

Corneal Transplantation Procedures.

A number of different corneal transplant procedures are now performed. Until 15 years ago, the main procedure performed was a Penetrating Keratoplasty which involved removal of the entire central portion of the cornea and replacement with a donor cornea. With better understanding, improvements in technology and surgical skill, a variety of options are now available including:

Deep Anterior Lamellar Keratoplasty (DALK)

Descemet's Stripping Automated Endothelial Keratoplasty (DSAEK)

Femtosecond Laser Penetrating Keratoplasty (FSPK)

Deep Anterior Lamellar Keratoplasty (FSDALK)

What is the difference between a Penetrating Keratoplasty and a Deep Anterior Lamellar Keratoplasty? To understand this a few lessons in corneal anatomy are required:

Corneal Anatomy

The cornea is the only transparent tissue in the body and being curved acts as a lens. Any abnormality in corneal shape or clarity will affect vision. The cornea consists of 5 layers. From outside inwards:

1. Epithelium

This outer layer acts as a barrier and is a shiny mucous layer typically 6 cells thick which shed off and are replaced. This layer has tight junctions between the cells and is "waterproof". It also protects against attack from micro-organisms preventing infection.

2. Bowman's Layer

This layer is a condensation of collagen that is well demarcated and is strong and inelastic, contributing to the shape and strength of the cornea.

3. Corneal Stroma

This makes up the bulk of the cornea and consists of collagen fibres packed more tightly towards the front. The fibres are arranged in an even and highly precise distribution allowing the cornea to be clear.

4. Descemet's Membrane

This layer is attached to the underside of the corneal stroma. Normally it is a uniform layer and is very thin. On the underside of this layer is the 5th layer of the cornea, the Endothelium.

5. Endothelium

The Endothelium is a layer of highly specialised "Endothelial cells" which like the epithelium the top layer have tight junctions and do not allow water to penetrate. They also have an important function and that is to pump fluid out of the corneal stroma to keep the architecture uniform and cornea clear. Unlike the epithelium, endothelial cells do not multiply and decrease in quantity with age. Abnormalities of this layer (e.g. Fuchs Endothelial Dystrophy) can result in increased fluid in the cornea with thickening and with loss of clarity.

Penetrating Keratoplasty (PK)

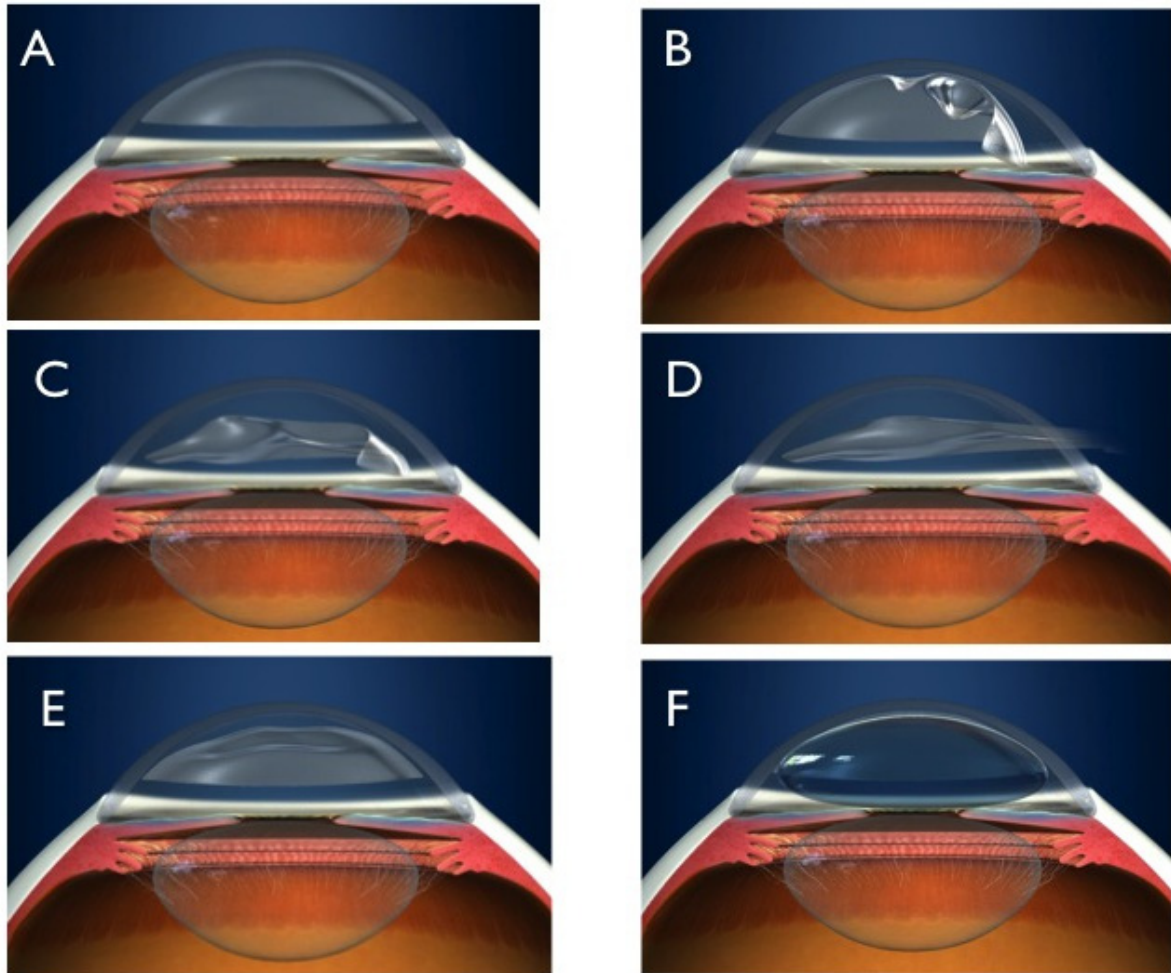
This is a corneal grafting procedure that involves penetrating the whole cornea with removal of all 5 layers and replacing this with a cornea from a donor. This procedure is performed when both the endothelial layer and stromal layer are affected and where replacement of just one layer will not be sufficient to provide corneal clarity.

