

# Penetrating Keratoplasty PK in the “Lamellar Age”

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**On 01/07/2019, penetrating excimer laser assisted keratoplasty celebrated its 30<sup>th</sup> anniversary**

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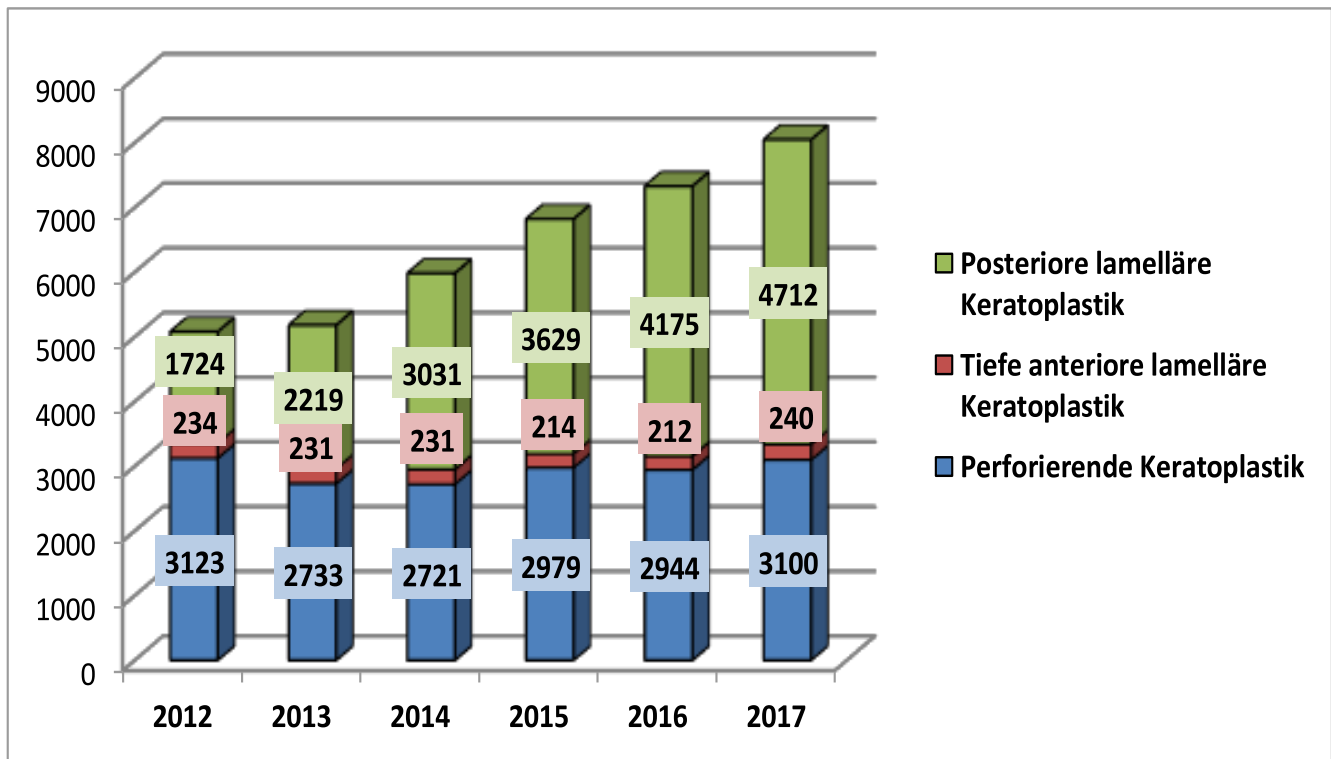
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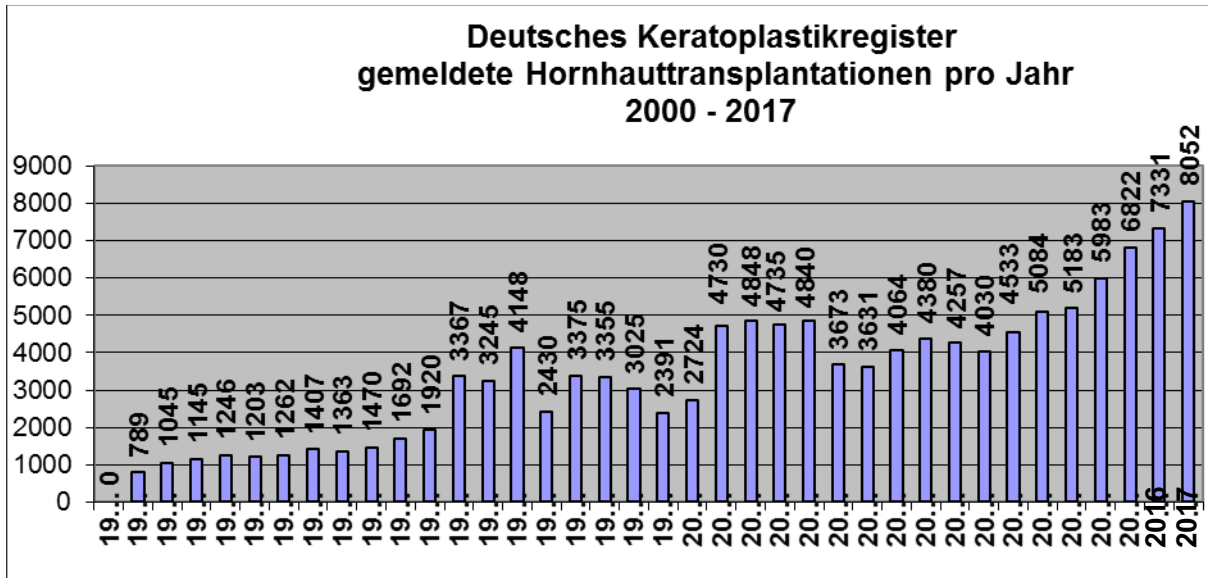
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Since 2000, the *German Keratoplasty Registry* has been managed by the *Corneal Section* of the DOG. For 2017, it accounts for 38.4% of penetrating keratoplasty (PK), 58.6% of posterior lamellar keratoplasty (> 90% Descemet membrane endothelial keratoplasty = DMEK), but only 3.0% of anterior lamellar keratoplasty (mainly deep anterior lamellar keratoplasty = DALK) (**Figure 1A**) [Flockerzi 2018]. Overall, the number of keratoplasties performed in Germany has risen to over 8,000 in 2017 (**Figure 1B**). In Homburg/Saar, the number of keratoplastic surgeries has almost increased nine-fold over the last 13 years (**Figure 1C**). With 609 surgeries in 2019, the third most keratoplastic surgeries overall and by far the most PKs were performed in Germany (**Figure 1D**). The number of processed donor tissues in our LIONS Corneal Bank has almost tripled since it was founded in 2000 (**Figure 2**). On 19/02/2019, the new *Klaus Faber Centre for Corneal Diseases, incl. LIONS Corneal Bank Saar-Lor-Lux, Trier/Western Palatinate* was inaugurated in Homburg/Saar, which meets the highest cleanroom requirements.

