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CASE REPORT

Triple chamber: a clinical rarity after deep anterior lamellar keratoplasty and role of optical coherence tomography in management

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Abstract
Purpose To report a case demonstrating triple chamber following deep anterior lamellar keratoplasty (DALK) and its successful intra-operative optical coherence tomography-guided management.
Method Case report of a young male with macular corneal dystrophy, who underwent DALK in his left eye by Big-Bubble technique. The surgery was uneventful. On the first post-operative day, triple chamber was observed and followed-up with serial clinical photography and anterior segment optical coherence tomography. Due to decrease in graft clarity and increase in volume of the two extra chambers, interface drainage along with descemetopexy was undertaken 4 days later.
Result The compartments constituting the triple chamber were those in-between the donor tissue and host pre-Descemet layer (Dua's layer), the latter and host Descemet membrane and the true anterior chamber. Presence of viscoelastic in the interface was identified as the cause. Microscope integrated optical coherence tomography (MiOCT) guided drainage followed by intracameral air tamponade ensured near total disappearance of the two extra chambers at the end of surgery. Examination on the next day confirmed complete apposition of the graft and host.
Conclusion To the best of our knowledge, this is a unique demonstration of Dua's layer in vivo by slit lamp biomicroscopy and description of MiOCT guided management of triple chamber.

Keywords Deep anterior lamellar keratoplasty · Dua's layer · Interface viscoelastic · MiOCT guided · Pre-Descemet layer · Triple chamber

Introduction

Deep anterior lamellar keratoplasty (DALK) is a technique by which the pathological anterior corneal layers up to the Descemet membrane (DM) are replaced. It can be done for optical indications such as stromal dystrophies, keratoconus, and corneal scars which have a healthy DM and endothelium. Therapeutic and tectonic DALK is also well known [1]. Though different methods have been described to achieve the right cleavage plane for DALK, the 'Big Bubble technique' [2] has become the most popular. This method has serendipitously proved useful to redefine the corneal anatomy by discovery of a new pre-Descemet layer [3]. Here, we report a case of DALK by Big Bubble technique showing post-operative triple chamber, with distinct demonstration of

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the pre-Descemet layer on slit lamp biomicroscopic photography and anterior segment optical coherence tomography (ASOCT). We also describe 'Microscope integrated Optical Coherence tomography' (MiOCT) guided successful management of the above complication. The guideline of Helsinki declaration has been followed.

Case report

A 27-year-old male presented to us with complaints of decrease in vision in left eye (OS) for past 4 years. He had similar complaints in his right eye (OD) also until a year back, when he was diagnosed macular corneal dystrophy OU and underwent DALK in his right eye. Surgery and post-operative course were uneventful with good gain of vision in the eye. He presented again for the treatment of his left eye. His presenting best-corrected Snellen visual acuity (BCVA) was OD 6/9 and OS 3/60. The intraocular pressure (IOP) was 18 mm Hg in both eyes. Slit lamp biomicroscopy (Haag-Streit Diagnostics, BQ900, USA) of right eye showed a clear corneal graft with a well-apposed graft-host junction (GHJ) and a clear interface. Left eye showed classical features of macular dystrophy (Fig. 1a). Rest of the ocular examinations was unremarkable. ASOCT (Visante^{TM} OCT, Carl Zeiss Meditec Inc, USA) revealed corneal opacification up to the level of deep stroma and thinning.

The patient underwent left eye DALK by Big Bubble technique under general anaesthesia. Partial trephination and lamellar dissection were done. Air was injected in the posterior stroma, and a Big Bubble was formed. A nick was given through the stromal layers to deflate the bubble, and dissection was continued after injecting hydroxypropyl methylcellulose 2% (Visilon®, Shah & Shah, India) to avoid inadvertent Descemet membrane injury or perforation. Dissection up to Descemet membrane in depth and edge of trephination mark in extent was completed. The donor button Descemet membrane was stained with trypan blue dye 0.06% w/v (Auroblue®, Aurolab, India) and was peeled off the donor tissue. The graft was placed over the host bed and secured with interrupted 10-0 monofilament nylon sutures. The graft appeared well apposed to the host bed, and hence the surgery was concluded.

