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Scleral-Fixated Intraocular Lenses: Past and Present

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Abstract

Intraocular lenses (IOLs) can have inadequate support for placement in the capsular bag as a result of ocular trauma, metabolic or inherited conditions such as Marfan's syndrome or pseudoexfoliation, or complicated cataract surgery. Surgical options for patients with inadequate capsular support include alternative placement in the anterior chamber (ACIOLs), fixation to the iris, or fixation to the sclera. The surgical techniques for each of these approaches have improved considerably over the last several decades resulting in improved visual and ocular outcomes. If no capsular or iris support exists, the surgeon can fixate an IOL to the sclera or the patient can remain aphakic. IOLs can be fixated to the sclera using sutures or by tunneling the IOL haptics into the sclera without sutures. This review summarizes the pre-operative considerations, surgical techniques, outcomes, and unique complications associated with implantation of scleral-fixated IOLs.

Keywords

Secondary IOL implantation; sutureless intrascleral fixation; aphakia; scleral fixation; scleral-sutured IOL

BACKGROUND

Successful intraocular lens (IOL) placement in patients undergoing cataract surgery has become synonymous with the IOL being placed in the capsular bag. In such cases, the IOL is positioned within the lens capsule, well-centered to the pupillary axis, and the IOL-capsular complex is adequately supported by lens zonules. "In-the-bag" placement of an IOL maximizes the chances of optimal surgical and refractive outcomes. In the absence of

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adequate posterior capsular support, such as during complicated cataract surgery when the posterior capsule is violated, it is often possible to place an IOL in the ciliary sulcus and maintain excellent visual outcomes.¹ While the Food and Drug Administration (FDA) has not approved IOLs for placement in the ciliary sulcus, 3-piece IOLs, such as the Acrysof MA60AC (Alcon, Fort Worth, TX), are commonly placed there when in-the-bag placement is not possible. In cases of inadequate capsular support, the surgeon must use alternative surgical approaches to place an IOL in the eye.

Compromised anterior and posterior capsular integrity can result from a myriad of conditions that can be broadly categorized into ocular trauma, inherent zonular weakness (e.g. Marfan's syndrome, homocystinuria, pseudoexfoliation syndrome, etc.), or complicated cataract surgery. The prevalence of poor capsular support is much higher than it may at first seem. First, patients with traumatic open globe injuries are at increased risk for damage to the lens capsule and/or iris.² The incidence of open globe injuries in the United States (US) was 4.1 in 100,000 in 2011 according to a recent study of emergency room visits for ocular complaints.³ With an estimated 311 million people living in the country at that time,⁴ this translates to over 12,000 open globe injuries per year in the US alone. Second, the most common systemic condition associated with weakened zonules and crystalline lens subluxation, Marfan's syndrome, has an incidence of 1 in 5,000 people.⁵ Third, pseudoexfoliation, the most common risk factor for late IOL-capsular bag dislocation, has an estimated incidence of approximately 1 in 4,000 individuals.⁶ Pseudoexfoliation accounts for over 50% of cases of late IOL dislocation, a complication that is estimated to occur in 1.7% of post-cataract surgery patients after 25 years.⁷ Fourth, an estimated 1–2% of cataract surgeries in developed countries will be complicated by vitreous loss, which may prohibit placement of the new IOL in the capsular bag.⁸ When considering that over 3 million cataract surgeries are performed in the U.S. each year,⁹ even a 1% rate of vitreous loss would translate into a significant number of eyes that may require secondary IOL placement. Overall, these statistics underscore the need for effective surgical methods that can be employed when an IOL cannot be placed in the capsular bag.

Currently, the surgical options for placing an IOL in an eye without adequate anterior or posterior capsular support include anterior chamber intraocular lenses (ACIOLs), iris-fixated intraocular lenses (IFIOLs), and scleral-fixated intraocular lenses (SFIOLs). A comprehensive review of the literature surrounding IOL implantation in the absence of capsular support was undertaken in 2003 by the American Academy of Ophthalmology.¹⁰ The authors compared outcomes and complication rates among ACIOLs, IFIOLs, and SFIOLs. Based on the comparative studies available at the time, they concluded that there was insufficient evidence to recommend one type of IOL over another for patients in whom all three options are viable.^{11–15} A 2007 study comparing primary ACIOL vs. SFIOL implantation after complicated cataract surgery suggested that ACIOL implantation was associated with better visual acuity outcomes and fewer complications compared with SFIOL surgery.¹⁶ However, more recent studies have failed to demonstrate a significant difference in postoperative visual acuity or complication rates between ACIOLs, IFIOLs, and SFIOLs.^{17–20} Each approach has its advantages and unique set of disadvantages. This review will focus on the use of both sutured and sutureless techniques for SFIOL

implantation (Table 1). Specifically, the preoperative considerations, surgical techniques, complications, and outcomes for both sutured and sutureless SFIOLs will be discussed.