Deep Anterior Lamellar Keratoplasty (DALK)

This procedure is suitable for those with problems involving the corneal stroma, either scarring or thinning (Keratoconus) resulting in abnormal corneal shape. This procedure involves removal of the top 3 layers of the cornea leaving behind Descemet's membrane and Endothelial cell layer. A donor cornea with Descemet's membrane removed is stitched into the space. The patient or host endothelial cell layer removes fluid from the cornea. As this layer belongs to the patient, it will never reject and the risk of blindness from rejection is nil.

Descemet's Stripping Endothelial Keratoplasty (DSEK)

This procedure is suitable for those who have problems with the endothelial cell layer of the cornea and where the front layers of the cornea are normal in shape and clarity. Fuchs endothelial dystrophy or pseudophakic bullous keratopathy are conditions where this layer is affected and poorly functional. As there are no cells to pump fluid out of the cornea, the cornea fills with fluid and becomes cloudy. The DSEK procedure or an automated form DSAEK is where the bottom portion of the cornea, a little stroma with Descemet's membrane and endothelium are transplanted into the eye through a small (4mm) incision. The patient's own Descemet's membrane is stripped off and the partial graft is implanted and held in position with an air bubble. The advantage of this procedure is rapid visual recovery and the safety of a small incision.



DSAEK procedure

- A:** Micro-incision is made in the sclera (white part of the eye).
- B to D:** The innermost layer (Descemet's layer) is removed from the eye.
- E:** A new layer is introduced in the eye.
- F:** An air bubble is used to push the new layer up to the inner part of the patient cornea. The air bubble remains in the eye and the patient lies flat with the head facing the ceiling for 24 hours.

The Femtosecond Laser in Keratoplasty

Technologic advances in particular lasers have improved the precision of eye surgery. The Femtosecond laser that revolutionised LASIK laser eye surgery has been adapted to make precise incisions in the cornea. A major advance has been the use of the device to perform both Penetrating and Deep Anterior Lamellar Keratoplasty and since 2004 corneal transplants have where appropriate been performed using the Femtosecond laser.

A further benefit of the laser besides high precision is the ability to perform Geometric cuts in both the corneal donor and host. These types of incisions allow the grafts to slot into place without slippage and promote good biomechanical stability and stronger wounds. Data has demonstrated more rapid healing as well as a reduction in astigmatism. The laser is used for both Penetrating and Deep Anterior Lamellar Keratoplasty.