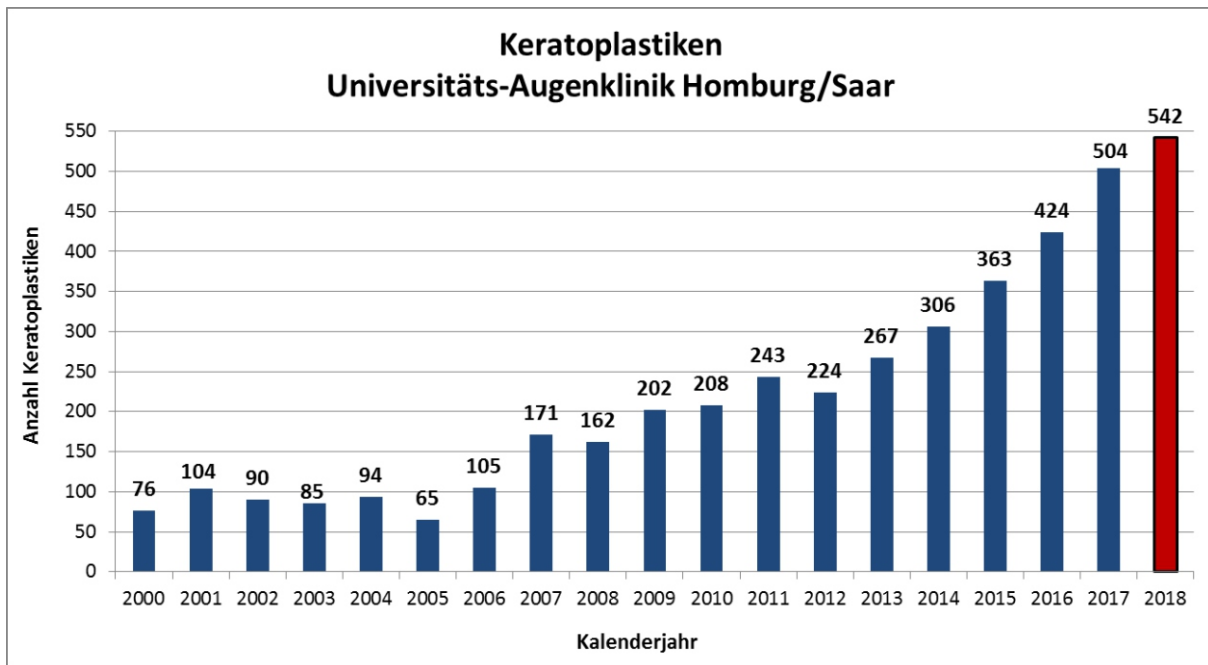


**Fig. 1: German Keratoplasty Registry**

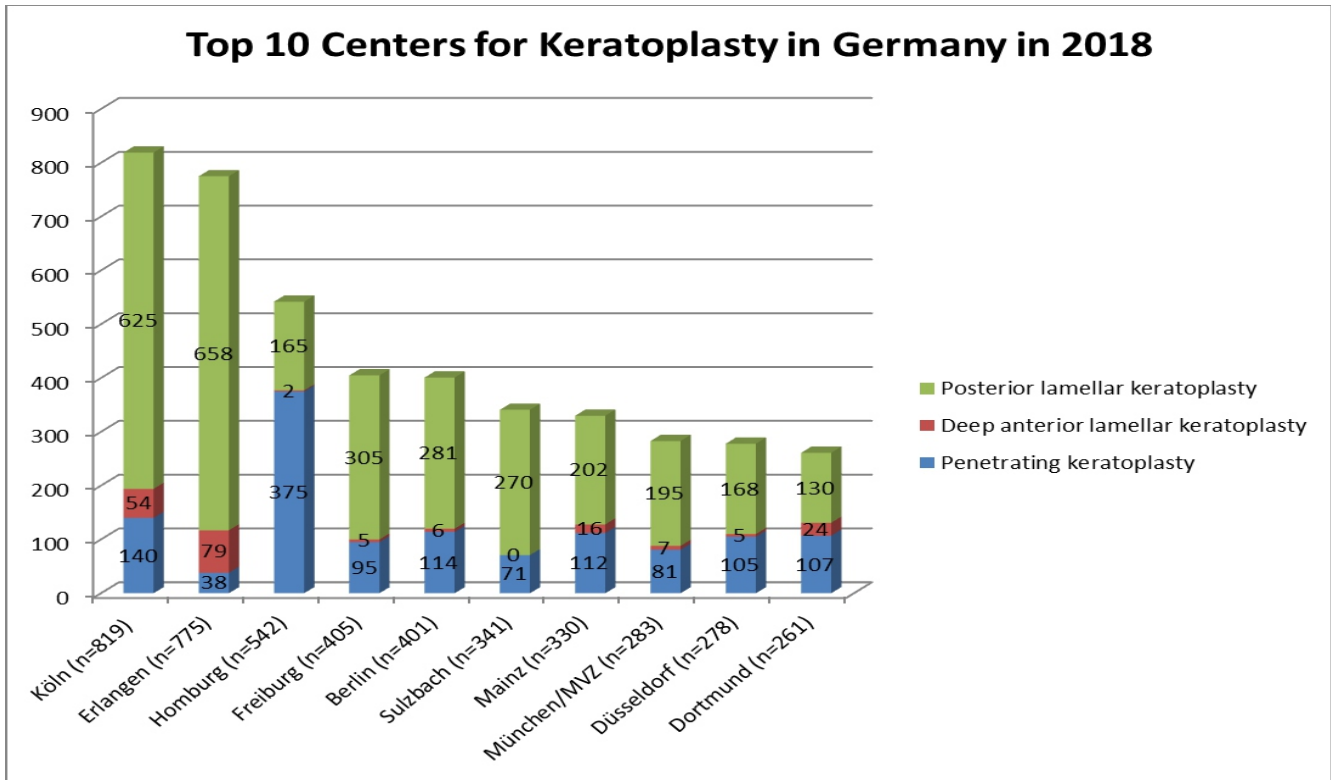
**Fig. 1A:** In 2017, 38.4% of all transplants were performed as penetrating keratoplasty, 58.6% as posterior lamellar, and only 3.0% as anterior lamellar keratoplasty.



