Original Article

Sutureless femtosecond anterior lamellar keratoplasty: A 1-year follow-up study

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Aim: To study the safety and efficacy of sutureless femtosecond anterior lamellar keratoplasty (FALK) in patients with corneal stromal opacities. **Materials and Methods:** Eleven eyes of 11 consecutive patients with corneal stromal opacities involving <250 μ due to various pathologies were included in the study. Preoperatively, all underwent anterior segment imaging with spectral domain optical coherence tomography (SD-OCT) (Bioptigen Inc., Durham, North Carolina, USA) to measure the depth of the stromal opacity. All patients underwent FALK, and bandage contact lens was placed for a period of 2 weeks. Postoperatively, uncorrected visual acuity, best corrected visual acuity (BCVA), and SD-OCT evaluation were performed. **Results:** All patients showed significant improvement in BCVA. The mean postoperative BCVA (in decimals) improved from 0.11 ± 0.06 preoperatively to 0.59 ± 0.08. There were no intraoperative or significant postoperative complications that were noticed. **Conclusion:** FALK is a safe and effective alternative to deep anterior lamellar keratoplasty or penetrating keratoplasty in the treatment of anterior stromal opacities.

Key words: Anterior stromal opacities, femtosecond anterior lamellar keratoplasty, spectral domain optical coherence tomography

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Penetrating keratoplasty (PKP) has been a time tested and well-accepted surgical treatment over the past few decades.[1-4] However, it can be complicated by allograft endothelial rejection with subsequent risk of graft failure, suture-related and long-term topical steroid-related complications. Deep anterior lamellar keratoplasty (DALK) has the advantage of reducing the risks of graft rejection and intraocular complications. However, it is more technically demanding and may result in suboptimal visual outcomes due to interface irregularities.

Over the past few decades, several techniques of anterior lamellar keratoplasty (ALK) have been described which has led to improved clinical results.[5,6] Recently, femtosecond laser technology has caused a revolution in corneal surgery. The accuracy, safety, and efficacy of this new technology have already been tested for several corneal surgeries.[7-9] The highly reproducible dimensions of the cuts at the graft- host junction and the adjustable vertical side cut orientation of the femtosecond laser increase the precision of ALK.

Our study is aimed at assessing the safety and efficacy of sutureless femtosecond anterior lamellar keratoplasty (FALK) in various anterior corneal stromal disorders.

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Materials and Methods

Patients who underwent FALK at the department of cornea and external eye diseases in our hospital were included in the study after taking informed consent. The study was performed under the Tenets of the Declaration of Helsinki.

All patients had corneal stromal pathologies not exceeding 250 μ [Fig. 1]. Preoperatively, all patients underwent slit lamp and fundus examination. Anterior segment imaging was done using hand held spectral domain optical coherence tomography (SD-OCT) to evaluate the depth of the scar tissue [Fig. 2]. Those patients with herpetic eye disease, anterior segment inflammation, posterior segment pathologies, and systemic conditions such as diabetes and pregnancy were excluded.

Surgical technique

All procedures were performed under topical anesthesia (proparacaine hydrochloride 0.5%). All surgeries were performed by trained corneal surgeons. A 200-kHz femtosecond laser (WaveLight® FS200, Alcon Laboratories Inc, Ft Worth, Texas) was used in all eyes to create the lamellar cut in the donor corneas followed by the recipient cornea the donor graft was prepared by mounting the corneoscleral donor tissue on an artificial anterior chamber (Moria, Anthony, France). Epithelium was removed using a mechanical epithelial scrapper before creation of the lamellar cut. The femtosecond laser lamellar cuts for both recipient and donor corneas were adjusted according to the depth of the lesions measured by the SD-OCT with 20–30 μ additional for correction of the manual error that might have occurred during calculation of depth. Femtosecond lamellar cuts had the following settings: Donor lenticule diameter, 8.1 mm, 360°side cut, 90° side cut angle; donor corneal lenticules were oversized by 0.1 mm in diameter compared with the recipient lamellar cut, while rest

of the parameters were kept the same. (Parameters for recipient cornea: Diameter was set at 8 mm in all patients with 360° side cut and 90° side cut.) The recipient's scarred corneal tissue was removed and replaced with the corneal donor lenticule.

A bandage contact lens was fitted over the cornea, which was removed on the 3rd week follow-up visit. Patients were administered topical antibiotic 4 times daily for 1 week and continued 2 times a day till the BCL was removed, and prednisolone acetate drops (Pred Forte, Allergan, Irvine, CA) 4 times daily, which was slowly tapered over a period of 6 weeks. Topical lubricants were prescribed for 8 weeks following the surgery.

Intraoperative phototherapeutic keratectomy was performed in one case to remove residual scars and further smoothens the recipient corneal bed after the femtosecond laser lamellar cut.