Femtosecond Deep Anterior Lamellar Keratoplasty (FSDALK)

In this procedure the laser is used to make a geometric incision (typically Zag Square Figure 1) in both the donor and patient. The side incisions are performed using the laser. The patient is transferred to the operating theatre and front portion of the cornea is removed either by dissection manually or by using an injection of air – “the Big Bubble Technique”. The Donor cornea has the bottom Descemet’s layer removed and is then stitched into the bed of the patient cornea.

Donor preparation is performed on a disposable artificial anterior chamber (Fig 2.) Once this has been accomplished the patient is then treated and an identical incision with similar dimensions is made in the patient. The patient is transferred to the operating theatre where the remainder of the procedure is completed (Fig 3- 5). The advantage of this type of incision is demonstrated at 6 weeks (Fig 6.) where the Zag square graft to host contact is clearly seen and further demonstrated on an Ocular Coherence Tomography (OCT) scan (fig 7).

Stitches are typically removed between 9 and 12 months, on average 6 months earlier than conventional graft surgery with metal circular blade trephines.

Femtosecond penetrating keratoplasty(FSPK)

This procedure in terms of process is almost identical to FSDALK except other geometric patterns such as the Zig-Square or Top-hat are used. Again wounds are stronger and heal faster with more rapid visual rehabilitation compared to traditional surgery.

Femtosecond Deep Anterior Lamellar Keratoplasty

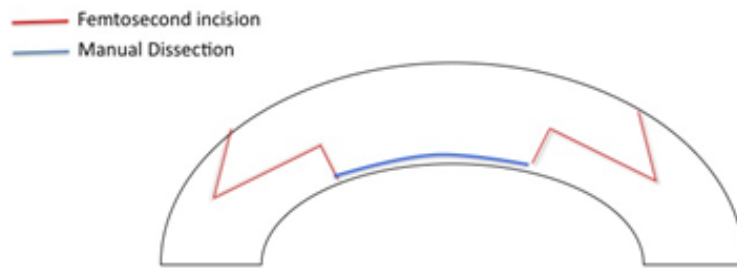


Fig. 1 .“Zag-Square” Geomtric Configuration for donor and host – developed at Centre for Sight.

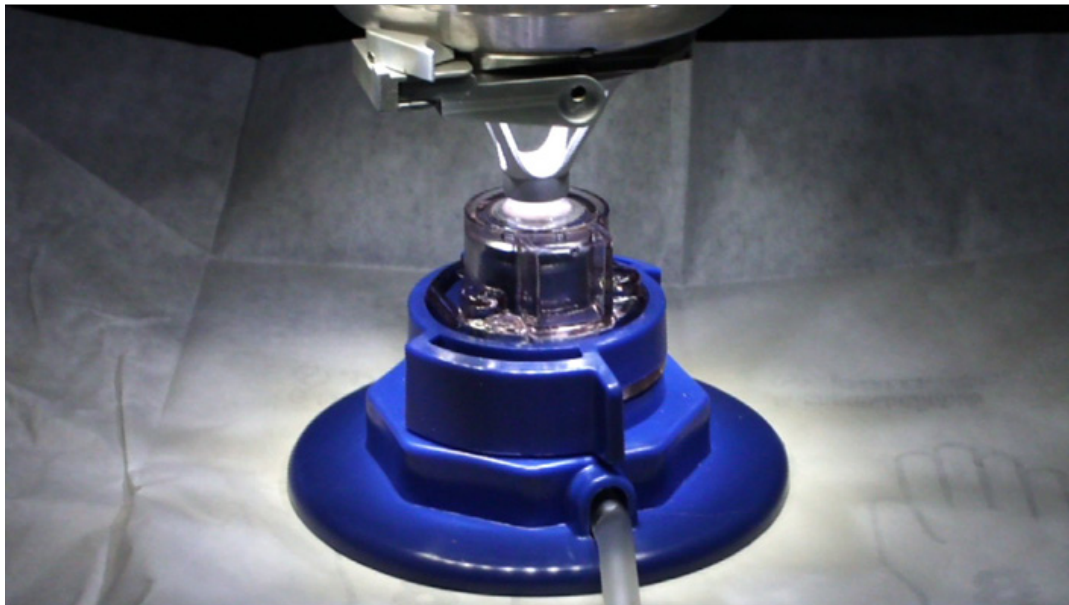


Fig 2. Donor preparation on an artificial anterior chamber.

