Early Bubble Modification of the Big Bubble Technique for DALK

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Abstract

Purpose: To modify the Deep Anterior Lamellar Keratoplasty Big Bubble technique for more safety and ease of performance.

Methods: We describe our modification of the big-bubble technique that involves injecting the air bubble through the depth of an incision made using a limbal relaxing incision knife in the corneal periphery, 1mm from the limbus. This is done before trephination of the recipient cornea, hence the name "early bubble". The goal of this technique is to reduce the risk of intraoperative corneal perforation and to obtain a large air bubble between Descemet’s membrane and the corneal stroma. We have performed this technique on 21 eyes.

Results: At 6 months 16 eyes showed BCVA of 20/50 and all the rest had BCVA of 20/80 or better. The postoperative corneal astigmatism was 3.6 ± 0.9 diopters at 3 months and after 6 months it was 3.15 ± 0.67 diopters. The rate of conversion to penetrating keratoplasty was 14%.

Conclusion: We find deep anterior lamellar keratoplasty easier, safer and more predictable with this technique.

Key Words: Lamellar keratoplasty – Big bubble technique.

Introduction

LAMELLAR keratoplasty (LKP) was developed more than 150 years ago [1,2]. The first attempt to dissect near Descemet’s membrane (DM), attempting deep anterior lamellar keratoplasty (DALK) was by Hallermann [1,3]. The main disadvantage of DALK is of being both a technically more challenging and time-consuming procedure with a steep learning curve compared with penetrating keratoplasty (PK) with high possibility of DM perforations, particularly when the host stroma is manually removed layer by layer until the DM is exposed [4]. Another reason for surgeons to perform a PK for anterior corneal disorders is that lamellar transplants often show decreased best corrected visual acuity owing to irregular astigmatism and/or scarring at the donor to recipient interface [5,6].

Less scarring may occur with deeper that is, smoother keratectomies and techniques such as air injection and hydrodelamination or photoablation of the posterior stroma have been advocated to obtain a deep recipient stromal bed [7-9]. Archila [9] and Anwar [10] were the first to describe complete baring of DM in the recipient cornea. This technique promised to result in less interface opacity and hence improved visual acuity postoperatively, yielding vision comparable to that resulting from PK.

As concluded by Anwar [11] in 1972 when he described the dissection technique for LKP, lamellar transplants are more advantageous in being followed by fewer complications as the globe is not opened, also, the donor material does not have to be as fresh as that required in full-thickness keratoplasty. He stressed the importance of improving the visual results of the lamellar operation as well as making it the first choice intervention if the endothelium is found to be healthy.

In our study, we are presenting a modification of the big bubble technique [1] aiming to overcome some of the difficulties encountered by various surgeons during the procedure.

Subjects and Methods

Technique:

In our technique (Figs. 1-5), we start with performing a separate corneal incision, 1mm inside the limbus, using a 550m guarded limbal relaxing incision knife after performing pachymetry (Fig. 1 top). A peripheral paracentesis was performed. A 27- or 30-gauge needle is attached to a 1 to 3mL air-filled syringe. The needle is bent approximately 5.0mm from its tip so that the terminal segment angles up approximately 60 degrees while the bevel
faces down. The tip is introduced, bevel down, into the corneal stroma at the chosen entry site, in the depth of the incision. Under direct visual control, the needle is carefully advanced towards the centre of the cornea in a direction halfway between a tangential and a radial one until the bevel is completely buried, about 3.0mm from the entry point. Air is injected progressively into the stroma, with the aim of achieving the formation of a large air bubble between the DM and stroma extending as peripheral as possible (Fig. 1 bottom). This usually appears in the form of a white disk starting near the tip of the needle and gradually enlarging towards the periphery of the cornea. If the bubble doesn’t form, air injection can be repeated by re-entering from the incision site. When a sufficient bubble is achieved, a small amount of aqueous is allowed to escape to lower the intraocular pressure. As the bubble is injected before trephination of the recipient bed, we chose the name “Early Bubble Modification of the Big Bubble Technique”.

The size of trephination of the recipient bed is determined aiming to surround the entire superficial stromal pathology. Partial-thickness trephination of the cornea is performed (Fig. 2 top) to a depth between 350m - 400m using a Hanna suction trephine (Moria, Paris, France) that can be set in 100m steps only or a Hessburg-Barron vacuum trephine (Jedmed Instrument Co., Katena Products Inc.) which is less precise but easy to use and disposable.

A lamellar superficial keratectomy is performed with a crescent knife (Alcon Laboratories, Forth Worth, Texas, USA); aiming to leave a layer of corneal stroma in place anterior to the air bubble. A 15° slit-knife (Alcon Laboratories, Forth Worth, Texas, USA) is inserted into the large bubble, allowing the air to escape and collapsing the bubble. Viscoelastic is injected from the opening done by the knife, then the stroma is removed by Blunt-tipped scissors (Figs. 2 bottom & 3 top).