Results

Eleven eyes of 11 consecutive patients who underwent FALK were included in the study. Mean age of the patients was 26 years (range-18-33 years). 7 males and 4 females with corneal stromal opacities involving <250 μ were included in the study. The mean depth of opacities as measured on SD-OCT was 186.36± 44.02 μ (range: 120-240 μ). Mean depth of ablation performed using FS laser was 203.64 ± 41.42 μ. All patients were followed up at 1 week, 1, 3, 6, 9, and 12 months. Mean follow-up period was 14 months (12-16 months). BCL was removed after 3 weeks in all patients [Fig. 3]. Table 1 gives details regarding the patients involved in the study. SD-OCT was performed in all postoperative visits [Fig. 4]. The mean postoperative best corrected visual acuity (BCVA) (in decimals) improved from 0.11± 0.06 preoperatively to 0.59 ± 0.08. In all patients who underwent FALK, the BCVA improved to 20/40 or better irrespective of the underlying etiology. There was no induced astigmatism in any of the cases; however, we did notice a slight hyperopic shift ranging from 0.5 DS to 1.0 DS in 7 patients.

No intra-operative complications related to donor or recipient cornea were noticed during the procedure. The FS laser showed good lamellar and side cut in areas of the cornea where there was scarring.

Postoperatively, one patient had epithelial ingrowth involving 1-clock hour, which was observed at the 6 months follow-up. However, further follow-up did not show any progression of the epithelial ingrowth and hence, no further

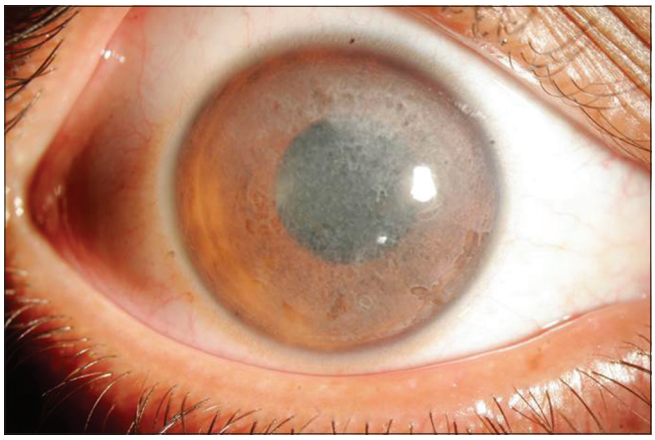

Figure 1: Preoperative slit lamp photo showing anterior stromal scarring in a patient with Reiss-Buckler dystrophy

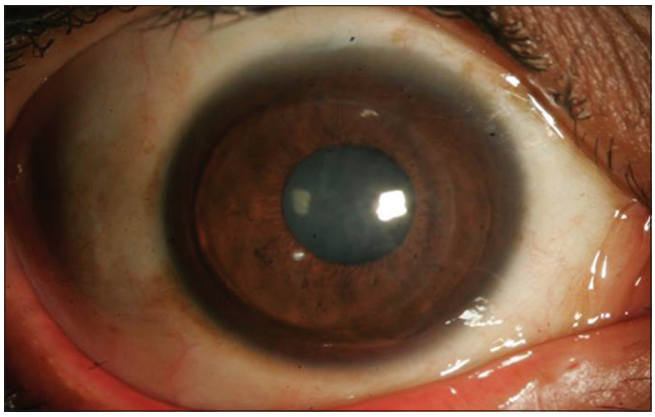

Figure 3: Postoperative slit lamp photo at 3 weeks post femtosecond anterior lamellar keratoplasty

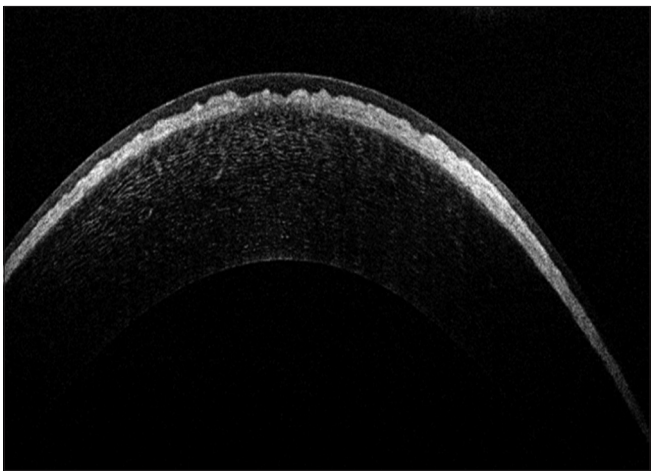

Figure 2: Spectral domain optical coherence tomography imaging of a patient with Reiss-Buckler dystrophy showing irregular epithelium and basement membrane with anterior stromal scarring