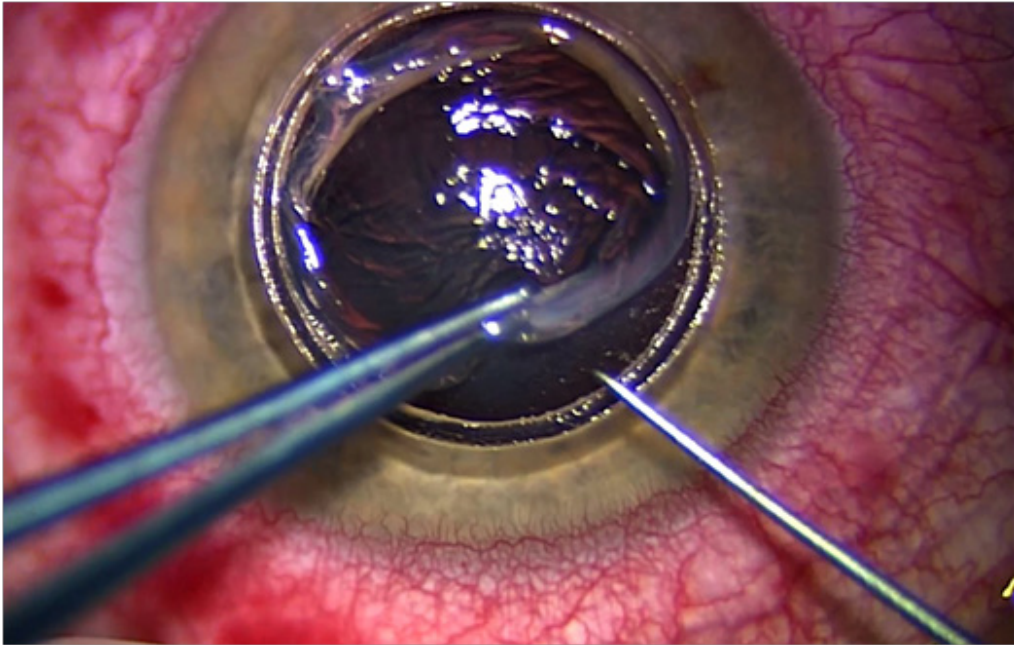


Fig 3. Host trephined with the laser – notice the precise layered trephination.

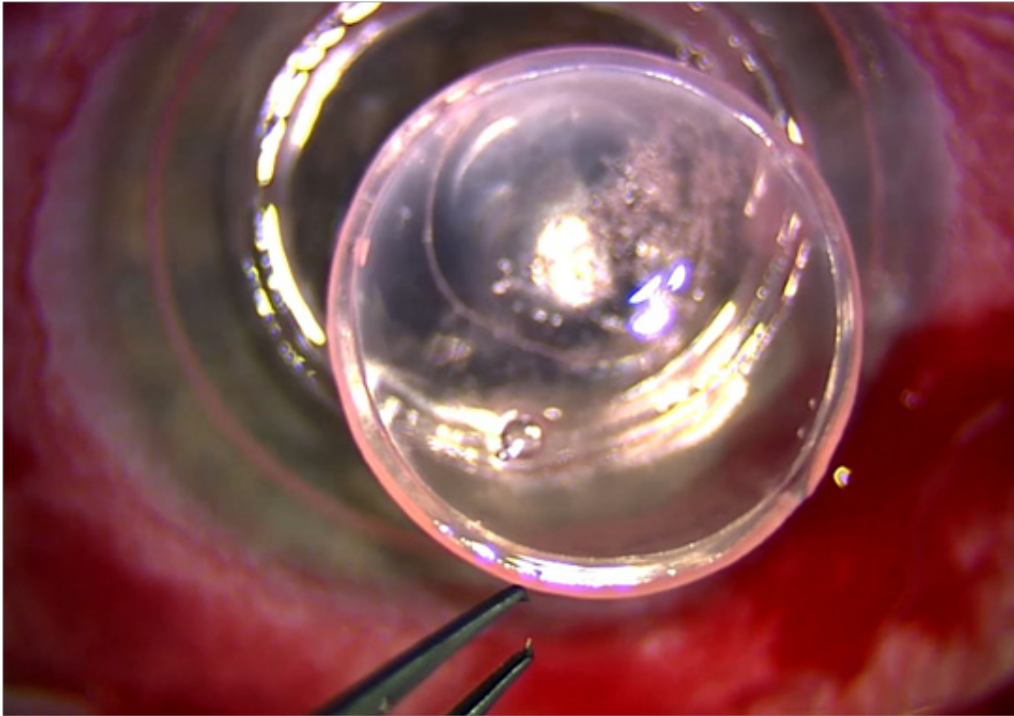


Fig 4. Underside of Donor Button. Notice the precise geometric cuts.