PREOPERATIVE CONSIDERATIONS

Scleral-fixated IOLs are indicated when there is no capsular or iris support and the patient does not wish to remain aphakic. Patients with an intact capsule may be candidates for sulcus IOLs. Patients with an intact iris would be candidates for ACIOL or IFIOL placement. However, even in cases where placement of an ACIOL may be possible, an SFIOL may be the preferred option if the patient has a shallow anterior chamber or corneal disease such as Fuch's dystrophy, corneal edema, or a corneal transplant.^{21,22}

IOL Repositioning vs. Exchange vs. Secondary Placement

The surgeon who is faced with implanting an SFIOL is likely to encounter one of three different preoperative scenarios: 1) the patient has an IOL that has subluxed or dislocated and the IOL can be repositioned; 2) the patient has an IOL that cannot be repositioned and therefore must be exchanged; or 3) the patient is aphakic and requires secondary IOL placement. For example, in the event of a 3-piece IOL dislocation into the vitreous cavity, as may be seen in cases of ocular trauma,²³ pseudoexfoliation,²⁴ or high myopia²⁵, the IOL can be "rescued" and fixated to the sclera rather than exchanged for an ACIOL or IFIOL.²⁶ Single-piece IOLs that have dislocated into the vitreous generally need to be exchanged; however, single-piece IOLs that have subluxed within the capsular bag can sometimes be sutured into the correct position using techniques that will be described later in this review.

Special Populations: Children

Children who need IOLs but who do not have capsular support represent a unique population for which the optimal management has yet to be defined. ACIOLs or IFIOLs have potential complications in this age group, such as iris chafing, glaucoma, and persistent inflammation.²² There are no prospective randomized studies comparing outcomes between SFIOLs, ACIOLs, and IFIOLs in children, so decisions are based largely on surgeon preference and patient circumstance. Retrospective and longitudinal case series of children implanted with mainly sutured SFIOLs^{2,27–38} have yielded promising short-term results at follow-ups ranging from one to approximately six years, but concerns regarding glaucoma, endophthalmitis, lens decentration/dislocation, and need for additional surgery have steered some clinicians toward the use of aphakic spectacles or contact lenses as a first-line treatment in children.^{39,40} Recently, IOL implantation via sutureless intrascleral fixation has been performed in children with no lens dislocations after six months of follow-up, but long-term data are needed to more completely assess the efficacy and safety of this technique.⁴¹

Anterior vs. Posterior Segment Surgeon

Both anterior segment⁴² and posterior segment⁴³ surgeons have successfully implanted SFIOLs. There have been no prospective randomized trials evaluating outcomes between SFIOLs managed with anterior vitrectomy (AV) or pars plana vitrectomy (PPV). In a recent retrospective study, visual outcomes and complications of patients with SFIOLs and either AV (n = 36 eyes) or PPV (n = 47 eyes) were evaluated.⁴⁴ Visual acuity improvement was

similar in both groups. Eyes in the SFIOL/AV group were more likely to experience lens dislocation (28%) compared to those in the SFIOL/PPV group (9%) ($p = 0.036$). Patients in the PPV group were more likely to experience a myopic shift and had a higher rate of IOL capture (23%) compared to the AV group (3%) ($p = 0.01$). However, this was a retrospective analysis and biases are inherent to this design. For example, the clinician decided to pursue either AV or PPV based on patient and surgeon factors, so definitive conclusions cannot be drawn.

There are advantages of a posterior approach as surgeons may have more ability to deal with unforeseen intraoperative surgical complications, such as posterior IOL dislocation or intraoperative retinal tears or detachments. Especially in cases with posterior dislocation of the IOL, modern vitreoretinal instrumentation allows an IOL to be “rescued” and fixated to the iris or sclera.

Timing of Surgery

In cases of SFIOL implantation following complicated cataract surgery, it is important to decide whether the IOL will be implanted primarily (i.e. at the time of cataract surgery) or secondarily (i.e. at a future date). Prospective, randomized trials comparing timing options for surgery have not been performed, but data from retrospective studies suggest that primary or secondary implantation of an SFIOL results in similar visual outcomes and complication rates.^{45,46} Therefore, the decision to implant an IOL primarily or secondarily will likely largely depend on the surgeon’s comfort level and experience with SFIOL placement and the clinical circumstances surrounding the need for an SFIOL.⁴⁷

IOL Selection

Several types of IOLs can be sclerally fixated, and the choice of IOL depends in large part on the clinical context and whether the surgeon plans to use sutures or not. Specific examples of IOLs used in SFIOL surgery will be discussed later in this review. While there is no consensus on the target spherical equivalent to use when implanting an SFIOL, we have had relative success using an in-the-bag target of approximately -1.00 diopters.⁴³ The post-operative refraction is more variable with SFIOL surgery than it is with placement of an IOL in the capsular bag, so we prefer to err on the side of myopia to prevent hyperopic surprises.

