Pole to Pole Surgery in Ocular Trauma: Standardizing Surgical Steps

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ABSTRACT

This commentary describes steps in ocular reconstruction surgery following ocular globe injuries in both the anterior and posterior segment causing corneal opacity and aphakia. The authors propose to reorder the sequence of surgical manoeuvres during pars plana vitrectomy combined with keratoplasty and aphakia treatment without capsular support and highlight the advantages in the choice of the intraocular lens to implant. A mental outline of all surgical manoeuvres, being aware of the complications that can arise during surgery and knowing the long-term benefits of making more careful choices, can make this surgery more effective and safer.

Keywords: Ocular globe injuries; Pars plana vitrectomy; Keratoplasty; Aphakia

Key Summary Points

The ‘pole to pole’ surgical approach in ocular globe injuries (OGI) with opaque cornea involves the use of a temporary keratoprosthesis (TKP). A TKP allows one to perform all surgical manoeuvres in the posterior and anterior segment of the eye, maintaining a closed operating system.

A detailed description of the most efficient sequence of surgical steps in a ‘pole to pole’ complex surgery is lacking.

The scope of this work is to describe a surgical sequence in ocular reconstruction surgery in cases of OGI with corneal opacity and aphakia, in which a combined surgery of pars plana vitrectomy, penetrating keratoplasty and aphakia correction is required.

The aim is to optimize the efficiency of surgery and to avoid unnecessary and possibly unsafe procedures.
COMMENTARY

The mean estimated incidence of ocular globe injuries (OGIs) is about 3.5/100,000 cases per year, i.e. 200,000 cases per year worldwide [1, 2]. OGIs involving anterior segment may cause damage to the cornea, crystalline lens and capsular bag, leading to severe corneal opacity and aphakia [1]. In these cases, pars plana vitrectomy (PPV), penetrating keratoplasty (PK) and anterior segment reconstruction is required [3, 4]. The ‘pole to pole’ surgical approach in OGI with opaque cornea involves the use of a temporary keratoprosthesis (TKP). A TKP allows one to perform all surgical manoeuvres in the posterior and anterior segment of the eye, maintaining a closed operating system. In fact, one of the major risks during open sky surgery is hypotonia caused by the removal of the cornea. This causes subsequent collapse of the anterior segment’s structures and the sclera, making surgery more challenging [5]. Furthermore, with an open sky surgery approach, the eye is exposed to surgical manoeuvres that may lead to choroidal detachment and expulsive hemorrhage [6]. A closed system surgical approach such as TKP reduces this risk; however, some steps are still commonly performed by the surgeon in an open sky setting. This could be avoided with a planned sequential surgical approach. Although the use of TKP in OGI has been reported by several authors [7–16], a detailed description of the most efficient sequence of surgical steps in a ‘pole to pole’ complex surgery is lacking.

The scope of this work is to describe a surgical sequence in ocular reconstruction surgery in cases of OGI with corneal opacity and aphakia, in which a combined surgery of PPV, PK and aphakia correction is required. The aim is to optimize the efficiency of surgery and to avoid unnecessary and possibly unsafe procedures.

Pre- and Postoperative Investigations

The management of OGI begins with assessing its extension and severity. Several preoperative parameters must be collected, such as best corrected visual acuity (BCVA) and intraocular pressure (IOP). The anterior segment appearance should be documented with appropriate imaging. Magnetic resonance imaging (MRI) or computer tomography (CT) scans are fundamental to measure the length and thickness of an eventual intraocular foreign body. MRI should be avoided in cases of suspected metallic intraocular foreign body. Other useful additional investigations are corneal topography and endothelial cell count (ECC); these can be repeated postoperatively to evaluate corneal morphological changes following PK. The pupillometry study in scotopic and mesopic conditions can provide useful information documenting an eventual permanent traumatic mydriasis. The pupil spread function study evaluates the high-order aberrations and the quality of vision. Finally, postoperative anterior chamber depth (ACD) measurement provides information about the maintenance of a reasonable distance between the inserted intraocular lens (IOL) and the cornea. Surgery is carried out following the described preoperative investigations (Fig. 1).

