

Intraocular lens implantation in the absence of capsular support

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Abstract:

In the absence of capsular support, it is not always possible to safely place an intraocular lens (IOL) in the capsular bag at the time of surgery. Several techniques have thus been developed to enable safe placement of a secondary IOL outside the capsular bag. These techniques include placement of anterior chamber IOLs, iris-fixated IOLs (sutured, iris-claw), and scleral-fixated IOLs (sutured, sutureless). Secondary IOL placement can take place at the time of the initial surgery or in a second surgery. Each technique has its own unique advantages, as well as its potential complications. At this time, comparison studies have found no secondary IOL technique to be superior in terms of visual acuity or rate of complications. Additional comparison studies with longer follow-up times are needed to confirm these findings. The decision on which secondary IOL technique to perform depends on numerous factors including surgeon experience and comfort, as well as patient comorbidities.

Keywords:

Aphakia, intraocular lens, iris-sutured intraocular lenses, scleral-fixated intraocular lenses, secondary intraocular lenses

INTRODUCTION

Lack of capsular support may limit the ability of the surgeon to safely place an intraocular lens (IOL) in the ideal position within the capsular bag. Several conditions can result in zonular loss including trauma, previous complicated intraocular surgery (especially pars plana vitrectomy), inflammation (endophthalmitis, uveitis), hyper-mature cataracts, high myopia, hereditary causes (Marfan syndrome, homocystinuria, Ehlers-Danlos, Weill-Marchesani, retinitis pigmentosa, pseudo-exfoliation syndrome), and repeated intravitreal injections.^[1,2] If implantation within the capsular bag is not possible but there remains anterior capsular support, then placement of an IOL within the sulcus with or without optic capture is possible and preferred. Yet, if no capsular support remains, then there are still several options for IOL placement including within the anterior chamber (anterior chamber IOL, [ACIOL]),

fixated to the iris (iris-fixated IOL, IF-IOL), or fixated to the sclera (scleral-fixated, SF-IOL).^[3] There is no consensus on the optimal approach and each of these methods provides distinct advantages and disadvantages. Of note, if an IOL is placed outside of the capsular bag, IOL power adjustment should be performed.^[4] For example, if the IOL is placed more anteriorly, the IOL power should be reduced, typically by one half to one full diopter. Ultimately, if it is determined that primary IOL implantation is not safe, then leaving the patient aphakic with a plan for future secondary IOL implantation is reasonable.

ANTERIOR CHAMBER INTRAOCULAR LENS

An ACIOL is placed within the anterior chamber with the haptics of the IOL situated in the iridocorneal angle. Traditionally, this method of IOL implantation is less technically complicated and shorter in length than a sutured IOL procedure and thus may be a reasonable option depending on surgeon experience or the medical comorbidities of the patient, respectively.^[5] Open-loop ACIOLs are currently the only FDA labeled option

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for aphakia in the absence of capsular support. Relative contraindications to this procedure include prior history of endothelial decompensation or dystrophy, shallow anterior chambers and/or angles, the presence of peripheral anterior synechiae, defects of the iris, aniridia, younger patients, or uncontrolled glaucoma.^[6] Historically, closed-loop ACIOLs of the 1970s and 80s were associated with unacceptable rates of postoperative inflammation, secondary glaucoma, cystoid macular edema (CME), and corneal endothelial cell loss and decompensation.^[1,7] However, contemporary open-loop ACIOLs have significantly less incidence of these complications.^[8,9] Proper selection of ACIOL size is paramount to avoid these complications. A lens that is too small may lead to increased movement within the anterior chamber resulting in endothelial decompensation, corneal edema, and CME. A lens that is too large may lead to damage of iridocorneal angle structures resulting in secondary glaucoma, inflammation, or hyphema. The ideal size of an ACIOL is 1 mm greater than the horizontal white-to-white diameter.^[5,10] Since no ACIOL is foldable, placement within the anterior chamber requires a large 6–7 mm corneal incision. The surgeon should constrict the pupil prior to insertion in order to open the angle for haptic placement and a peripheral iridotomy must be performed to decrease the risk of pupillary block. Following placement, the pupil should be examined to ensure roundness as a peaked or irregular pupil may indicate a haptic imbedded in the iris, which has a higher incidence of complications.^[5] The authors of this chapter avoid placing ACIOLs in any cases given the need for a large wound and given the potential long-term complications.