On post-operative day 1, the BCVA was 6/24 with graft clarity (GC) of 3 + (Collaborative corneal transplantation study group grading) but a 'triple chamber' was appreciable (Fig. 2a). Thinking this to be interface fluid, we initially observed the patient for spontaneous resolution. However, in view of progressive deterioration in vision and reduction in graft clarity accompanied by widening of the extra chambers (Fig. 2b), surgical intervention was undertaken 4 days later. Microscope integrated optical coherence tomography (MiOCT) (OPMI LUMERA 700 and RESCAN 700, Carl Zeiss, Meditec, Germany) guided interface drainage was performed under topical anaesthesia. On releasing one suture, there was visible egression of retained viscoelastic from the interface (Fig. 3b). Residual viscoelastic was further aspirated using a cannula, and simultaneous decrease in size of the extra chambers was appreciated on MiOCT. Few pockets of viscoelastic sequestration were still noticeable on the MiOCT, giving a tabletop configuration (Fig. 3c). An additional suture corresponding to the residual pocket (infero-temporal) was released and

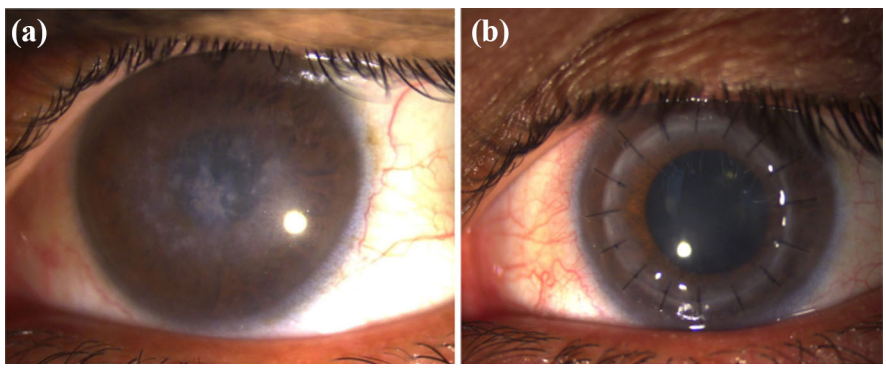

Fig. 1 Slit lamp biomicroscopic photographs showing. **a** Pre-operative discrete nebula-macular opacities with indistinct margins and intervening stromal haze suggestive of macular corneal dystrophy. **b** Post-deep anterior lamellar keratoplasty 3 weeks showing a clear graft

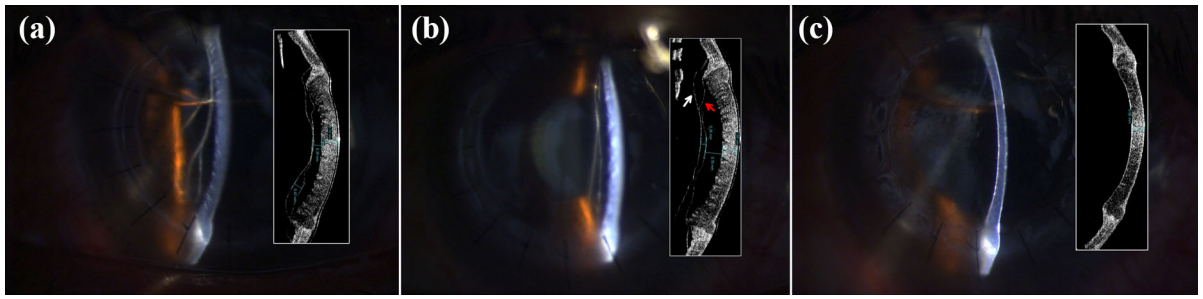

Fig. 2 Slit lamp biomicroscopic photographs and its corresponding anterior segment optical coherence tomography (ASOCT) as inset. **a** Post-operative day 1 showing triple chamber. **b** Post-operative day 3 showing widening of the extra chambers (Red arrow: Pre-Descemet layer; white arrow: Descemet membrane). **c** Post-interface drainage + descemtopexy day 1 showing complete graft-host apposition