Surgical Technique

Before starting surgery, the authors suggest not using standard chemical preparation of the eye, because povidone–iodine solution topically used could penetrate through the eye wound into the eye, causing toxicity damage. The authors suggest washing the eye with balanced salt solution (BSS).

After conjunctival peritomy at 360°, a Flieringa ring is secured to the sclera with Vicryl 7.0 interrupted sutures. The distance between corneal limbus and Flieringa ring should be not inferior to 4.5 mm in order to leave space for the trocars insertion, considering that they are inserted at 3.5 mm from the corneal limbus (Fig. 2a). The four valved trocars are inserted, two in the superior nasal and temporal quadrants, one for the infusion cannula inserted in the inferior temporal quadrant and one for the endoilluminator chandelier placed in the inferior nasal quadrant (Fig. 2a). To prepare for the TKP, six 7/0 vicryl sutures are passed through the sclera at fixed distances, in order to anchor...
the TKP to the sclera. Six different needles should be used and each needle left attached to the thread (Fig. 2b). If needed, two scleral pockets are prepared for the IOL implantation, to fixate it to the sclera (Fig. 2c). The pockets are not needed in case of an iris-fixated IOL implant. Before KP, infusion cannula and endoilluminator chandelier are attached to the respective trocars, without turning the infusion on and endoillumination (Fig. 2d). The following step is the trephination of the cornea: the recipient cornea trephination diameter is 8 mm, equal to the diameter of the TKP, and the donor cornea corneal diameter is calibrated to 0.25 mm larger than the recipient’s. The affected central part of the cornea is removed with a trephine under vacuum and replaced with the TKP. It is advisable to use the same diameter of trephination as the diameter of the available TKP. The TKP is then fixed onto the recipient cornea by using the previous preloaded six interrupted sutures (Fig. 2f). When the anterior chamber is sealed with the TKP, the infusion is activated (Fig. 2f). Following the vitrectomy, the vitreous chamber is completely filled with perfluorocarbon liquid (PFCL). To fix the IOL to the sclera, two straight 17-mm-long needles mounted to 10.0 polypropylene sutures are passed through the anterior chamber (AC) from a scleral flap to the opposite one, previously constructed (Fig. 3a, b). Then the two threads are pulled out from the AC under the TKP at 12 o’clock by using a hook without cutting the sutures anchoring the keratoprosthesis (Fig. 3c). Once the threads are out of eye, they are cut in order to have two threads on the right and two on the left to fix the IOL underneath the two suture ends.
Fig. 3 Temporal sequence of the surgical steps of the scleral fixation technique to implant the intraocular lens (a–k)
scleral flaps (Fig. 3d, e). The sutures are anchored to the loops of the IOL (Fig. 3f). The three superiors of the six sutures anchoring the TKP are cut and the TKP is partially raised to implant the IOL in the AC and then immediately repositioned to seal the AC (Fig. 3g, h). At this point, the sutures are pulled out from the scleral pocket, the IOL is centred in the AC and then the knot is tightened and pushed under the scleral pocket (Fig. 3i, j and k). Then, the TKP is removed and a full-thickness corneal graft of 8 mm sutured with 16 detached 10-0 nylon stitches is applied while maintaining a constant pars plana infusion throughout the surgery. The removal of PFCL and the exchange with the final tamponade (air, gas or silicon oil) is performed following the corneal graft.