IRIS-FIXATED INTRAOCULAR LENS

IF-IOL implantation involves suturing the haptics of a three-piece posterior capsule IOL (PCIOL) to the peripheral iris. In this technique, the proximal portion of the haptics are sutured to the peripheral iris, or alternatively the haptics are sutured at the positioning holes.^[11] 9-0 or 10-0 polypropylene is the most commonly used suture material.^[12] Several knot techniques have been employed to secure the haptics to the iris, including the modified McCannel, the Siepser, or the girth knot technique. The iris bites should be as small and peripheral as possible to minimize both pupil distortion and reactivity.^[13-15] The IF-IOL provides a good alternative to scleral-fixation if there is dislocation of an IOL previously placed in the capsular bag or sulcus, it is necessary to spare the conjunctiva, or in the presence of filtering blebs.^[16] Relative contraindications to placement of an IF-IOL include complete lack of remnant capsule, iris trauma, multiple iridectomies, or aniridia as these result in inadequate iris support to the IOL and pseudo-phacodonesis. Complications of IF-IOLs include chronic iris chafing resulting in uveitis, pigment dispersion, secondary glaucoma, pupil distortion, and CME.^[17]

Briefly, iris claw IOLs have also been used in phakic as well as aphakic patients without capsular support.^[18,19] The iris claw IOLs do not have traditional haptics, but instead two “claws” on either side which secure the IOL to the mid-peripheral iris

via enclavation, ensnaring a small bunch of iris tissue after a peripheral iridotomy is performed.^[5] The modern-day iris claw lens is the Artisan aphakic IOL (Ophtec BV, Groningen, The Netherlands). Currently under debate, the Artisan can be placed either anterior or posterior to the iris. The Artisan, while demonstrating safety and efficacy in Europe, is not currently available in the United States or FDA approved, although undergoing active investigation.^[6,20,21]

SCLERAL-FIXATED INTRAOCULAR LENS

The first reported SF-IOL technique was in 1983 by Gess which utilized one haptic of a PCIOL.^[22] Currently, SF-IOLs are divided into two categories consisting of sutured and sutureless techniques. The general principle is for the IOL haptics to be fixed to the sclera, by sutures or other means, through a ciliary sulcus or pars plana approach.^[23] One disadvantage of SF-IOLs is that this technique is technically more complex than either ACIOL or IF-IOL placement. SF-IOLs typically also require either an anterior vitrectomy or pars plana vitrectomy, as all as anterior chamber maintainer to preserve intraocular pressure during the procedure. Complications of SF-IOLs include suture breakage, erosion, or exposure in suture-fixated techniques, lens tilt, vitreous hemorrhage, suprachoroidal hemorrhage, retinal detachment, uveitis, and/or secondary glaucoma.^[24-28] A peripheral iridotomy could be placed to decrease the potential risk of pupillary block or capture.^[29]

SUTURED SCLERAL FIXATION

Polypropylene (Prolene; Ethicon) and CV-8 polytetrafluoroethylene (Gore-Tex; W. L. Gore and Associates) are the most commonly used sutures for scleral fixation. However, prolene sutures have been shown to have high rates of breakage ranging from 0% to 27.9% over the course of 3–10 years following implantation. Many surgeons have thus adopted the use of Gore-Tex; however, this suture is not yet approved for intraocular use and is used off-label.^[30] Typically, a scleral flap, groove, or tunnel is utilized to help with ciliary sulcus access, knot protection, and suture erosion prevention.^[5]

