

# Microkeratome-Assisted Superficial Anterior Lamellar Keratoplasty for Anterior Stromal Corneal Opacities After Penetrating Keratoplasty

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**Purpose:** To describe the surgical technique and report the outcomes of patients treated with microkeratome-assisted superficial anterior lamellar keratoplasty for anterior stromal corneal opacities developing after penetrating keratoplasty (PK).

**Methods:** All patients with post-penetrating keratoplasty anterior stromal opacities treated with microkeratome-assisted superficial anterior lamellar keratoplasty between July 2005 and June 2007 were reviewed. A 130- $\mu$ m superficial keratectomy was performed, followed by the placement of an appropriately sized donor graft, which was secured with overlay sutures. Refraction, corneal topography, and uncorrected and best-corrected visual acuities (UCVA, BCVA, respectively) were noted at each examination.

**Results:** Nine eyes of 8 consecutive patients were identified. Causes of anterior stromal opacities included dystrophy recurrence (n = 3), post-photorefractive keratectomy haze (n = 2), and scarring after stromal melt (n = 4). BCVA improved in all 9 eyes at final follow-up, and 7 of 9 eyes achieved  $\geq 20/40$  within the first month. Average follow-up period was  $28 \pm 3.9$  months. Refractive astigmatism also improved by an average of 0.7 diopters.

**Conclusions:** Superficial anterior lamellar keratoplasty is a viable and effective alternative to repeat PK in treating anterior stromal scars. It avoids open-globe surgery and exposure to endothelial rejection associated with repeat PK, and visual rehabilitation is considerably quicker.

**Key Words:** lamellar keratoplasty, automated lamellar therapeutic keratoplasty, penetrating keratoplasty, corneal opacity

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Anterior stromal opacities may develop for various reasons in post-keratoplasty eyes, for example, recurrence of original dystrophy, haze after surface ablation, melting secondary to chronic epithelial defects, or infection. Until recently, the only available treatment for this complication was repeat penetrating keratoplasty (PK) surgery. Repeat PK, however, is associated with higher rejection rates, poorer visual outcome, and reduced graft clarity and survival.<sup>1–3</sup>

Manual dissection may be used for discrete raised superficial lesions. However, the irregular interface obtained when this type of dissection is performed in the superficial stroma may result in a poor visual outcome. Phototherapeutic keratectomy (PTK) has been shown to be effective in treating such opacities but is limited by the depth of the opacity. In addition, irregular astigmatism, visually significant hyperopic shifts, and scarring may also follow PTK treatment.<sup>4,5</sup>

Microkeratome-assisted dissection has been used to perform laser in situ keratomileusis in post-PK eyes with the purpose of correcting refractive errors.<sup>6</sup> The procedure has been proven safe, and the quality of the interface obtained in these eyes is compatible with 20/20 vision. Similarly, the procedure has been performed for therapeutic purposes in scarred non-PK eyes.<sup>7–9</sup> Therefore, as an alternative, we evaluated the feasibility of a microkeratome-assisted superficial anterior lamellar keratoplasty (SALK) for the treatment of such opacities in 9 post-PK eyes. This procedure is encompassed within the term automated lamellar therapeutic keratoplasty (ALTK); however, it differs significantly in the management and rate of visual rehabilitation from deep anterior lamellar keratoplasty (DALK).

## MATERIALS AND METHODS

Records of all the patients with post-PK superficial opacities presenting at our institution between July 2005 and June 2007 who had undergone microkeratome-assisted SALK were reviewed. Data collected included patient demographics, indications for initial PK, preoperative and postoperative Snellen uncorrected visual acuities (UCVAs) and best-corrected visual acuities (BCVAs), preoperative and postoperative

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refractive astigmatism, time interval from PK to microkeratome-assisted SALK, and follow-up period.

Outcome measures were final UCVA and BCVA, refractive astigmatism, and graft survival. A Wilcoxon–Mann–Whitney *U* test was used to analyze the change in refractive astigmatism induced by the surgery.

### Surgical Technique

A detailed informed consent approved by the Institutional Review Board was signed by all 8 patients undergoing surgery. Intravenous droperidol 3 mL was administered immediately before peribulbar anesthetic injection (50% mixture of 2% lidocaine and 0.5% bupivacaine) to achieve sedation. All cases underwent operation by a single surgeon (M.B.).