SURGICAL TECHNIQUES: SCLERAL-SUTURED IOLs

Scleral-Sutured IOLs: Past

Malbran and colleagues have been credited with the first published description of sutured SFIOLs for the management of aphakia following intracapsular cataract extraction in the 1980s.^{22,48} This technique used a 10-0 polypropylene suture to fix the haptics of the IOL to the sclera at 3 and 9 o’clock at a distance of 2 mm posterior to the limbus. With a 28-gauge needle, suture loops are introduced *ab externo* (from the outside of the eye to inside the eye) to create an internal loop of suture at each horizontal clock hour. From a corneal incision or during an “open sky” approach as seen with a penetrating keratoplasty (PKP), the two suture

loops are externalized and secured with a hitch to each haptic. The IOL is drawn into the eye and positioned posterior to the iris, and the sutures are tied onto the sclera.

In 1991, Lewis popularized the concept of *ab externo* suture passes and made use of scleral flaps to cover the suture knots.⁴⁹ While Malbran's 1986 technique also used *ab externo* passes, most surgeons at the time were making large corneal wounds or operating under an open sky to allow for suture passes to be made from inside the eye to outside the eye (*ab interno*). This was a blind maneuver that was associated with retinal detachment, hemorrhage, and unpredictable placement of the lens haptics. Lewis introduced the concept of "docking" a straight needle on a 10-0 polypropylene suture into a 28-gauge needle 180 degrees away. Entry points for both needles were measured 2 mm posterior to the limbus, which gave a more reproducible final IOL position in the ciliary sulcus compared to *ab interno* approaches. The suture traversed the eye from sulcus to sulcus, and after it was externalized with the use of a second instrument inserted through a corneal wound, the suture was cut and each end was tied to one haptic of the IOL. The IOL was subsequently introduced into the eye and maneuvered posterior to the iris with the haptics resting in the ciliary sulcus. Another suture bite was taken near each of the previous scleral entry points, and each entry suture was tied to its neighboring scleral suture to secure the haptics to the sclera (Figure 1). This technique is still being used today with relatively good success rates; a recent 2015 study of 13 eyes with long-term follow-up ranging from 5–10 years found only two eyes with minimal lens decentration; the decentration in these two eyes did not affect visual acuity.⁵⁰

Since Lewis's 1991 paper, surgeons have experimented with techniques such as transillumination⁵¹ and endoscopic placement of *ab interno* sutures⁵² to facilitate placement of the sutures in the ciliary sulcus and avoid injury to nearby ocular structures. While some have advocated for positioning of IOLs in the pars plana,⁵³ this requires suture placement closer to the retina and choroid and theoretically increases the risk of devastating complications such as retinal detachment and suprachoroidal hemorrhage. However, this dogma was called into question by a recent comparison of ciliary sulcus vs. pars plana fixation of IOLs, which failed to reveal an increase in the rate of complications with pars plana fixation.⁵⁴ Nevertheless, the technique has never gained much popularity among surgeons who perform sutured SFIOL surgery.²²

Scleral-Sutured IOLs: Present

Since scleral suturing an IOL was introduced, the technique and materials have been modified to improve success rates and reduce the risk of complications. For example, newer IOLs such as the CZ70BD (Alcon, Fort Worth, TX) and the Akreos AO60 (Bausch and Lomb, Rochester, NY) incorporate suture eyelets, which help to prevent suture slippage and subsequent IOL dislocation. 10-0 polypropylene sutures are a common suture of choice, but 9-0 polypropylene and 7-0 Gore-Tex (CV-8) sutures are also being used because of concerns about the long-term instability of the 10-0 polypropylene suture.^{22,40,55} Suture knot placement has evolved because externalized knots may erode through conjunctiva and increase the risk of endophthalmitis.^{56–58}