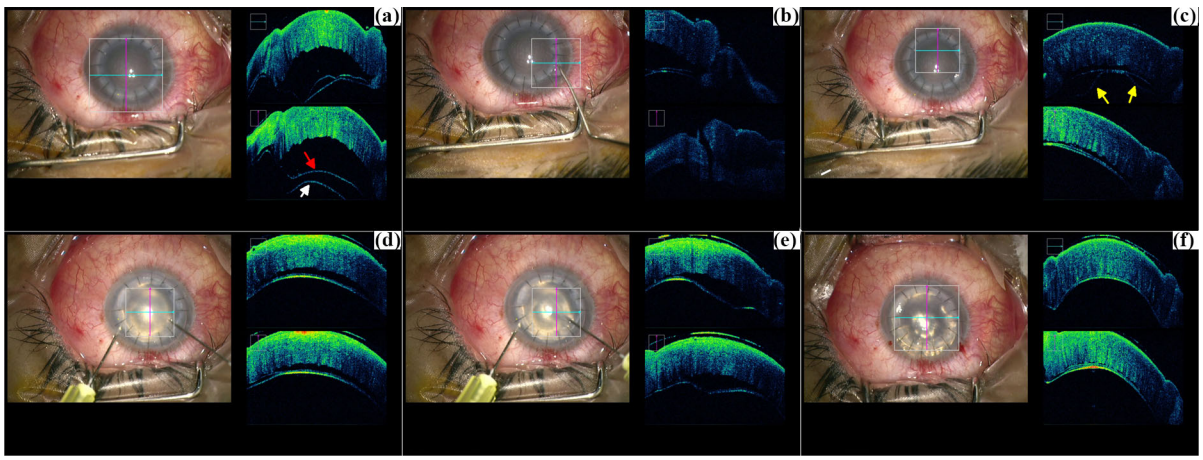

Fig. 3 Intra-operative microscope integrated optical coherence tomography (MiOCT) pictures. **a** Triple chamber with two redundant layers originating from the host (Red arrow: pre-Descemet layer; white arrow: Descemet membrane). **b** Viscoelastic egressing out of the interface on opening the wound with Sinskey hook. **c** Narrowing of the extra chambers noted after viscoelastic aspiration from the interface. Peripheral sequestration of viscoelastic shows a tabletop configuration on OCT (yellow arrows). **d** Residual viscoelastic noted between the graft and host pre-Descemet layer after intracameral air tamponade. Location for stab incision being planned under MiOCT guidance. **e** Stab incision of required depth to reach the residual viscoelastic given under MiOCT guidance with a 30 gauge needle. **f** Near total resolution of the extra chambers, adequate intracameral air tamponade and anatomical apposition of the host Descemet membrane, pre-Descemet layer and the graft confirmed on table

viscoelastic aspirated. Air was injected into the anterior chamber to provide intracameral tamponade (descemetopexy). The chamber between the pre-Descemet layer and DM disappeared, while residual pockets with retained viscoelastic still persisted between the graft and pre-Descemet layer (Fig. 3d). Guided by the MiOCT, a stab incision with 30G needle was made at the highest point and of required depth until the viscoelastic pocket at the interface was reached (Fig. 3e).The two extra chambers were thus emptied, and the apposition of graft and host layers was confirmed on table (Fig. 3f). The air tamponade was augmented and surgery concluded.

Examination on the next post-operative day confirmed the disappearance of both the extra chambers by slit lamp biomicroscopy and ASOCT (Fig. 2c). Seven days after the interface drainage and descemetopexy, the BCVA was 6/24 with a clear graft which was well attached and the vision improved further to 6/12 3 weeks post-operatively (Fig. 1b).