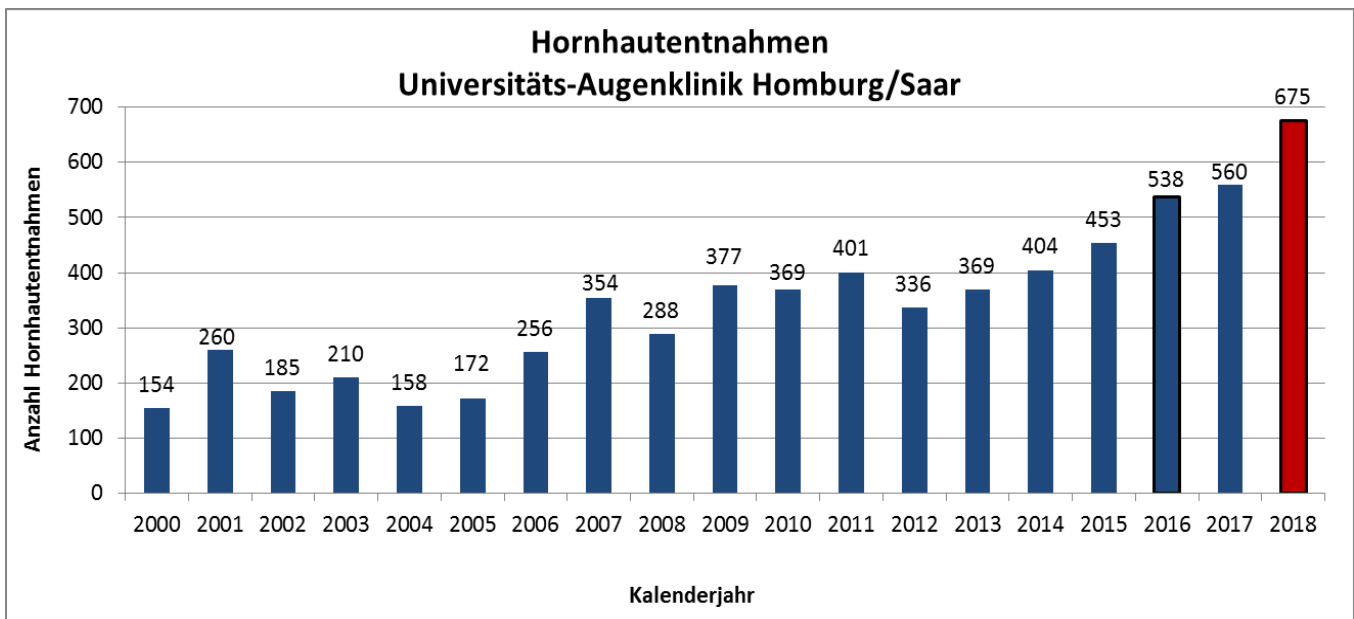
**Fig. 1B:** In 2017, 8,052 keratoplasties were performed. At the end of 2017, about 4,500 patients were on waiting lists of German transplant centres.



**Fig. 1C:** The number of keratoplastic surgeries performed at the Department of Ophthalmology at the Saarland University Hospital in Homburg/Saar (542 in 2018) has increased almost ninefold since 2005. Since 2006, a total of more than 4,000 keratoplasties have been performed.



**Fig. 1D:** The Top 10 keratoplasty centres in Germany in 2018. By far the most PKs in Germany are performed in Homburg/Saar.