Prior to the advent of haptic suture eyelets, suture slippage from around the haptics was a contributor to IOL dislocation after sutured SFIOL implantation. The Alcon CZ70BD lens has become a popular choice for SFIOL cases due to its having eyelets on each haptic through which suture can be passed. However, this lens has only two eyelets and thus is used often with a two-point fixation technique. Therefore, it may be susceptible to lens tilt that can cause higher-order aberrations that cannot be corrected with spectacles. Holladay found that lens tilt > 15 degrees causes such aberrations,⁵⁹ while Tsai and colleagues have shown that a tilt of just five degrees can induce additional refractive error.⁶⁰ While CZ70BD lens tilt has not been quantified *in vivo*, an experimental study by Teichmann showed how difficult it is to avoid a torque or tilt effect using this lens *in vitro*.⁶¹ Other studies using two-point fixation techniques in patients inform surgeons of the risk of lens decentration and tilt with this method. In one study directly comparing tilt between sutured SFIOL and in-the-bag IOLs, the authors found a two-fold increase in the mean IOL tilt angle among the sutured SFIOL patients compared to the in-the-bag IOL patients (6.35 degrees vs. 3.18 degrees, respectively).⁶² The author used a two-point fixation technique originally described by Mittelman and Wiek in 1993 whereby sling sutures are passed *ab interno* through the eyelet of each haptic to secure the haptics to the sclera.⁶³ In contrast to the CZ70BD lens, the Bausch and Lomb Akreos AO60 lens has four haptics, each with its own eyelet for suture passage. The four-point stabilization inherent in the Akreos lens theoretically decreases the risk of lens tilt and decentration^{64,65} though head to head studies comparing lens tilt between Akreos AO60 and CZ70BD lenses have not been performed. Another major difference between the Akreos and CZ70BD lenses is that the Akreos lens is hydrophilic and therefore susceptible to optic opacification via calcium salt deposition following intraocular gas or air fill.⁶⁶

Recently, Khan and colleagues described the technique of combined 27 gauge PPV with scleral fixation of an Akreos AO60 lens (Digital Supplement, Video 1).⁶⁷ This technique requires the creation of superonasal and inferotemporal limbal peritomies. The first 27 gauge cannula is placed outside the peritomy sites and is used for the infusion. The second cannula is placed 3 mm from the limbus in either of the peritomy sites. Next, a sclerotomy is made 5 mm from this cannula with the 27 gauge trocar while maintaining a limbal distance of 3 mm. The process is repeated in the opposite peritomy site. After completion of the vitrectomy, the CV-8 Gore-Tex suture is cut into two halves, and each half is threaded through the two eyelets on each side of the Akreos lens. The nasal suture ends are then passed into the eye through a corneal incision and grasped with MAXGrip (Alcon Laboratories) or similar forceps via a handshake technique through the nasal sclerotomy and cannula. The Akreos lens is next folded, inserted into the eye, positioned centrally, and the remaining two suture ends are pulled through the temporal sclerotomy and cannula with MAXGrip forceps. The Gore-Tex sutures are tied and the knots rotated into the sclerotomy sites. The conjunctiva is closed over the sutures.

As previously mentioned, there has been a trend towards using thicker sutures such as 9-0 polypropylene and 7-0 Gore-Tex over the traditional 10-0 polypropylene for scleral fixation of IOLs due to the presumed enhanced durability of these sutures. Multiple case series, retrospective analyses, and prospective studies have reported late IOL dislocation due to suture breakage when 10-0 polypropylene is used to secure the IOL to the sclera.^{40,68} This

tends to occur years after the IOL is implanted; in one case series, suture breakage occurred 3 – 9 years after the initial surgery in four eyes.⁶⁹ In another retrospective analysis of 63 eyes with SFIOLs affixed to the sclera with 10-0 polypropylene, two eyes (3%) developed IOL dislocation secondary to suture breakage at 15 and 54 months post-procedure.⁷⁰ Malta and colleagues reported a similar rate of suture breakage and IOL dislocation in a cohort of 105 eyes that underwent combined PKP with SFIOL implantation using 10-0 polypropylene sutures.⁴² In their study, two of the 109 eyes (2%) experienced suture breakage at five and eight years post-procedure. Buckley evaluated the use of 10-0 polypropylene for SFIOLs in children; in his series, four out of 26 patients (15%) experienced IOL dislocation secondary to suture breakage at a mean of 5.6 years following the initial surgery.⁴⁰ He concluded that 9-0 polypropylene might be a better alternative to 10-0 polypropylene to fixate the IOL to the sclera in the pediatric population. Long term results using 9-0 polypropylene³⁴ or 7-0 Gore-tex⁵⁵ for scleral fixation of IOLs are lacking, but short-term results are promising. Price reported five cases of 10-0 polypropylene suture breakage in patients with SFIOLs (four spontaneous, one due to trauma) that were repositioned with 9-0 polypropylene sutures. The IOL was still secured to the sclera in all five eyes at the most recent follow-up, including the eye with the longest follow-up of 22 months.⁶⁸ Khan's 2015 series using the Akreos or CZ70BD lens with 7-0 Gore-tex suture included 85 eyes, and there were no reported cases of suture breakage during follow-up ranging from three to 33 months post-procedure.⁵⁵