There are several IOLs developed that have been used for scleral fixation, many of which have eyelets on the haptics to assist in scleral suturing, lens stabilization, and to reduce the risk of dislocation. More frequently used SF-IOLs include the Alcon CZ70BD, Akreos AO60, and the Bausch and Lomb Envista [Figure 1]. The CZ70BD lends itself to only 2-point fixation which can result in IOL tilt; however, utilizing the cow hitch suture technique can decrease that risk.^[31] The Akreos lens has some advantages including having four eyelets that allow for increased stabilization and reduced lens tilt, as well as being foldable to allow scleral-fixation through a standard cataract incision, limiting the risk of large-incision surgery.^[32,33] However, the Akreos is hydrophilic, which has been reported to opacify postvitrectomy or following corneal endothelial grafting with gas or oil.^[34] The Envista has one eyelet at each of the two optic-haptic junctions, allowing for

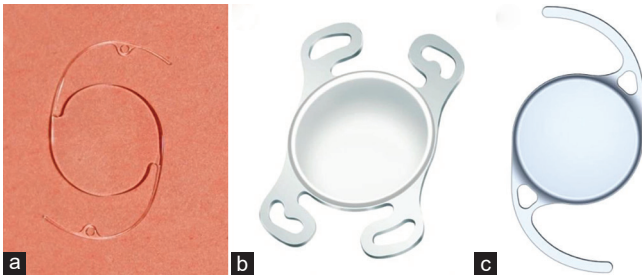


Figure 1: Selected intraocular lenses typically used in a sutured-scleral fixation technique. (a) CZ70BD (Alcon) with two haptics each containing an eyelet. (b) Akreos A060 (Bausch and Lomb) with four haptics each containing a terminal eyelet. (c) Envista (Bausch and Lomb) with two eyelets at the optic-haptic junctions. (Used with permission by Alcon and Bausch and Lomb)

“pseudo-four-point” fixation, however, there are reports of eyelet fracture intra- and postoperatively.^[35,36]

There are several techniques described for performing sutured scleral fixation. Malbran *et al.* described an *ab interno* approach in 1986 during an “open sky” procedure.^[37] Lewis described an *ab externo* approach using a straight needle with a 10-0 prolene suture in the 1990s.^[38] There is a 2013 case report of a scleral-fixated 1-piece toric IOL that had subluxated but was successfully re-centered and secured using prolene sutures in a lasso-type approach.^[39] Other techniques use a “cow-hitch” or girth knot suture fixation to avoid intraocular knots with free suture ends.^[40]

SUTURELESS SCLERAL FIXATION

Sutureless scleral-fixation (intrasceral haptic fixation, [ISHF]) has been recently gaining favor due to the absence of complications associated with large wounds and sutures, including suture breakage and erosion over time. Sutureless techniques involve fixating the haptics of a 3-piece IOL within the sclera through scleral flaps or limbus-parallel scleral tunnels.^[41,42] The haptics are externalized in a sutureless technique with either forceps or needles (25-, 27-, or 30-gauge).^[41-47] Using larger gauge needles to make the sclerotomies during the procedure has a higher risk of postoperative hypotony, wound leakage, and may require sutures to close.^[41,44,47] There are two main methods for intrasceral fixation of the haptic: Glued or flanged.

The first published glued scleral fixation technique used fibrin glue to adhere the IOL haptics within a scleral flap.^[47] The glued technique was found to have long-term stable IOL positioning in a 5-year study.^[48] First described by Shin Yamane in 2017, the flanged technique involves cauterization of the tips of a 3-piece IOL haptic after externalization through the sclera, thus creating a terminal bulb for intrasceral fixation.^[29,46] In this technique, two transconjunctival sclerotomies are placed 2.5 mm from the limbus at exactly 180°. Specialized TSK thin-walled, 30-gauge needles are used to reduce the sclerotomy size as much as possible and still allow for haptic insertion within the needles. After externalization, low-temperature

cautery at the tip of the haptics creates a lip (flange) that can be embedded within the sclera [Figure 2].^[46] This technique relies on two-point fixation which increases the risk for postoperative tilt. In Yamane’s original paper, the average IOL tilt was $3.4^\circ \pm 2.5^\circ$ in the 97 consecutive patients studied.^[46] The most common cause of a decentered or tilted IOL in this technique is due to unequal haptic length or placement, which can be mitigated with properly placed sclerotomy sites of equal length and direction.^[49,50] The ideal IOL for the flanged technique is one with polyvinylidene fluoride haptics, e.g., Zeiss CT Lucia, as these resist kinking and breakage [Figure 3].^[49] This technique has gained recent popularity due to its relative ease once learned, early visual recovery, and outcomes.

