, Lim and Lim¹⁰ have reported the use of manual dissection of the peripheral residual recipient stroma between bare DM and the trephination cut to manage incomplete bubble formation. Their method, proposed for eyes without previous PK surgery, supports the same concept applied by us in post-PK eyes: dissection does not need to further expose DM but rather simply modify the recipient bed to allow proper allocation of the donor tissue. Large grafts of 9 mm or larger in diameter can therefore be used with the same risk of smaller grafts, while increasing the chances of a more regular postoperative corneal curvature. Finally, if microperforations or a dehiscence of the PK wound occurs, completion of the procedure by manual dissection can be attempted similarly to the big-bubble technique.

Conclusions

Small-bubble DALK is a viable and effective procedure for treating recurrence of ectasia or stromal opacities that develop after PK; visual acuity is significantly improved, and complications can be managed with no need for conversion to full-thickness transplantation.

ARTICLE INFORMATION

Author Affiliations: Department of Ophthalmology, University of Magna Graecia, Catanzaro, Italy (Scordia, Busin); Centre for Eye Research Australia, Royal Victorian Eye and Ear Hospital, Melbourne, Australia (Beltz, Busin); Department of Ophthalmology, Ospedale Privato Villa Igea, Forlì, Italy (Busin).

Corresponding Author: Vincenzo Scordia, MD, Department of Ophthalmology, University of Magna Graecia, Via dei Crociati 40, 88100 Catanzaro, Italy (vscordia@libero.it).

Submitted for Publication: February 24, 2014; final revision received April 7, 2014; accepted April 8, 2014.

Published Online: August 7, 2014.
doi:10.1001/jamaophthalmol.2014.2756.

Author Contributions: Dr Scordia had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Scordia, Busin.
Acquisition, analysis, or interpretation of data:

Scorcia, Beltz.

Drafting of the manuscript: Scorcia, Busin.

Critical revision of the manuscript for important intellectual content: Scorcia, Beltz.

Statistical analysis: Scorcia.

Administrative, technical, or material support: Beltz.

Study supervision: Scorcia, Busin.

Conflict of Interest Disclosures: Dr Busin reported receiving travel expense reimbursement and royalties from Moria (Antony, France). No other disclosures were reported.

REFERENCES

1. Yalniz-Akkaya Z, Burcu Nurozler A, Yildiz E, Onat M, Budak K, Duman S. Repeat penetrating keratoplasty: indications and prognosis, 1995-2005. *Eur J Ophthalmol*. 2009;19(3):362-368.
2. Al-Mezaine H, Wagoner MD; King Khaled Eye Specialist Hospital Cornea Transplant Study Group. Repeat penetrating keratoplasty: indications, graft survival, and visual outcome. *Br J Ophthalmol*. 2006;90(3):324-327.
3. Patel NP, Kim T, Rapuano CJ, Cohen EJ, Laibson PR. Indications for and outcomes of repeat penetrating keratoplasty, 1989-1995. *Ophthalmology*. 2000;107(4):719-724.
4. Reinhart WJ, Musch DC, Jacobs DS, Lee WB, Kaufman SC, Shtein RM. Deep anterior lamellar keratoplasty as an alternative to penetrating keratoplasty: a report by the American Academy of Ophthalmology. *Ophthalmology*. 2011;118(1):209-218.
5. Patel AK, Scorcia V, Kadyan A, Lapenna L, Ponzin D, Busin M. Microkeratome-assisted superficial anterior lamellar keratoplasty for anterior stromal corneal opacities after penetrating keratoplasty. *Cornea*. 2012;31(1):101-105.
6. Fontana L, Parente G, Sincich A, Tassinari G. Influence of graft-host interface on the quality of vision after deep anterior lamellar keratoplasty in patients with keratoconus. *Cornea*. 2011;30(5):497-502.
7. Anwar M, Teichmann KD. Big-bubble technique to bare Descemet's membrane in anterior lamellar keratoplasty. *J Cataract Refract Surg*. 2002;28(3):398-403.
8. Busin M, Arffa RC. Microkeratome-assisted mushroom keratoplasty with minimal endothelial replacement. *Am J Ophthalmol*. 2005;140(1):138-140.
9. Scorcia V, Busin M. Survival of mushroom keratoplasty performed in corneas with postinfectious vascularized scars. *Am J Ophthalmol*. 2012;153(1):44-50, e1.
10. Lim L, Lim SW. Donor cornea preparation in partial big bubble deep anterior lamellar keratoplasty. *Clin Ophthalmol*. 2014;8:363-367.