First, a superficial lamella (free cap) was cut from the recipient cornea (Fig. 1A) with a microkeratome (Moria, Antony, France) using a 130- $\mu$ m microkeratome head and “0” suction ring (Fig. 1B). A lamella of the same thickness was obtained from the donor cornea mounted on an artificial anterior chamber.

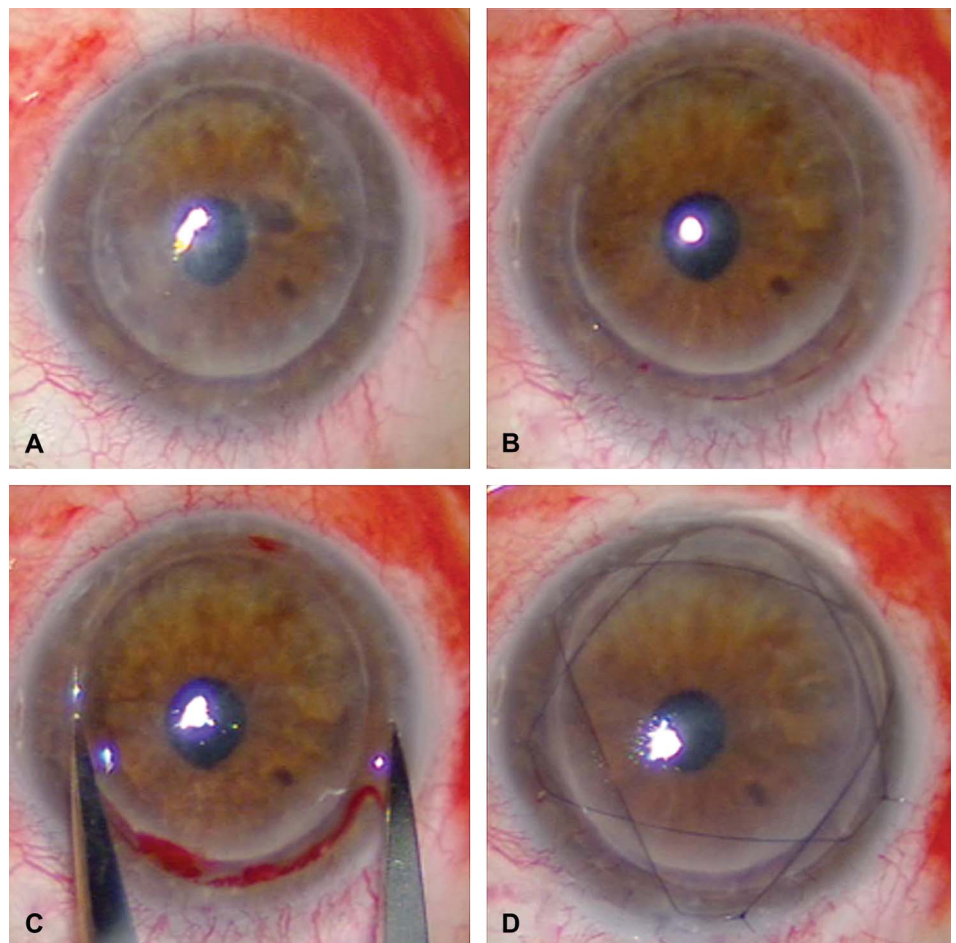
The recipient bed was then measured with calipers (Fig. 1C), and the donor tissue was punched to the same size using a Hessburg–Barron punch (Katena Products, Denville, NJ). The donor graft was thereafter secured onto the recipient

bed by means of 2 overlay sutures (10-0 nylon) each with 3 passages through the peripheral cornea (Fig. 1D).