Many variants are available in the surgical management of OGI. The aim of this paper is to propose a sequence of manoeuvres to safely avoid intraoperative hypotony. The first surgical step that the authors recommend is the use of the Flieringa ring. Despite being a surgical device reported in the literature for many years, this ring is not always used or at least is not often mentioned in the description of surgical techniques in PPV combined with PK. The support given by the Flieringa ring is of fundamental importance in complex and long open globe surgeries. Passing the scleral sutures induces a partial scleral depression which in open sky surgery prolongs the time of hypotonia, increasing the risk of complications. The preparation of the scleral flaps for the IOL fixation requires one to tilt the eye and produces continuous and sudden ocular micromovements. Furthermore, the edges of the TKP could be an obstacle for the correct execution of the scleral flaps. Hence, preparing the sutures for the fixation of the TKP and the scleral flaps for IOL fixation, when a scleral fixation is chosen, are steps to be performed before the cornea removal. The preparation of the sutures before the trepanation allows the surgeon to work safely and to position and fix the TKP in a shorter time.

An important precaution is avoiding activation of the pars plana infusion before removing the cornea and positioning the TKP. The fluid turbulence due to open sky infusion activation makes it more difficult to place the TKP. Once the TKP has been positioned, the surgeon is in the ideal conditions to perform vitrectomy and manoeuvres such as silicone removal, endolaser, and peeling of epiretinal membrane (ERM) in the vitreous chamber. A crucial moment concerns the placement of the IOL. Nowadays there are many options for secondary IOL implantation in the absence of capsular bag: AC IOL, iris-fixated IOL, retropupillary iris-fixated IOL, three-piece IOL sutured to the iris, and sutured (SF) or sutureless scleral-fixated (SSF) IOL [5, 17–27]. All the techniques have advantages and disadvantages. Selection of a technique is based on the surgeon’s experience, skill level and the specific conditions of the traumatized eye. However, some differences between the implantation of different types of IOL are removed when it is performed by open sky technique. First of all, by implanting the IOL with the open sky technique, a corneal incision is not necessary, so the advantage of a smaller corneal incision required for the implantation of a folding IOL with SF or SSF IOL technique compared to the iris-fixated technique is removed. In addition, the difficulties of preparing the sutures to fix the IOL to the sclera or of enclaving the IOL to the iris are considerably reduced, when these are performed in open sky in comparison to closed eye. Retropupillary iris-fixated IOL has gained some popularity, but there is not a standardized technique for its implantation and some complications, such as pupil ovalisation and occurrence of IOL tilt, are strong related to the surgeon’s skills. Furthermore, it requires manipulation of the iris tissue with pigment dispersion and the distance of the IOL from the endothelium will be less than with the positioning with scleral fixation technique [19–23]. The oldest SF technique has recently been revalued [5, 17, 18]. Infection or inflammation and IOL dislocation caused by suture degradation or breakage are some of the suture-related complications. Several techniques have been proposed to improve this technique: the use of scleral flaps or scleral tunnel, or fibrin glue-assisted [24–27]. Indeed, the implantation of an SF or SSF-IOL guarantees a better compartmentalization between anterior and posterior segment, and allows the
implantation of the IOL in a more natural position and at a greater distance from the corneal endothelium than the iris-fixated IOL. In these traumatic cases, the authors recommend choosing the scleral fixation implant. The technique proposed by the authors allows the surgeon to place the sutures underneath the scleral flaps and to tie them to the loops of the IOL before the TKP is removed, thus reducing the time spent working in the open sky.

The authors propose to reorder the sequence of surgical manoeuvres and highlight the advantages of the choice of the IOL in the treatment of ocular trauma involving both the anterior and posterior segment. These surgeries are very long and difficult to standardize. However, having a mental outline of all surgical manoeuvres, being aware of the complications that can arise during surgery and knowing the long-term benefits of making more careful choices can make this surgery more effective and safer.

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**REFERENCES**

1. Yucel OE, Demir S, Niyaz L, Sayin O, Gul A, Ariturk N. Clinical characteristics and prognostic factors of scleral rupture due to blunt ocular trauma. Eye (Lond). 2016;12:1606–13. https://doi.org/10.1038/eye.2016.194.

