· Brief Report ·

Manual Bowman-stroma onlay transplant for the treatment of symptoms post-radial keratotomy: proof of concept and preliminary results

Abdo Karim Tourkmani[1,2,3], Jorge L. Alio del Barrio[3,4], Hao Zhang[4], Jorge L. Alio[3,4]

[1]Great Western Hospitals NHS Foundation Trust, Swindon, England SN3 6BB, UK
[2]Ulster University, Northern Ireland BT15 1ED, UK
[3]Universidad Miguel Hernandez, Elche 03202, Spain
[4]Vissum Miranza, Alicante 03016, Spain
Correspondence to: Abdo Karim Tourkmani. Great Western Hospitals NHS Foundation Trust, Swindon, England SN3 6BB, UK. abdo.tourkmani@nhs.net
Received: 2025-06-10 Accepted: 2025-09-05

Abstract
● **AIM:** To describe the technique and the outcomes of manual Bowman layer and stroma transplant-onlay (BLST-o) for 2 cases of radial keratotomy (RK).
● **METHODS:** Two patients with visual fluctuations and corneal irregularity due to RK were offered manual BLST-o as an alternative to penetrating keratoplasty (PKP). Visual acuity, refraction, corneal topography, corneal aberrometry, and corneal optical coherence tomography (OCT) pre- and postoperative were analyzed. Histology was obtained for 1 case.
● **RESULTS:** Both patients had corneal anatomical and morphological improvement, with elimination of the visual fluctuations. In one case, a subsequent excimer laser treatment improved corneal shape further, thus improving vision. The other case, whereas initially improved, developed epithelial ingrowth following suture removal. The latter was explanted and had a xenogeneic implant. The explanted sample was sent for histology, showing a viable graft of Bowman layer and anterior stroma.
● **CONCLUSION:** Manual BLST-o is a potential option for the management of symptoms post RK. These grafts may facilitate subsequent treatments such as laser corrections, and may not preclude from other interventions after explantation.
● **KEYWORDS:** radial keratotomy; Bowman layer transplant; Bowman layer and stroma transplant
DOI:10.18240/ijo.2026.01.22

Citation: Tourkmani AK, Alio del Barrio JL, Zhang H, Alio JL. Manual Bowman-stroma onlay transplant for the treatment of symptoms post-radial keratotomy: proof of concept and preliminary results. *Int J Ophthalmol* 2026;19(1):181-184

INTRODUCTION

Numerous corneal disorders can cause poor vision due to corneal irregularity, and may require invasive surgery such as penetrating keratoplasty (PKP) or deep anterior lamellar keratoplasty (DALK).

Bowman layer onlay transplant (BLT-o) has emerged as a new form of treatment for many of these conditions[1-3], including radial keratotomy (RK)[4]. Following RK, there can be complains of visual disturbances and diurnal visual fluctuations due to variable degrees of corneal irregularity, and edema around the keratotomies.

Bowman layer transplant (BLT) possesses several advantages over PKP or DALK[5], such as quicker recovery time and no risk of rejection. Previous literature reported a rate of Bowman layer (BL) graft wastage of approximately 30%.

We published 2 works with the results of Bowman layer inlay transplant (BLT-i) for the treatment of keratoconus[6-7]. We introduced slight changes in our BL harvest technique, which was easier in our hands. Intraoperatively, the tissue would spontaneously curl into a roll, suggesting that the graft was formed of isolated BL. We published an additional work where a further modification was implemented, obtaining consistently a BL and stroma (BLS) graft, which was used as an onlay (Bowman layer and stroma transplant-onlay; BLST-o) for tectonic purposes[8]. We observed in these cases that the additional layer (or layers) of stroma would adapt to the underlying host irregularities, in some kind of lock-and-key fashion, preserving a smoother corneal surface.

Considering the observed properties of a BLST-o graft, and the stromal irregularities induced by RK cuts, we considered BLST-o a better suited option for RK cases. For this work, 2 patients with severely irregular corneas following RK were offered a BLST-o.

PARTICIPANTS AND METHODS

Ethical Approval Written informed consent was obtained from the patients for the surgeries described in this manuscript and for the use of their medical records in writing this case report. Ethics approval from Vissum Miranza Ethics Review Board was not required for the completion of this brief report. Two patients with history of RK, subjective poor visual quality and fluctuations, and unwilling to undergo DALK or PKP were included. We offered a BLST-o as an alternative.

In a previous works of our group, we introduced some modifications to the original graft harvest technique[5], resulting in repeatable harvest of BLS used as an onlay[8]. We used the same technique for this work. Briefly, after mounting the donor cornea in an artificial anterior chamber (AC) and filling it with air, the epithelium of the donor cornea was debrided. A superficial scoring was performed with a 30g needle 360 degrees in the periphery. A 360 degree Bowman flap was lifted *via* scraping with the short end of a Morlett spatula. The scraping was continued until complete graft harvest.