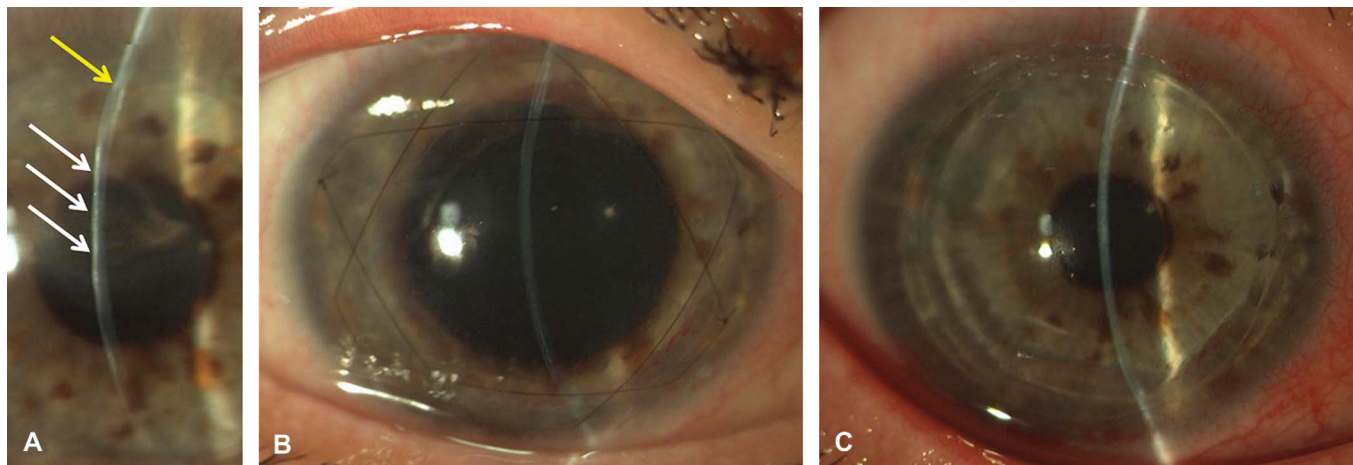
Postoperatively, all the patients received 2 hourly 0.3% tobramycin and dexamethasone 0.1% eye drops. Each patient was examined twice weekly until reepithelialization was complete, and suture removal was aimed at 1 week postoperatively. Early removal of sutures was indicated if these were noted to be too tight, too loose, or underriding the graft edge. Refraction, UCVA and BCVA, and corneal topography were assessed at follow-up visits.

### RESULTS

Nine eyes of 8 patients were identified (4 women and 4 men). The mean patient age was 57 years (range, 34–71 years). The anterior stromal opacities were because of granular dystrophy recurrence ( $n = 3$ ), post–photorefractive keratectomy (PRK) scarring ( $n = 2$ ), and scarring secondary to previous stromal melting ( $n = 4$ ). The 2 patients with post-PRK scarring had previously undergone PK for keratoconus and subsequent excimer laser treatment for the correction of high-degree ametropia. The 4 patients with post-melt scarring had undergone PK for pseudophakic bullous keratopathy. The stromal melting was noted to have developed soon after PK



**FIGURE 1.** Recipient preparation. A, Preoperative appearance. B, Residual stromal bed after microkeratome dissection using a 130- $\mu$ m microkeratome head. C, Dissected stromal bed measured using callipers. D, Donor lamella secured with two 10-0 nylon overlay sutures.



**FIGURE 2.** A, Paracentral corneal scar with thinning (white arrows). PK interface (yellow arrow). B, Clear cornea 1 week postoperatively with overlay sutures in place. C, One day after removal of overlay sutures (patient 6).

due to persistent nonhealing epithelial defects. At the time of surgery, epithelialization was complete and corneal sensation intact in all cases. Figure 2A to 2C illustrates the preoperative appearance and postoperative outcome of a patient with a post-stromal melt scar. All PK graft sizes were smaller than 8 mm in diameter (average,  $7.75 \pm 0.21$  mm).

The mean time interval between PK and microkeratome-assisted SALK was 4.7 years (range, 2–9 years). Sutures related to the PK had been removed previously in all cases. The patients had a follow-up of at least 24 months (range, 24–36 months).

The recipient bed after the superficial keratectomy measured 9.0 mm in diameter and incorporated the PK wound in all cases. All donor lamellae were thus punched to the same size to match the recipient bed. No intraoperative complications were noted, and suture removal was performed between 2 days and 2 weeks after the surgery. Two cases required early suture removal (case 1 due to an underriding suture and case 7 due to a loose suture). Late removal (>1 week) of suture was performed in 2 cases, because the patients were unable to attend clinic 1 week postoperatively.