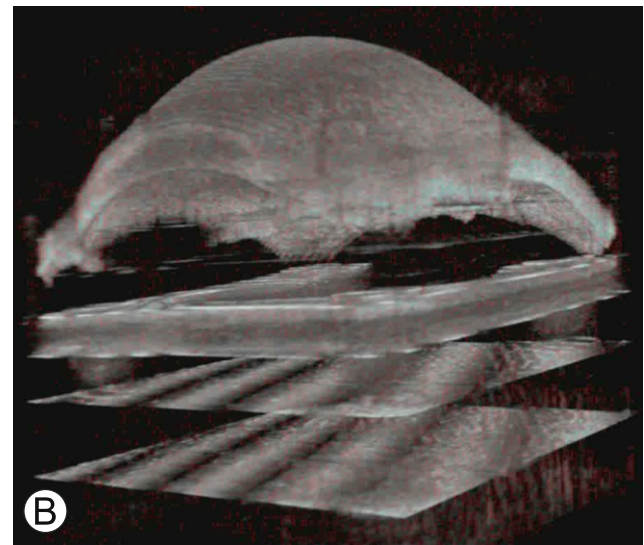
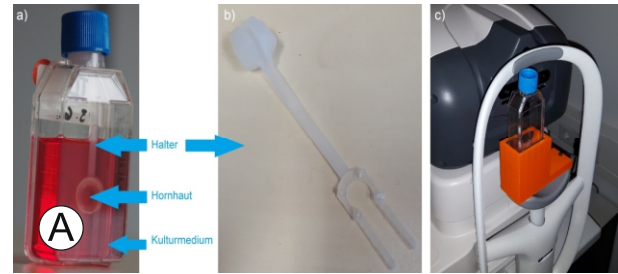
**Fig. 2:** The number of processed corneas (675 in 2018) has more than tripled since the founding of the **LIONS Corneal Bank in Homburg/Saar** in 2000 – not least thanks to effective cooperation with Luxembourg since 2012.

## Surgical technique

A clear transplant with high and/or irregular astigmatism or high anisometropia with aniseikonia can no longer be considered a success after PK. The main reason for this are intraoperative determinants (e.g. decentration, horizontal torsion, vertical tilt) [Naumann 1995]. With increasing experience of the microsurgeon, the **keratoplasty technique** goes far beyond the replacement of two collagen discs and is very crucial for the functional outcome in addition to a number of other details:

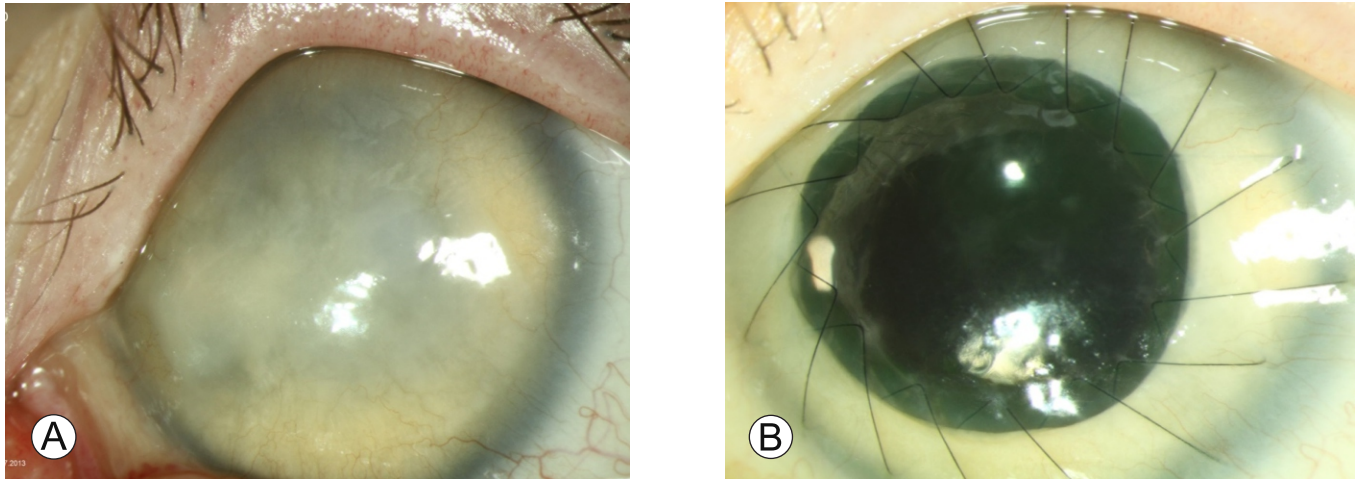
**1. Donor tomography** using an anterior segment (AS)-OCT should be sought to rule out past refractive surgery, keratoconus or high astigmatism. In Homburg/Saar we have been able to carry out sterile donor computed tomography on almost every planned transplant in the corneal bank for one year [Janunts 2016, Damian 2017, Mäurer 2018]. Tomey's AS-OCT CASIA 2 measures anterior and posterior surface curvature and thickness in the holder (**Figure 3**). About 10% of the almost 400 transplants measured so far revealed values outside +/- 2 standard deviations from the mean and are, therefore, used for DMEK or DSAEK, not for PK or DALK [Mäurer 2018]. In the future, high-resolution two-photon microscopy could also help to evaluate the biodegradation of donor stroma in the