2. Négrél AD, Thylefors B. The global impact of eye injuries. Ophthalmic Epidemiol. 1998;3:143–69. https://doi.org/10.1076/opep.5.3.143.8364.

3. Kenyon KR, Starck T, Hersh PS. Penetrating keratoplasty and for severe ocular trauma. Ophthalmology. 1992;99(3):396–402. https://doi.org/10.1016/s0161-6420(92)31961-x.

4. Petrelli M, Schmutz L, Gkaragkani E, Droutsas K, Kymionis GD. Simultaneous penetrating keratoplasty and implantation of a new scleral-fixated, sutureless, posterior chamber intraocular lens (Soleko, Carlevale): a novel technique. Cornea. 2020;39(11):1450–2. https://doi.org/10.1097/ICO.0000000000002378.

5. Al-qahtani FA. Scleral fixation of intraocular lenses combined with penetrating keratoplasty. J Cataract Refract Surg. 2010;36(3):373–6. https://doi.org/10.1016/j.jcrs.2009.09.041.
6. Nardi M, Giudice V, Marabotti A, Alfieri E, Rizzo S. Temporary graft for closed-system cataract surgery during corneal triple procedures. J Cataract Refract Surg. 2001;27(8):1172–5. https://doi.org/10.1016/s0886-3350(01)00748-9.

7. Bové Álvarez M, Arumí CG, Distéfano L, et al. Comparative study of penetrating keratoplasty and vitreoretinal surgery with Eckardt temporary keratoprosthesis in ocular trauma versus non-trauma patients. Graefe’s Arch Clin Exp Ophthalmol. 2019;257:2547–58. https://doi.org/10.1007/s00417-019-04420-0.

8. Ayyildiz O, Hakan DA. Comparison of endoscopic-assisted and temporary keratoprosthesis-assisted vitrectomy in combat ocular trauma: experience at a tertiary eye center in Turkey. J Int Med Res. 2018;46(7):2708–16. https://doi.org/10.1177/0300060518769798.

9. Mayalı H, Kayıkçıoğlu Ö, Altınışik M, Bıçak F, Kurt E. Clinical results in patients with combined penetrating keratoplasty and vitreoretinal surgery using Landers wide-field temporary keratoprosthesis. Turk J Ophthalmol. 2019;49(5):270–6. https://doi.org/10.4274/tjo.galenos.2019.87059.

10. Chen HJ, Wang CG, Dou HL, et al. Anatomical outcome of vitreoretinal surgery using temporary keratoprosthesis and replacement of the trephined corneal button for severe open globe injuries: one-year result. J Ophthalmol. 2014. https://doi.org/10.1155/2014/794039.

11. Chun DW, Colyer MH, Wroblewski KJ. Visual and anatomic outcomes of vitrectomy with temporary keratoprosthesis or endoscopy in ocular trauma with opaque cornea. Ophthalmic Surg Lasers Imaging. 2012;43:302–10.

12. Beekhuis WH, Zivojnovic R. Use of temporary keratoprosthesis in the management of severe ocular trauma with retinal detachment and proliferative vitreoretinopathy. Dev Ophthalmol. 1989;18:86–9. https://doi.org/10.1159/000417093.

13. Garcia-Valenzuela E, Blair NP, Shapiro MJ, et al. Outcome of vitreoretinal surgery and penetrating keratoplasty using temporary keratoprosthesis. Retina. 1999;19(S):424–9. https://doi.org/10.1097/00003226-199909000-00010.

14. Gelender H, Vaiser A, Snyder WB, Fuller DG, Hutton WL. Temporary keratoprosthesis for combined penetrating keratoplasty, pars plana vitrectomy, and repair of retinal detachment. Ophthalmology. 1998;95(7):897–901. https://doi.org/10.1016/s0161-6420(88)33089-7.