COMPLICATIONS

As with any procedure, each technique provides its own set and rate of unique complications. Mild postoperative IOL tilt may induce astigmatism or lead to glare and severe lens tilt may lead to iris chafe, resulting in inflammation or elevated intraocular pressure. The incidence of lens tilt for 10-0 prolene scleral-sutured IOLs and ISHF IOLs ranges from 0% to 10.4% and 0%–1%, respectively.^[51,52] Regarding IOL dislocation, for all secondary IOLs rates range from 0% to 28%. Studies with longer follow-up periods report higher rates of IOL dislocation, likely due to a higher risk of suture breakage with time.^[3] The highest rates are in studies on 10-0 prolene scleral-sutured IOLs (27.9% and 28%).^[24,53] The mean interval between IOL implantation with suture and breakage is 50 ± 28 months, which is reduced in younger patients.^[24] A study analyzing gore-tex scleral-sutured IOLs did not report any incidence of IOL dislocation but only had 11 months of mean follow-up.^[30] Displaced haptics with ISHF IOLs range from 0% to 5.7% of eyes.^[3] The rate of pupillary capture for secondary IOLs ranges from 0% to 9.6%, however, the incidence is unknown in Gore-Tex scleral-sutured IOLs or 10-0 prolene iris-sutured IOLs.^[3] The addition of pars plana vitrectomy may result in a much higher rate of pupillary block (23% in one study).^[53] Care to avoid lens tilt can decrease that rate. One can also consider performing a peripheral iridotomy at the time of surgery.

Postoperative uveitis has been reported in <5% of eyes undergoing secondary IOL implantation.^[3] However, in one study of eyes with iris-claw IOLs uveitis occurred in 7.7% of patients.^[19] The incidence of CME ranges from 0% to 28%. CME has been reported with all types of IOLs (typically 2%–7% of eyes) with the highest rate in 10-0 prolene iris-sutured IOLs (28%); however, this study included concomitant PKP at the time of surgery.^[3,54] A 2016 comparison study by Brunin *et al.* found the rate of CME in IF-IOLs to be 23%.^[55] Another study on ISHF IOLs found the rate of CME to be 21%.^[52] Additionally, 8-0 prolene scleral-sutured IOLs found a slightly higher rate of CME (13.2%) than 10-0 prolene scleral-sutured IOLs (0%–10.4%).^[3,56] Rates of endophthalmitis were low overall, ranging from 0% to 2.6%. Studies with longer follow-up tended to capture more cases of endophthalmitis

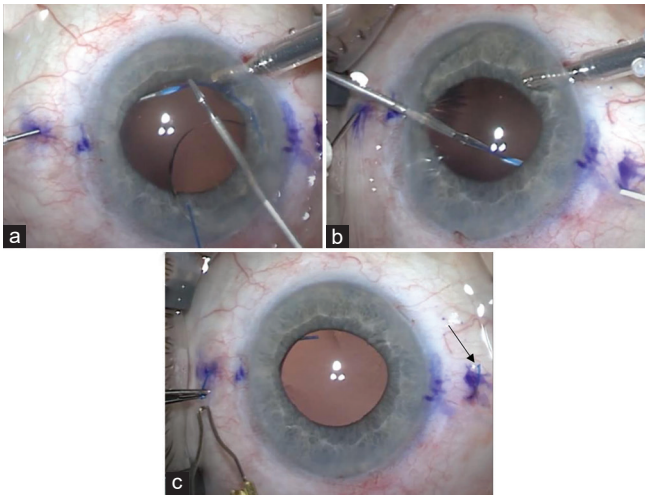


Figure 2: Intraoperative stills demonstrating the intrascleral haptic fixation technique, i.e., Yamane technique. (a) Passage of the first intraocular polyvinylidene fluoride haptic through a specialized thin-walled 30-gauge needle to be later externalized through a transconjunctival sclerotomy. (b) Passage of the second intraocular polyvinylidene fluoride haptic (note the 180° placement of the sclerotomies to reduce postoperative tilt). (c) Cauterization of the polyvinylidene fluoride haptic resulting in a “flanged” terminal bulb for intrascleral fixation (note the other haptic is already “flanged,” black arrow). (Surgeon Dr. Zaina Al-Mohtaseb, used with permission)

and longer surgical times are expected to lead to increased risk of infection.^[3]