As early as 1 month postoperatively, 7 of 9 eyes had BCVA  $\geq 20/40$ . At the final follow-up, UCVA had improved in 8 of 9 eyes and remained unchanged in 1 case; BCVA, however, improved in all 9 eyes. Refractive astigmatism improved in 6 of 9 eyes by an average of 1.54 diopters (D). The remaining 3 eyes showed an average increase of 0.92 D. Overall, a mean reduction of  $0.7 \pm 1.42$  D was noted ( $P > 0.1$ ). No graft failure or immunologic rejection episodes were noted during the follow-up period. Patient demographics, diagnosis, time interval from PK to SALK, follow-up, refractive and visual results are summarized in Table 1.

## DISCUSSION

Anterior lamellar surgery offers several advantages over PK, including maintaining globe integrity, preserving healthy stromal and endothelial tissue, and reducing complications related to rejection and open-sky surgery.<sup>10–13</sup> Furthermore, microkeratome-assisted dissection results in a smooth surface,

which is consistent with good visual acuity.<sup>14,15</sup> It is relatively simple and quick to perform and, although large irregularities may reflect in the microkeratome-cut bed, small focal irregularities are bridged-over (Fig. 2).

DALK, as an alternative, involves meticulous manual dissection and the need to match the removed stromal tissue to the donor lenticule.<sup>16</sup> Compared with automated SALK, the interface obtained with manual deep dissection would be irregular and visual rehabilitation would be longer, considering the need for deep sutures. Furthermore, the “big-bubble” technique<sup>17</sup> would not be recommended given the risk of disrupting the PK wound.

In one study, no significant difference in visual outcome was noted between lamellar keratoplasty and PK for granular dystrophy.<sup>18</sup> Although no direct comparison studies exist, visual rehabilitation with microkeratome-assisted SALK in our series was considerably quicker than results from PK for keratoconus,<sup>19</sup> and the visual, refractive, and survival outcomes were better than repeat PKs for superficial opacities and other indications.<sup>3,20</sup>

In our series, use of the “0” suction ring with the aforementioned ALTK system, irrespective of the keratometry readings, led to a recipient bed that measured 9.0 mm in all cases. Furthermore, the area of dissection always incorporated the entire PK wound. This, however, may not always occur, especially if the PK is large or small and decentered. Careful wound evaluation is required in all cases irrespective of the relationship between the PK wound and the dissected area. The donor lamellae were punched to 9.0 mm to match the recipient bed. Although none of the lamellae obtained was smaller than the recipient bed, should this occur, in our experience, the area of bare stroma usually epithelializes without consequence.

Seven of 9 eyes achieved BCVA  $\geq 20/40$  within the first month after surgery, and maximal visual acuity was attained within 6 months of surgery. Although the change in astigmatism was not statistically significant, 6 of 9 eyes experienced a decrease (mean, 1.54 D) in refractive astigmatism. Also, the 3 eyes that had an increase (mean, 0.92 D) in astigmatism conversely experienced improvement in their UCVA.