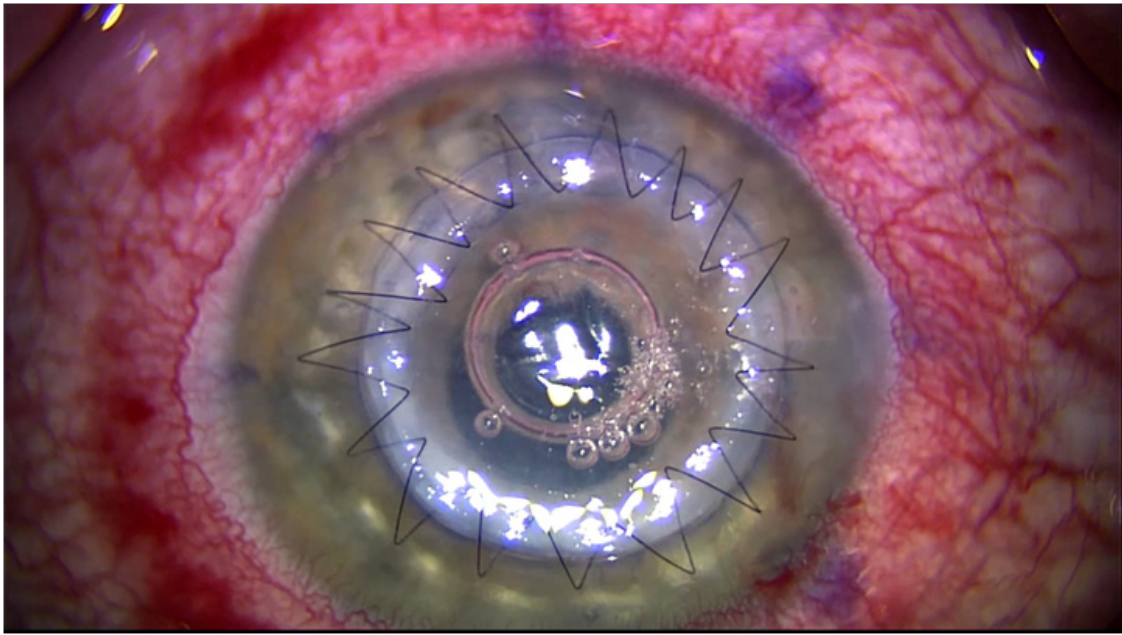


Fig 5. Donor sutured into the host with perfect alignment of tissue.