Other potential complications to consider include glaucoma, retinal breaks or detachments, or vitreous hemorrhage. The overall incidence of glaucoma ranges from 0% to 27.9% across all secondary IOLs with the highest rate from a 10-0 prolene scleral-sutured IOL study.^[3,57] Historically, ACIOLs have been suspected of causing the highest rates of postoperative glaucoma; however, in a comparison study between 10-0 prolene scleral-sutured IOLs versus ACIOLs there were comparable rates of glaucoma between the 2 groups, 0%–23% and 0%–16.7%, respectively.^[9,56,58-60] The reported rates of retinal breaks and detachments are 0%–3% and 0%–8.2%, respectively.^[3] The highest rate of retinal detachments occurred in the 10-0 prolene scleral-sutured IOLs (4.2%–8.2%),^[24,61-63] Interestingly, iris-sutured IOLs showed significant rates of retinal detachment (0.5%–5.5%), while iris claw, AC, and ISHF IOLs showed the lowest rates of retinal detachment (0%–1%).^[3,54,64-66] Vitreous hemorrhage rates range from 0% to 26% of eyes undergoing secondary IOL implantation. Iris claw and iris-sutured IOLs had the lowest rates of vitreous hemorrhage, while 10-0 prolene scleral-sutured IOLs had the highest rate (26%).^[3,67]

Suture or haptic exposure and/or erosion is an important long-term postoperative consideration in SF IOLs. Thinning of overlying sclera or conjunctiva as well as shallow placement of haptics may lead to a higher risk of these complications. Exposed haptics or sutures have a higher risk for endophthalmitis or epithelial downgrowth.^[3] In separate



Figure 3: Computed tomography Lucia (Zeiss) 3-piece lens with polyvinylidene fluoride haptics to resist kinking and breakage during the flanged technique (intrascleral haptic fixation, i.e., Yamane technique)

10-0 and 8-0 prolene scleral-sutured IOL studies, exposed suture ranged from 0% to 1% and 3.3%, respectively.^[3,56] A comparison study of 10-0 prolene scleral-sutured IOLs and ISHF IOLs found 8% of eyes with eroded sutures and 4% of eyes with exposed haptics, respectively, at 6-month follow-up.^[68] For the scleral-sutured IOLs and ISHF IOLs, it is vital to rotate the knot under the sclera and to make sure the haptic is embedded in the sclera and not just placed subconjunctivally.

COMPARISON OF SECONDARY INTRAOCULAR LENSES

In 2020, an Ophthalmic Technology Assessment Report by the American Academy of Ophthalmology reviewed 45 articles regarding the visual acuity outcomes and complications of these different IOL implantation techniques in the absence of zonular support. All reviewed studies showed an improvement in postoperative visual acuity with each technique. Inconsistent visual acuity reporting across the studies complicated comparison between the techniques. In this meta-analysis, the reviewed complications included IOL decentration and tilt, IOL dislocation, pupillary optic capture, chronic uveitis, CME, glaucoma, retinal breaks or detachments, endophthalmitis, vitreous hemorrhage, suprachoroidal hemorrhage, suture or haptic erosion/exposure, and wound leak. Corneal edema was not included in this analysis due to inconsistent study reporting and improvements in surgical management. Overall, there was no evidence to show superiority of any IOL implantation technique in the absence of capsular support.^[3]

CONCLUSION

Each IOL placement technique presents with its own unique advantages and disadvantages, as well as challenges and complications, which should be considered prior to implantation. The decision of which technique to pursue should consider surgeon experience and comfortability, as well as patient ocular and systemic comorbidities. Given the

recent development of several of these techniques, long-term follow-up studies are needed to continue to assess their safety and efficacy.

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Conflicts of interest

There are no conflicts of interest.

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