corneal bank before keratoplasty [Batista 2018].



**Fig. 3: Donor tomography. (A)** The donor specimen remains sterile in the organ culture bottle. It is placed in front of the AS-OCT camera in a holder, which was manufactured with a 3D printer and is fixed to the chin rest. **(B)** 3D volume data of the donor corneoscleral disc are recorded within a 7.0 mm central optical zone by means of a so-called raster scan through the back surface of the cornea.

**2. Endotracheal general anaesthesia** has safety advantages over local anaesthesia, especially in young patients. The arterial blood pressure should be kept as low as possible while the eye is open (**'controlled arterial hypotension'**).



**Fig. 4: PK for congenital aniridia. (A)** 65-year-old patient, according to medical history ‘bilaterally blind for 30 years’ **(B)** 9 months after excimer laser-assisted traditional triple PK on the OS with simultaneous amniotic membrane transplanting (‘patch’), autologous serum eye drops and systemic immunosuppression (visual acuity 0.16).

**arterial hypotension**’). Mivacurium should not be used as a **muscle relaxant** because it leads to an increase of the vis à tergo in the open eye more than atracurium and rocuronium [Fiorentzis 2017, Morinello 2018].

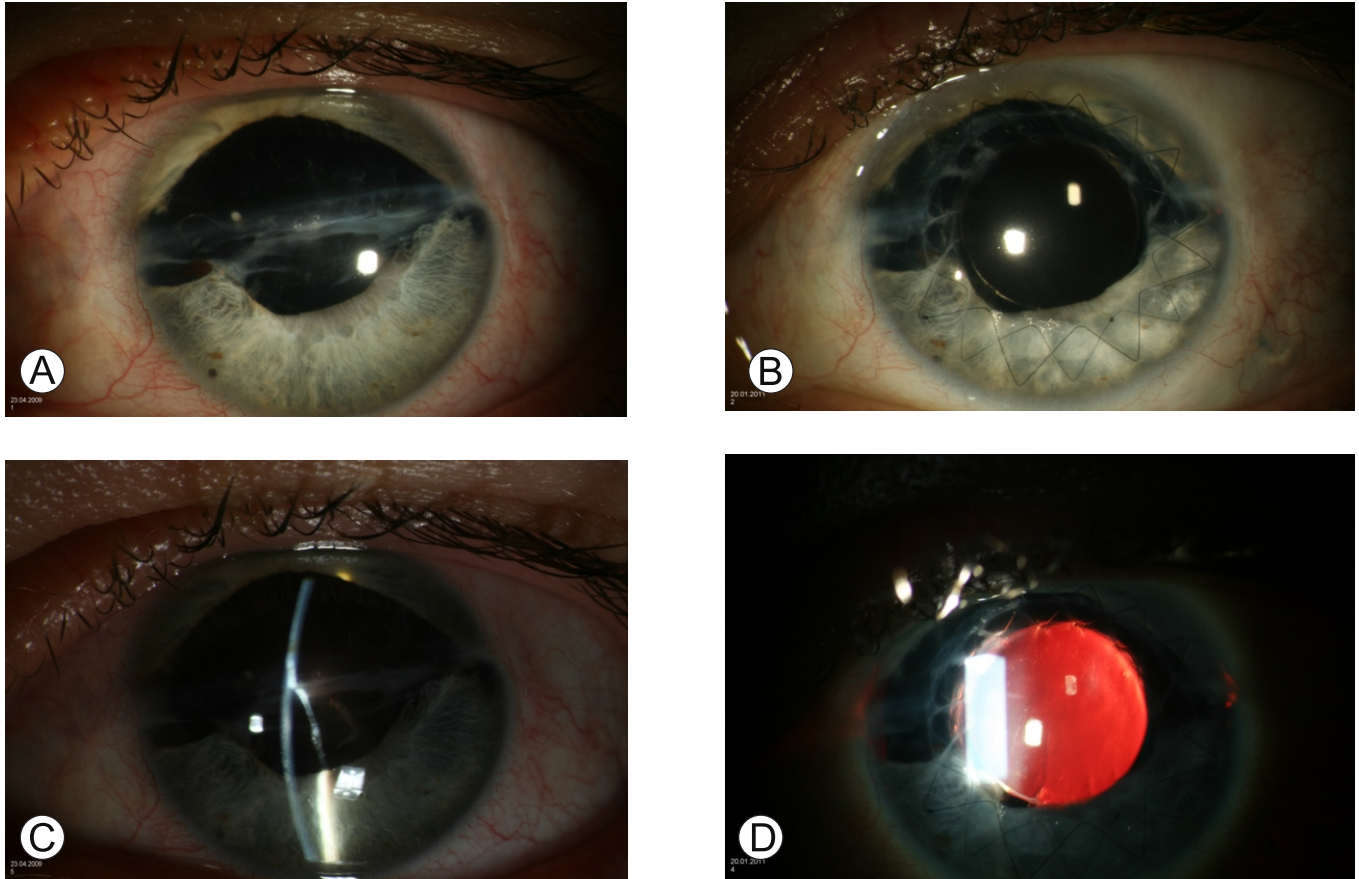
3. Typically, the pupil is **constricted with pilocarpine** in order to protect the lens of the phakic eye. PK in congenital aniridia requires special experience and precautions (**Figure 4**). In aphakic and vitrectomised eyes (**Figure 5**), we recommend a temporary episcleral fixation of a Flieringa ring to avoid collapse of the eye after recipient trephination [Ninios 2013].

4. **Paracentesis at the limbus** is recommended before trephination. During placement, make sure that the