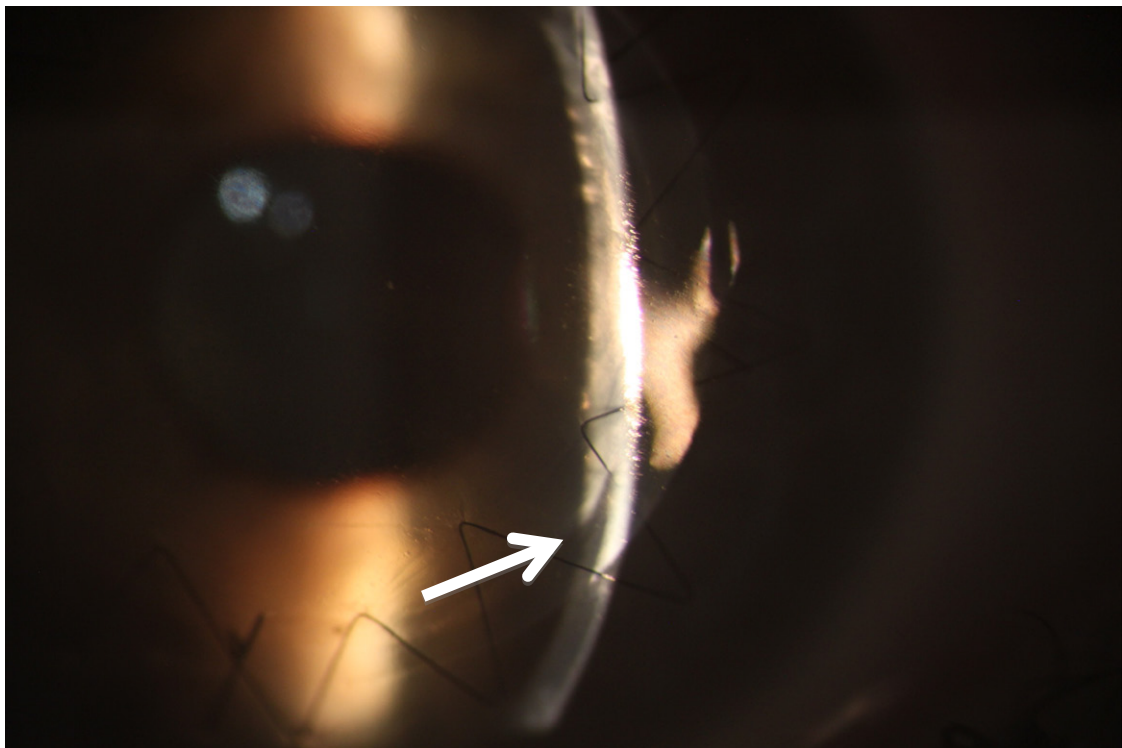


Fig 6. Slit beam showing graft-host interface at 6 weeks. Notice the Zag-square interface (arrow).

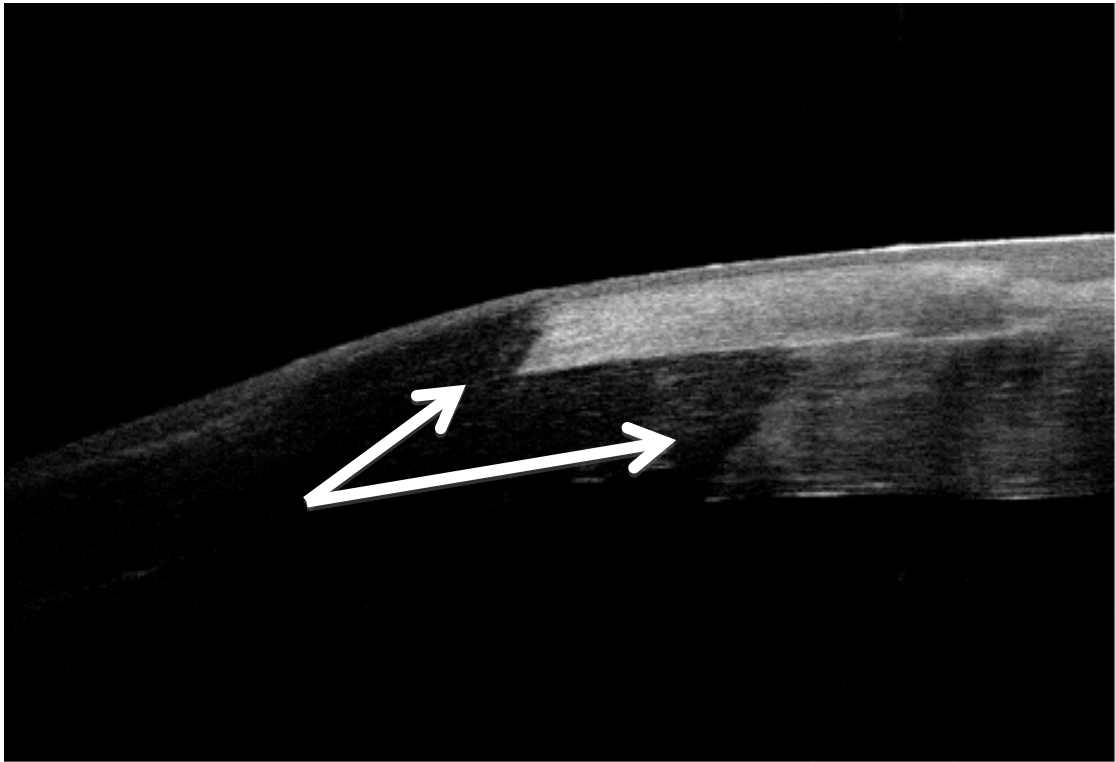


Fig 7. OCT showing graft- host interface 6 weeks postop – Notice the Zag-square configuration.