Discussion

Though double anterior chamber is a known complication of keratoplasty, 'Triple Anterior Chamber' has been described only twice in literature, as consisting of two pseudo-chambers, between the donor tissue and the host residual stroma, and between the latter and the host DM, along with the true anterior chamber [4, 5]. The phenomenon of residual stroma after Big-Bubble DALK had been reported earlier [6], but it was Dua et al. who later specifically attributed this residual stroma to a distinct layer in the cornea and reported it as a novel sixth layer of the human cornea, the pre-Descemet layer (Dua's layer) [3]. Hence, the three chambers clearly visible from anterior to posterior in our case are constituted by the following spaces: (a) Between the graft and the host pre-Descemet layer (Dua's layer) (b) Between the latter and the host DM and, (c) the true anterior chamber.

The etiopathogenesis of pseudo-chambers includes micro- or macro-perforations of the DM or its detachment [4, 5]. Fluid or viscoelastic may constitute these spaces [5, 7, 8]. In our case, it was the retained viscoelastic that was used to aid smooth and safe stromal dissection for baring an intact DM. In the absence of any intra-operative perforation, the question of interest to us was how the viscoelastic skeletonized the pre-Descemet layer by passing on either side of it. Our conjecture is that it seeped along, following the natural anatomical path taken by the injected air, as can happen with a mixed type Big Bubble. Dua et al. showed that the type-1 Big Bubble formed anterior to pre-Descemet layer, type-2 formed between the pre-Descemet layer and Descemet membrane, and mixed bubble was a combination of both [3]. He hypothesized that the pre-Descemet layer ends short of the edge of Descemet membrane, and hence, the occurrence of a mixed type Big Bubble indicates that apparently there is a continuum of the spaces on either side of it, at the periphery. This provides a path for spread of fluid into both the spaces simultaneously. A recent case report has demonstrated the post-operative splitting of DM from the pre-Descemet layer, post a mixed bubble DALK [9]. However, they had noted a micro-perforation and the chambers collapsed with only re-bubbling, while the situation in our case, being recalcitrant and subsequent clinical course suggesting retained viscoelastic, demanded further intervention. Regardless of the cause, both these cases underscore the heightened tendency of DM detachment from the pre-Descemet layer following mixed bubble formation, due to establishment of a potential space between them by the deeper type-2 part of the mixed bubble.

In view of uneventful surgery, we initially decided to observe the patient for spontaneous resolution. Subsequently, we surmised the cause as interface viscoelastic, when a gradual expansion of the extra chambers was noticed. Somewhat akin to capsular bag distension syndrome, where retained viscoelastic [10] progressively expands by imbibing aqueous, the trapped viscoelastic in the corneal spaces in this case, also possibly imbibed fluid and progressively expanded in volume requiring surgical intervention. Intra-operative findings and post-operative outcome confirmed the above.

Management of triple chamber can be conservative or surgical. Surgical management includes descemetopexy, where air or gas (C3F8 or SF6) is injected into the anterior chamber to provide internal tamponade, thereby apposing a detached DM to its overlying stromal bed by mechanical pressure from within the anterior chamber. It can be augmented with interface drainage when deemed necessary [7]. Though MiOCT has been used in the management of post-DALK DM detachment, such management of a post-DALK triple chamber is being reported here for the first time [7]. Intra-operative MiOCT scanning of the interface revealed the locations of residual viscoelastic and helped plan the site of suture release, replacement, and placement of stab incisions for optimal success. In addition, the adequacy of tamponade by the intracameral air bubble was easily assessed. The resolution of extra chambers and the anatomic apposition of the host DM, pre-Descemet layer, and graft was satisfactorily confirmed on the operating table giving the surgeon an added advantage.

Thus, this report elucidates the pre-Descemet layer in vivo by lucid clinical images correlated with their respective ASOCT images. Through this case report, we emphasize on a thorough interface wash in viscoelastic aided DALK procedures, which may prevent undue occurrence of post-operative extra chambers. However, complications can occur despite adequate measures. In such instances, this report may again be of help, which details the diagnostic clues and MiOCT guided step-by-step approach for successful

surgical management of 'Triple Chamber' post-Big-Bubble DALK.

Compliance with ethical standards

Conflicts of interest All 4 authors declare that they have no conflict of interest.

Informed consent Informed consent was obtained from the participant of this case report.

Research involving human participants The procedures performed in this report involving human subject were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments.

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