The donor cornea is punched out from the endothelial side with a Hanna donor punch (Moria, Paris, France) or a Barron donor punch (Katena), oversized by 0.25mm than the recipient. DM with endothelium is gently stripped off with a dry Weck-Cel sponge. The button is sutured in place using 16 bite continuous 10-0 nylon suture after copiously irrigating Descemet membrane to wash away all viscoelastic material (Fig. 3 bottom).

Postoperative medications included topical prednisolone acetate 1% four times daily for one month, gradually tapered over another month, ciprofloxacin 0.3% four times daily for 3 weeks and artificial tear preparations four to six times daily for 3 months.

**Results**

The Early Bubble was performed on 21 eyes of 21 patients with anterior stromal corneal pathology. All patients were informed of the procedure intended and consented for a lamellar and a possible conversion to a penetrating keratoplasty.

Intraoperatively, we were able to successfully perform the big bubble separation of the Descemet membrane from the posterior corneal stroma. Four cases out of the 21 cases (19%) needed a second incision and injection of air through that incision to attain the big bubble after failure to do so from the first incision. The second incision was also clear corneal and parallel to the limbus but three clock hours from the first one.

Three cases (14%) had to be converted to penetrating keratoplasty due to large perforations to the Descemet membrane. All 3 perforations happened during deroofing the Descemet membrane from the residual posterior corneal stroma using scissors.

Two cases (9.5%) had a tiny peripheral perforation in Descemet membrane, again discovered during removal of the posterior corneal stroma with scissors and evident by limited aqueous leak. In these two cases DALK was continued after filling the anterior chamber with viscoelastic material. One of these two cases had a double anterior chamber seen on the first postoperative day with graft edema due to escape of aqueous to the plain between the Descemet membrane and the graft. Intracameral air injection was carried out immediately in the operating theatre and the graft and Descemet membrane became coapted with improvement of graft edema over the next three days. Over the follow-up period of 6 months, no patient showed any sign of immunological graft rejection.

The preoperative best corrected visual acuity of all 21 eyes was less than 20/200 (6/60). After 3 months all 21 eyes had BCVA of 20/80 (6/24) or better and 13 eyes had a BCVA of 20/50 (6/15). At 6 months 16 eyes showed BCVA of 20/50 (6/15) and all the rest had BCVA of 20/80 (6/24) or better.

The postoperative corneal astigmatism was 3.6±0.9 diopters at 3 months and after 6 months it was 3.15±0.67 diopters.
Fig. (1):
Top: Anatomical considerations and incision placement.
Bottom: Needle injecting the air bubble.

Fig. (2):
Top: Trephination of the recipient stroma.
Bottom: Lamellar dissection of corneal stroma.

Fig. (3):
Top: Complete removal of stroma with baring of DM.
Bottom: Placement of donor stroma and suturing.
Fig. (4-A): Performing the scratch with the guarded 550 micron knife.

Fig. (4-B): Inserting the needle in the depth of the incision.

Fig. (4-C): Injecting Air to perform the EARLY bubble.

Fig. (5-A): Partial thickness trephination.

Fig. (5-B): Removal of the anterior stroma.

Fig. (5-C): Puncture of the Air bubble by the 15 degree slit knife.

Fig. (5-D): Removal of the rest of the stroma by scissors to leave bare Descemet Membrane.
Discussion

DALK is a relatively newer technique of lamellar corneal transplantation surgery used to treat corneal diseases that do not involve the DM [13]. The technique allows the placement of a nearly full-thickness corneal donor button onto the host bed containing minimal or no stromal tissue on DM and is preferred over performing PK for treating corneal stromal pathologies. It avoids the replacement of host endothelium with donor endothelium, thus removing the main antigenic load reducing the incidence of graft rejection [14]. Also it has minimal effect on endothelial cell count [8,15].

Other advantages of DALK over PK as a treatment for corneal stromal disease are well known, [18] being a lamellar procedure: Avoiding most complications associated with "open-sky" surgery, less chances of postoperative complications such as anterior synneciae of the iris or secondary glaucoma and easier postoperative management. Thus DALK retains all the advantages of lamellar keratoplasty over PK while providing a clear interface compared with that of conventional lamellar keratoplasty [16].

In 1959, Pierse and Casey [17] reported a case series of lamellar corneal grafts for various corneal pathologies. LKP for keratoconus was first discussed by Enrique Malbran in 1964 [14]. Since then, LKP may have lost its popularity owing to the imperfections of the existing surgical techniques rather than poor visual outcomes.