15. Langefeld S, Kompa S, Redbrake C, Brennan K, Kirchhof B, Schrage NF. Aachen keratoprosthesis as temporary implant for combined vitreoretinal surgery and keratoplasty: report on 10 clinical applications. Graefes Arch Clin Exp Ophthalmol. 2000;238(9):722–6. https://doi.org/10.1007/s004170000163.

16. Yan H, Cui J, Zhang J, Chen S, Xu Y. Penetrating keratoplasty combined with vitreoretinal surgery for severe ocular injury with blood-stained cornea and no light perception. Ophthalmologica. 2006;220(3):186–9. https://doi.org/10.1159/000091763.

17. Malta JB, Banitt M, Musch DC, Sugar A, Mian SI, Soong HK. Long-term outcome of combined penetrating keratoplasty with scleral-sutured posterior chamber intraocular lens implantation. Cornea. 2009;7:741–6. https://doi.org/10.1097/ICO.0b013e31819bc31f.

18. Kanellopoulos A. Penetrating keratoplasty and artisan iris-fixed intraocular lens implantation in the management of aphakic bullous keratopathy. Cornea. 2004;23(3):220–4. https://doi.org/10.1097/00003226-200404000-00002.

19. Rijnveld WJ, Beekhuis WH, Hassan EF, Dellaeert MM, Geerards AJ. Iris claw lens: anterior and posterior iris surface fixation in the absence of capsular support during penetrating keratoplasty. J Refract Corneal Surg. 1994;10(1):14–9.

20. Rüfer F, Saeger M, Nölle B, Roider J. Implantation of retropupillar iris claw lenses with and without combined penetrating keratoplasty. Graefes Arch Clin Exp Ophthalmol. 2009;247(4):457–62. https://doi.org/10.1007/s00417-008-0940-2.

21. Gonnermann J, Torun N, Klamann MKJ, et al. Visual outcomes and complications following posterior iris-claw aphakic intraocular lens implantation combined with penetrating keratoplasty. Graefes Arch Clin Exp Ophthalmol. 2013;251(4):1151–6. https://doi.org/10.1007/s00417-012-2226-y.

22. Frisina R, Pilotto E, Tozzi L, Parrozzani R, Midena E. A new technique of needle-guided retropupillary fixation of iris-claw intraocular lens. J Cataract Refract Surg. 2019;45(3):267–71. https://doi.org/10.1016/j.jcrs.2018.10.031.

23. Mora P, Calzetti G, Favilla S, et al. Comparative analysis of the safety and functional outcomes of anterior versus retropupillary Iris-Claw IOL fixation. J Ophthalmol. 2018;2018:8463569. https://doi.org/10.1155/2018/8463569.

24. Totan Y, Karadag R. Trocar-assisted sutureless intrascleral posterior chamber foldable intra-ocular lens fixation. Eye (Lond). 2012;26(6):788–91. https://doi.org/10.1038/eye.2012.19.
25. Karadag R, Bayramlar H, Azari AA, Rapuano CJ. Trocar-assisted, sutureless, scleral-fixated intraocular lens implantation combined with penetrating keratoplasty. Cornea. 2016;35(9):1261–5. https://doi.org/10.1097/ICO.0000000000000944.

26. Prakash G, Jacob S, Kumar DA, Narsimhan S, Agarwal A, Agarwal A. Femtosecond-assisted keratoplasty with fibrin glue-assisted sutureless posterior chamber lens implantation: new triple procedure. J Cataract Refract Surg. 2009;35(6):973–9. https://doi.org/10.1016/j.jcrs.2008.12.049.

27. Sinha R, Shekhar H, Sharma N, Tandon R, Titiyal JS, Vajpayee RB. Intrascleral fibrin glue intraocular lens fixation combined with Descemet-stripping automated endothelial keratoplasty or penetrating keratoplasty. J Cataract Refract Surg. 2012;38(7):1240–5. https://doi.org/10.1016/j.jcrs.2012.02.042.