The surgery on the host consisted of the removal of the corneal epithelium, resting the BLS graft on patient's cornea with the stromal side down (easily identifiable due to its mild roughness), then fixing the graft with a running 10×0 nylon suture, and secured with a bandage contact lens (BCL). Postoperative treatment consisted of Tobradex QD for 2wk, then BD for 2wk, and lubricating eyedrops. Upon full corneal epithelialization, the BCL and the suture were removed. Graft monitoring was done on an individualized basis. Visual acuity (VA), refraction, slit lamp examination, corneal topography, tomography, and aberrometry were performed as deemed necessary.

RESULTS

Case 1 A 31 years old male patient consulted due to poor quality vision and fluctuations in his left eye. He had a history of bilateral RK for myopia, and refractive lens exchange (RLE). Preoperative corrected distance visual acuity (CDVA) with +4 sphere (sph/-1.25×60) was 1.0 (decimal scale). Corneal topography showed significant asymmetry. We offered a BLST-o.

The surgery was uneventful. Ten months postoperative, CDVA with -2.25 sph (-3.25×174) dropped to 0.7 (decimal scale), and 1.0 with pinhole, without visual fluctuations and much less glare. Preoperative coma and spherical aberration were 1.21 and 0.36 μm for a 6 mm pupil. Postoperatively, the values were 0.88 and 0.74 μm. The increase in spherical aberration is attributable to the postoperative myopic shift. However, the patient was still unable to fit a rigid contact lens. Figure 1 shows the preoperative and postoperative corneal topography. Optical coherence tomography (OCT) scan showed a graft thickness of approximately 150 μm (Figure 1). Few months later, the patient underwent a transepithelial phototherapeutic keratectomy (PTK) to further reduce the corneal surface irregularity. CDVA remained 0.7, and reached 1.0 with a rigid contact lens (CL). Presently, patient is considering a topography guided laser treatment for refractive correction.

Case 2 A 60-year-old male with history of RK for myopia consulted due to poor, fluctuating vision in his left eye. He also had RLE and sulcus piggy back intraocular lens (IOL). Refraction and CDVA preoperatively were 0 sph (-3.00×55)=0.4 (decimal scale), with significant glare and fluctuations. Corneal topography showed an extremely irregular, asymmetric cornea. We offered a BLST-o.

The surgery was uneventful. The initial postoperative period showed satisfactory evolution, with maintained CDVA and resolution of his reported visual fluctuation. The corneal suture was removed after full epithelial healing. Six weeks later, the patient complained of a gradual drop in vision, attributed to epithelial ingrowth. Ultimately, a BLST-o removal, interface cleansing, and xenogeneic onlay implant (Xenia) was performed. His postoperative refraction and CDVA after stabilization of the Xenia implant were -1.50 sph (-4.00×40)=0.4 (decimal scale), and have remained stable since. Figure 2 demonstrated the topographical changes before BLST-o and right after the suture removal, before any epithelial ingrowth took place; and a slit lamp photograph and the OCT of the epithelial ingrowth after the suture removal. There was marked regularization of the cornea, with reduced aberrations for a 6 mm pupil. Coma and spherical aberration were 6.98 and 2.95 μm preoperatively; and 1.74 and 0.70 μm postoperatively. The extracted BLS graft was sent for histological examination, confirming a graft of BLS.

DISCUSSION

BLT-o has emerged as a new technique for the management of different corneal diseases[1-7].

The original graft harvest technique[5] aims for isolated Bowman grafts. However, the risk of wasting the tissue is as high as 30%.

The difficult process of obtaining an isolated BL graft is probably one of the main reasons that limits the spread of BLT. Hence, numerous research works have focused on newer techniques for graft harvest. These are mainly femtosecond laser assisted techniques[9] which are very expensive, and likely to obtain grafts of BLS. Preliminary results show comparable postoperative results to those of isolated BL grafts.

One group has published good results with BLS grafts as an inlay[10]. This technique still requires the use of expensive femtosecond lasers.

In a previous work, we introduced a few modifications in the manual BL graft harvest, which resulted in a consistent manual harvest of BLS grafts. These were satisfactorily used for tectonic purposes[8].

In our cases herein, the two patients suffered from irregular corneas and were adamant to try other therapies to avoid more aggressive procedures.