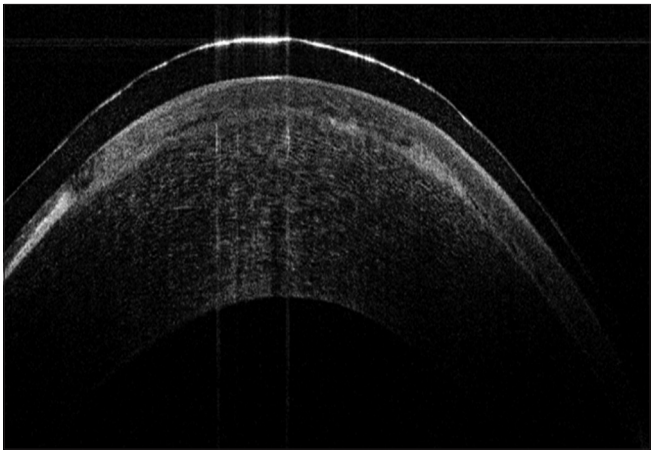

Figure 4: Spectral domain optical coherence tomography imaging of a patient with Reiss-Buckler dystrophy at 3 weeks post Femtosecond anterior lamellar keratoplasty

Table 1: List of the patients undergoing FALK

Pathology	Depth of scar (in μ as measured with SD-OCT)	Preoperative BCVA	Postoperative BCVA (at 1-year)
Partial LSCD with anterior stromal scar	160	20/400	20/30
Macular dystrophy	160	20/120	20/40
Granular dystrophy	170	20/120	20/30
Reiss-Buckler dystrophy	120	20/120	20/30
Postmicrobial keratitis	240	20/400	20/30
Reiss-Buckler dystrophy	130	20/120	20/40
Postmicrobial keratitis	220	20/320	20/30
Postmicrobial keratitis	220	20/120	20/30
Macular corneal dystrophy	200	20/200	20/40
Postmicrobial keratitis	240	20/400	20/40
Postmicrobial keratitis	190	20/320	20/30

BCVA=Best corrected visual acuity, LSCD=Limbal stem cell deficiency, FALK=Femtosecond anterior lamellar keratoplasty, SD-OCT=Spectral domain optical coherence tomography

intervention was required. None of the patients had any problems related to epithelial or stromal healing.

Discussion

Danjoux *et al*.,[10] explained that corneal scars may induce irregular astigmatism and loss of visual acuity. Vajpayee *et al*. reported positive results using automated lamellar keratoplasty for diseases affecting the anterior stroma to midstroma of the cornea.[11] ALK has the advantage of not needing sutures to hold the donor graft lenticule in place, and hence, no suture-related complications associated with DALK and PKP. Since the topical steroids are required for a short period of time, no long-term side effects of topical steroids are noticed.

Rycroft BW explained LK done by free-hand dissection leading to interface irregularities and subsequent subnormal visual acuity.[12] Barraquer introduced the microkeratome to perform mechanical lamellar dissections, improving the optical quality of the cut.[13] Sarayba *et al*. used femtosecond laser so that a better quality stromal bed resulted and hence, better optical quality as opposed to a mechanical microkeratome.[14] In our study, we noticed an improvement in visual acuity in all the cases post FALK.

Krumeich *et al*., concluded that in ALK, visual acuity can degrade over time, even if the microkeratome or a femtosecond laser is used to achieve a smooth initial resection.[15] In our study, there was no deterioration of visual acuity nor increase in the interface haze after 1 year follow-up. However, we did notice that the visual acuity never reached 20/20 in any of the cases, this might be attributed to the stroma to stroma interface causing a mild haze. Stroma-to-DM interfaces, as achieved in DALK, provide higher quality vision.[16,17] Mosca *et al*., in their study, on early results of femtolaser-assisted ALK found results, with slight patient's dissatisfaction in the first months after surgery. When they followed the patients over a period of 3 years, the improvement in BSCVA was significant, and they attributed this improvement to the residual stromal bed resulting in irregularities.[18]

Yoo *et al*., concluded that FALK with its ability to perform precise corneal dissections at preprogrammed depths, various orientation, and accurate fit between the donor tissue and the recipient cornea is a better alternative to conventional ALK and PK without significant short-term complications.[19] In our study, lenticule-related complication like incomplete lenticule, lenticule tear, etc., that can occur with microkeratome was not seen with FS laser.

Postoperative SD-OCT also showed that the cuts with MK gives a meniscus shaped corneal lenticule with thicker periphery and thinner center which may not be ideal for central anterior stromal opacities. This drawback is eliminated using femtosecond laser where the donor lenticule is of uniform thickness.

The drawbacks of our study are the limited number of patients and the need for a long-term follow-up.

Conclusion

Femtosecond anterior lamellar keratoplasty is an effective and safe procedure in the management of anterior corneal pathologies without the long-term complications seen in PKP or the technical difficulties seen during performing DALK.

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