suture does not raise the ‘roof’ of the paracentesis and thus cause leakage.

5. **Donor and recipient trephination** should be performed **from the epithelial side** with the **same trephine system**. This is the prerequisite for congruent cut surfaces and angles in the donor and recipient. An artificial anterior chamber is typically used today for donor trephination.

6. **Orientation structures in donor and recipient** facilitate the correct placement of the first four or eight cardinal sutures and, thereby, contribute towards preventing ‘horizontal torsion’. The **second cardinal suture** is absolutely crucial for a correct 360° symmetrical graft fit.



**Fig. 5: PK in aphakic eye (A,B)** Central, penetrating corneal scar after penetrating injury with traumatic aphakia, partial aniridia and vitreous body in the wound gap **(C,D)** Status post PK with temporary episcleral fixatin of a Flieringa ring with simultaneous anterior vitrectomy and sclera-fixed iris-print artificial lens

7. **Horizontal positioning of the head and limbal plane** are an indispensable precondition for the avoidance of decentration, ‘vertical tilt’ and ‘horizontal torsion’. Patients with ankylosing spondylitis sometimes require a special body support to achieve horizontal positioning of the head and limbal plane (**Figure 6**).
8. A **measurable improvement** in astigmatism is possible by using the

Homburg/Erlangen technique of non-mechanical trephination with the **excimer laser** [Naumann 1995, Seitz 1999, 2004, 2018, Szentmàry 2006].

9. The graft size should be adapted individually to the cornea size (**‘as large as possible, as small as necessary’**) [Seitz 2003]. Large transplants are more favourable with respect to astigmatism, smaller transplants are more favourable in terms of immunology.