**TABLE 1.** Patient Demographics, Diagnosis, Pre-SALK and Post-SALK Visual and Astigmatic Results, and Follow-up

| Patient | Age/Sex   | Initial Diagnosis  | Time Since PK (yr) | Pathology              | UCVA I | UCVA II | BSCVA I | BSCVA II | RA I | RA II | Follow-up (mo) |
|---------|-----------|--------------------|--------------------|------------------------|--------|---------|---------|----------|------|-------|----------------|
| 1       | 45/Male   | Granular dystrophy | 7                  | Dystrophy recurrence   | 20/400 | 20/200  | 20/200  | 20/30    | 2.5  | 4     | 24             |
| 2       | 34/Male   | Keratoconus        | 3                  | Post-PRK scar          | 20/200 | 20/60   | 20/100  | 20/30    | 6.5  | 3.75  | 30             |
| 3       | 64/Female | PBK                | 2                  | Post-stromal melt scar | CF     | 20/400  | CF      | 20/400   | 4.75 | 4     | 30             |
| 4       | 71/Male   | PBK                | 3                  | Post-stromal melt scar | 20/400 | 20/200  | 20/400  | 20/40    | 3.5  | 3.75  | 36             |
| 5       | 61/Female | Granular dystrophy | 7                  | Dystrophy recurrence   | 20/80  | 20/80   | 20/60   | 20/25    | 4    | 2.25  | 30             |
| 6       | 70/Female | PBK                | 4                  | Post-stromal melt scar | 20/100 | 20/80   | 20/80   | 20/25    | 4    | 2.5   | 27             |
| 7       | 41/Male   | Keratoconus        | 9                  | Post-PRK scar          | 20/200 | 20/100  | 20/100  | 20/40*   | 8.5  | 6.5   | 24             |
| 8       | 66/Female | PBK                | 2                  | Post-stromal melt scar | 20/400 | 20/200  | 20/200  | 20/100   | 5.5  | 5     | 24             |
| 9       | 61/Female | Granular dystrophy | 5                  | Dystrophy recurrence   | 20/200 | 20/60   | 20/100  | 20/30    | 3.25 | 4.25  | 27             |

\*Best contact-lens-corrected visual acuity.

BSCVA, best spectacle-corrected visual acuity; CF, counting fingers; I, before SALK; II, after SALK; PBK, pseudophakic bullous keratopathy; RA, refractive astigmatism (absolute value in diopters).

Furthermore, should any significant astigmatism or ametropia exist postoperatively, the microkeratome-assisted SALK procedure provides a lamellar flap, which can be lifted at a later stage for intrastromal ablative surgery to be performed.

In patients with post-PRK scarring, PTK may be used to treat the superficial scars. This, however, poses the risks of induced hyperopia, irregular astigmatism, and exacerbated scarring.<sup>5,14,21</sup> In our series, one of the patients with post-PRK scarring had undergone previous PTK resulting in exacerbation of scarring and another declined further ablative treatment.

Granular dystrophy has been reported to have a high recurrence rate after PK, lamellar surgery, and PTK.<sup>18,22</sup> The dystrophy has been noted to recur superficially, and lamellar surgery has been advocated in the past as these patients may have several recurrences and require multiple interventions.<sup>18,23</sup> In a series of 31 patients, Lyons et al<sup>18</sup> reported that visual outcomes and recurrence-free intervals were independent of the type of graft performed (penetrating versus lamellar) and recommended lamellar surgery as a primary option. In our series, the last follow-up, none of the 3 patients with granular dystrophy had evidence of recurrence. However, should this occur in the graft, management would involve a straightforward anterior lamellar replacement. We have also used microkeratome-assisted SALK to successfully treat other corneal dystrophies with primarily anterior involvement, such as Reis-Buckler and lattice dystrophy with similar results.

None of the patients in our series had any intraoperative or postoperative complications. However, experience with laser in situ keratomileusis in post-PK eyes reports that microkeratome failure, wound dehiscence, perforation, epithelial ingrowth, buttonhole formation, and late flap/lamellar dislocation are all possible.<sup>6</sup> Wound-related complications have been linked to the timing of lamellar surgery after PK, and some authors suggest waiting at least 1 to 2 years after PK before performing laser in situ keratomileusis.<sup>24,25</sup> Others, however, have reported successful outcomes in younger patients undergoing operation within 2 years of PK. Although the ideal timing remains debatable, all patients in our series had waited at least 2 years since PK and did not experience any wound-related complications. In addition to the general contraindications for keratoplasty, relaxing keratotomies, limbal relaxing incisions, or glaucoma filtration surgery

may be relative contraindications to performing SALK, especially if there is wound gaping or the suction ring cannot be applied safely.

Although none of the patients had residual opacity after the keratectomy, there is a risk that this may occur if the depth of scarring has not been determined accurately. In this series, we evaluated all patients with slit-lamp biomicroscopy; however, Scheimpflug imaging or anterior segment optical coherence tomography may be used to achieve better accuracy.

In conclusion, our small series of patients supports microkeratome-assisted SALK as a viable and effective procedure for superficial opacities developing after PK. It offers all the advantages of lamellar surgery with swift visual rehabilitation and also allows repeat lamellar or ablative surgery to be performed easily, if necessary.

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