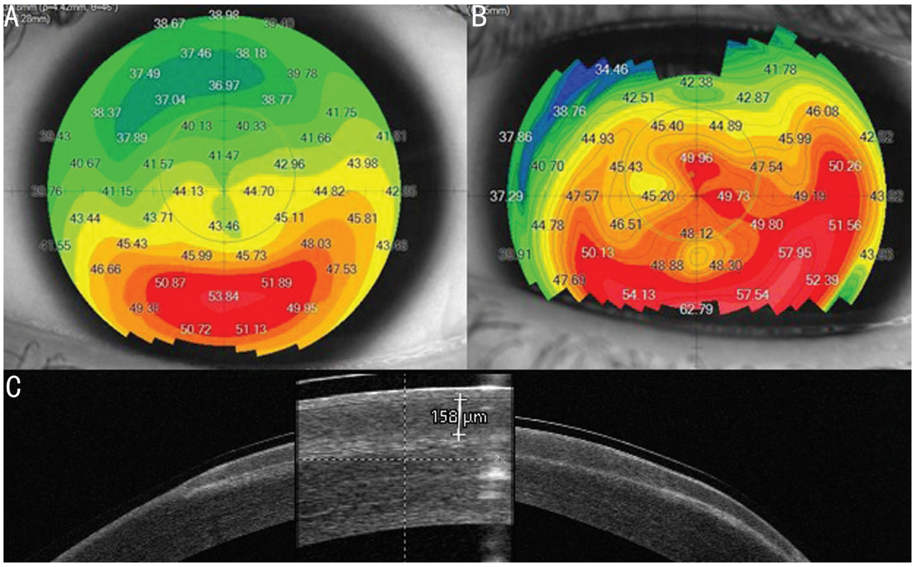

Figure 1 Cornea imaging before and after BLST-o for radial keratotomy A: Preoperative corneal topography. B: Corneal topography after BLST-o and prior to the subsequent PTK treatment. Note marked improvement in the corneal anatomy. C: Corneal OCT showing BLS graft of approx 158 µm. BLST-o: Bowman layer and stroma transplant-onlay; PTK: Phototherapeutic keratectomy; OCT: Optical coherence tomography.

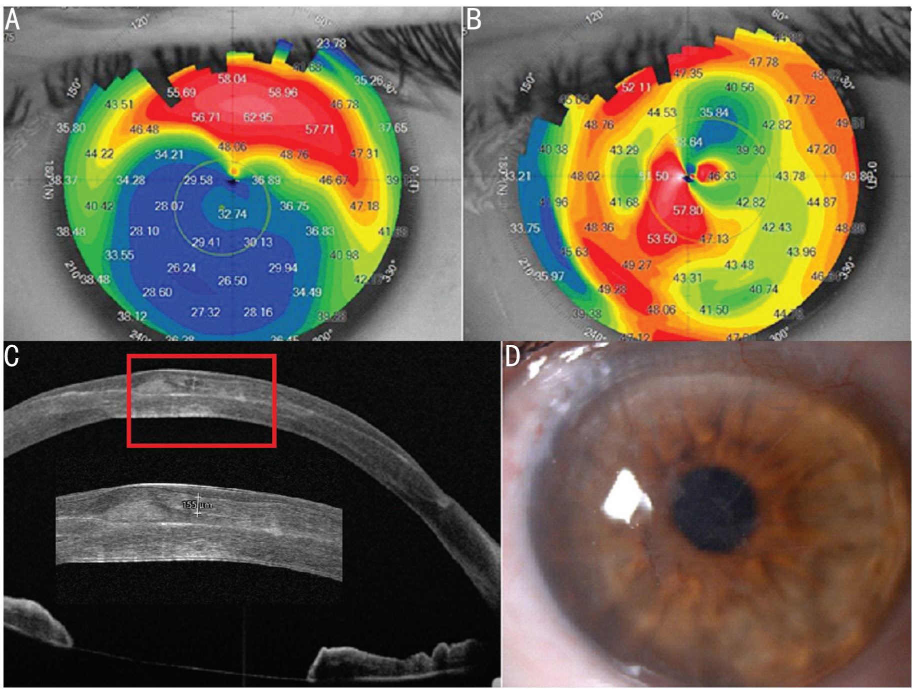

Figure 2 Corneal imaging before and after BLST-o for radial keratotomy Preoperative topography (A) and postoperative (B) after suture removal and before development of epithelial ingrowth. Note significant regularization of the corneal profile. C: OCT showing BLST-o graft and nest of epithelial ingrowth. Graft thickness is measured at around 155 µm. D: Slit lamp photograph showing a clear graft and nests of epithelial ingrowth. BLST-o: Bowman layer and stroma transplant-onlay; OCT: Optical coherence tomography.

We offered BLST-o as a less invasive option with a reproducible manual graft harvest, potentially with quicker visual recovery; and also an eventually reversible procedure, that wouldn't prevent a future PKP if required[1-5,8].