In 1972, Anwar [11] described the dissection technique for LKP. In 1998, Tsubota et al. [18] modified it using a divide and conquer like technique for lamellar dissection. Both started the dissection after partial trephination of a central disc in the recipient cornea. In an attempt to facilitate dissection, Melles et al., in 1999 [19] injected air into the anterior chamber to facilitate DM visualization during dissection. They started the dissection through a scleral incision 1mm outside the limbus, and injected viscoelastic in the dissected pocket before trephination. A more recent study by Marchini et al., in 2006 [20] used a similar technique, but started dissection from a limbal incision, using a specially designed set of instruments. We start through an incision 1mm inside the limbus, just as both of them proposed to make use of the maximum corneal thickness at the periphery for a safer dissection. However their use of viscoelastic necessitated performing a lot of irrigation to ensure as complete removal as possible, as this impairs adhesion between the donor stroma and recipient endothelium. In an earlier modification to the big bubble technique, we injected viscoelastic to replace the big bubble after lamellar dissection, before removing the deepest stromal layer and we faced this problem.

Although better microkeratomes have become available with the development of laser assisted in situ keratomileusis (LASIK), microkeratome lamellar resections cannot be used for disorders with deep stromal opacities, variable corneal thickness and surface irregularities [19]. Busin et al. [21] reported successful results in LKP for the surgical treatment of keratoconus using the microkeratome. The technique might be easier but the need for the equipment (microkeratome and artificial anterior chamber or whole donor globe) and the short term results are points that can be taken against this study. The use of the femtosecond laser in fashioning the donor and recipient corneal lenticules [22] faces the same problem of equipment availability (laser machine and artificial anterior chamber or whole donor globe) in addition to the expenses.

Other proposed delamination methods include hydrodelamination, in which a saline solution is used as a dissecting fluid [8,23] and viscoelastic dissection alone or after air injection into the anterior chamber [19,24].

Air injection technique into corneal stroma to facilitate dissection down to the DM was first proposed by Archila in 1984 [9]. This technique led to reduced interface haze and better postoperative visual results. However, the rate of intraoperative perforation was high (39.2%) [13]. The technique was later used by Price [7], Chau & coauthors [28] and Morris & coauthors [26]. However, none of them was able to consistently achieve cleaving of the DM from the stroma after air injection. DM separation is essential in improving the postoperative visual function, as stated by Ardjomand et al. [27]. They suggested that the main parameter for good visual function after DALK for keratoconus is the thickness of residual recipient stromal bed. An eye with a DALK with a residual bed of <20g can achieve a similar visual result as a PK, whereas those with a recipient thickness of >80g had a significantly reduced visual acuity [27].

In 2002, Anwar and Teichmann [1,14] then described the big-bubble technique to consistently achieve separation of the DM from stroma after intrastromal air injection. In contrast to the other described techniques of DLK, the big-bubble technique creates a perfect cleavage plane between
DM and the rest of the corneal tissue and appears to be much safer than the manual technique of achieving deep stromal dissection regarding the incidence of macroperforations. The big-bubble technique also ensures a maximum possible depth dissection achieving a complete baring of DM so that no stromal tissue is left to cause interface haze in the future [28]. Based on this data, we adopted the big bubble technique in our procedure for DM separation, after applying our modifications.

The importance of maintaining an intact DM was proven by Den et al. [29]. They found that the rate of endothelial decompensation was higher in patients with DM perforation. They attributed this to either direct insult to the cells associated with perforation or the ensuing pseudochamber formation or gas tamponade. Another finding was a higher incidence of postoperative pseudochamber formation which showed a tendency to persist and be refractory to treatment, compared to eyes with intact DM in which the detached DM repositioned itself spontaneously in most eyes. Therefore, use of a surgical technique that avoids macroperforation of the DM seems to be the key in achieving success in DLKP [29]. The technique we are describing here overcomes this issue as the needle is inserted, as mentioned above, in the thicker corneal periphery, ensuring easier insertion and better control of the needle. Even if perforation occurs, it is usually peripheral and outside the trephination area.

To sum up, our early bubble technique bears some advantages over other DALK techniques. Starting the injection in the thicker corneal periphery reduces the risk of DM perforation, especially in keratoconous patients with central corneal thinning. The peripheral cornea is known anatomically to be the thickest part of the cornea thus pachymetry is not necessary, especially with the use of the 550 µm guarded limbal relaxing incision knife. Even if the DM is perforated, the location is away from the centre of the graft. One other important advantage of the procedure is that DM stripping is well beyond the circumference of the trephination (Figs. 2,3 top), eliminating the need to extend the pocket between the DM and the peripheral residual recipient corneal stroma. Finally, if we decide to shift to PKP, all our attempts for air injection are done 1 mm from the limbus and the central cornea is left untouched. This allows a one step full thickness trephination with smooth neat edges.

Based on the above mentioned data, we find our "Early Bubble" technique safe, easier to perform and with a shorter learning curve compared to the original big bubble technique, while retaining the same advantages, even in case of the need for conversion to PKP.

References