In both cases the tissue integrated well, with a comparable initial response. One case achieved further improvement after a subsequent laser procedure. This could be applied following BLST-o, as there is additional stromal tissue, unlike with isolated BLT, in which the laser would ablate the full graft itself. The other case developed epithelial ingrowth and opted for other options of treatment. Since the ingrowth happened after suture removal, there's reasonable doubt that the graft was not primarily the problem.

The OCT scans showed a BLS graft. The case which developed epithelial ingrowth was explanted and sent for histology, confirming a BLS graft.

These findings throw light on several questions generated by previous reports, and raise some additional questions.

A scraping (not peeling) process delves deeper into the corneal stroma. This results in a BLS graft, without graft tears. The process is repeatable and the scraping from all 4 quadrants joins in one plane in the center. The thicknesses measured in OCT were reasonably repeatable (Figures 1 and 2), of approximately 150 µm. We propose that such repeatability with a scraping method can only be obtained when there is some kind of cleavage plane; otherwise, initiating the scraping from different quadrants should have resulted in different planes being created, not joining in the center. In the explanted case, histology confirmed that the tissue was a BLS graft. In retrospect, the case could have been eligible for a graft lift, scrape and cleansing of the interface, and resuturing; however without available evidence around this, we opted for explantation.

To summarise, our manual graft harvest technique results in consistent BLS grafts. In our two cases, there was a marked, relatively quick, improvement in the corneal anatomy and function. One case was eligible for subsequent laser treatment, and in the other case, the BLST-o did not preclude safe explantation and a subsequent intervention.

Since other techniques for graft harvest[9-10] obtain Bowman-stroma grafts, without tissue wastage, and comparable outcomes to isolated BL grafts, it would seem a logical step to transition from isolated BLT to BLST. And with our technique, there is no requirement for expensive equipment.

This research work adds evidence that BLST-o can be an alternative for the treatment of RK. We present grounds to support that manual BLS grafts should not be discarded; that BLST-o can provide with good results; that the procedure is reversible, and/or doesn't preclude other treatments over the graft itself or after its removal. And, whereas it is not possible to compare directly our results with those of DALK or PKP for the same indication, the available evidence suggests BLST-o is a less invasive procedure with less chances of rejection. Further studies are needed to confirm our findings.

ACKNOWLEDGEMENTS

Conflicts of Interest: Tourkmani AK, None; **Alio del Barrio JL,** None; **Zhang H,** None; **Alio JL,** None.

REFERENCES

1 Dapena I, Parker JS, Melles GRJ. Potential benefits of modified corneal tissue grafts for keratoconus: Bowman layer 'inlay' and 'onlay' transplantation, and allogenic tissue ring segments. *Curr Opin Ophthalmol* 2020;31(4):276-283.

2 Sirolova Z, Polachova M, Baxant AD, *et al*. A review of Bowman's layer structure, function, and transplantation. *Cell Tissue Bank* 2024;25(4):897-908.

3 Parker JS, Dockery PW, Melles GRJ. Bowman layer transplantation—a review. *Asia Pac J Ophthalmol* 2020;9(6):565-570.

4 Parker JS, Dockery PW, Parker JS, *et al*. Bowman layer onlay graft for reducing fluctuation in visual acuity after previous radial keratotomy. *Cornea* 2020;39(10):1303-1306.

5 Dragnea DC, Birbal RS, Ham L, *et al*. Bowman layer transplantation in the treatment of keratoconus. *Eye Vis* (*Lond*) 2018;5:24.

6 Tourkmani AK, Mohammad T, McCance E, *et al*. One-year front versus central and paracentral corneal changes after bowman layer transplantation for keratoconus. *Cornea* 2022;41(2):165-170.

7 Tourkmani AK, Lyons C, Hossain PN, *et al*. 1 year posterior corneal changes after Bowman Layer Transplant for keratoconus. *Eur J Ophthalmol* 2022;32(3):1370-1374.

8 Tourkmani AK, McAlinden C, Anderson DF, *et al*. Simultaneous tectonic Descemet stripping endothelial keratoplasty and tectonic Bowman layer transplant for the management of corneal perforation. *Int J Ophthalmol* 2023;16(9):1549-1554.

9 Barbosa Gonçalves T, Forseto ADS, Martins AL, *et al*. Femtosecond laser-assisted Bowman layer transplantation for advanced keratoconus. *Eur J Ophthalmol* 2022:11206721221143163.

10 Mittal V, Rathod D, Sehdev N. Bowman-stromal inlay using an intraocular lens injector for management of keratoconus. *J Cataract Refract Surg* 2021;47(12):e49-e55.