Knot erosion through the conjunctiva following sutured SFIOL surgery can be associated with endophthalmitis after the knots erode through the conjunctiva, as the suture provides a direct avenue for exogenous bacteria to enter the eye.^{56–58} To solve this problem, Lewis made triangular scleral flaps prior to entering the eye with his needle passes, and the hinged scleral tissue was used to cover the suture knots at the end of the procedure. However, a major drawback to the scleral flap technique is that it requires a conjunctival peritomy and presents problems if the patient requires subsequent glaucoma surgery. In 2006, Hoffman introduced the idea of creating scleral pockets that do not require a conjunctival peritomy but still allow for adequate coverage of the suture knots during sutured SFIOL implantation or rescue of a subluxated IOL.⁷¹ In brief, clear corneal incisions are made 180 degrees apart (in the same meridian of the IOL haptics in the case of a subluxated IOL). Next, a beaver blade is used to make a one clock-hour partial thickness scleral incision at the limbus just posterior to each of the corneal wounds, and the partial thickness scleral incision is dissected posteriorly to approximately 3 mm from the limbus. A paracentesis is then made just anterior to each of the corneal wounds. Next, a 27-gauge needle is passed through the conjunctiva and one of the scleral pockets at a distance of 1 mm posterior to the surgical limbus. From the opposite paracentesis, one end of the double armed 9-0 polypropylene suture on a long straight needle is passed into the eye and docked into the 27 gauge needle either above or below the displaced IOL haptic. The needle and suture are then externalized through the scleral pocket. The process is repeated with the other end of the polypropylene suture to capture the haptic. Once the two ends of the suture are externalized through the scleral pocket and conjunctiva, the ends are retrieved from the scleral pocket with a Sinsky hook and tied – the resulting knot buries itself within the scleral pocket as it is tightened.

Another approach to help prevent suture erosion through the conjunctiva is to bury the knot in the sclera,^{72,73} though this can be difficult with short suture passes and thicker sutures such as 9-0 polypropylene and 7-0 Gore-Tex. A creative way to avoid suture erosion through the conjunctiva is to avoid tying knots all together and run the end of the externalized 10-0 polypropylene suture partial thickness through the sclera in multiple locations in a “zigzag” pattern.⁷⁴ Five passes through the sclera is sufficient to secure the IOL in place. In a series of 45 eyes with sutured IOLs secured with this so-called “Z-suture”, there were no cases of IOL dislocation after follow-up ranging from six to 38 months.

Long-term studies of patients after sutured SFIOL implantation have generally been favorable, but sutured SFIOL surgery is not without its unique set of complications. The risks associated with sutured SFIOL surgery include the potential for postoperative lens dislocation,^{68,75,76} lens tilt,⁶¹ suprachoroidal or vitreous hemorrhage,^{77–79} retinal detachment,^{80,81} and endophthalmitis.^{57,58} The rates of these complications may vary based on the surgeon, patient circumstances, and the technique used to affix the IOL to the sclera. In general, the complications arise from suboptimal suture placement or use of less durable suture materials at the time of surgery. Recent studies have reported complication rates associated with sutured SFIOL surgery ranging from 10% – 54%.^{82–84} Postoperative complications felt to be unrelated to suturing the IOL have included hypotony,⁵⁵ ocular hypertension,^{55,81} and cystoid macular edema (CME).⁷⁸ Interestingly, the advent of endoscope assisted intraocular surgery may provide a means to lower the complication rate in the setting of sutured SFIOL implantation. A study comparing endoscope assisted vs. non-endoscope assisted trans-scleral fixation of IOL found a dramatic reduction in the rate of complications when the endoscope was used to visualize suture placement.⁸⁵

SURGICAL TECHNIQUES: SUTURELESS SFIOLs

Given some of the potential shortcomings associated with suturing an IOL to the sclera in patients who lack capsular support, it should come as no surprise that surgeons began to evaluate whether sutureless intrascleral (SIS) fixation of the IOL could be accomplished in these patients. Scharioth and coworkers are credited with the first description of an SIS technique that utilized 24-gauge cannulas to create diametrically opposite *ab externo* sclerotomies at a distance of 1.5–2.0 mm from the limbus.⁸⁶ Next, the cannulas were used to create 50% thickness scleral tunnels parallel to the limbus near each of the original sclerotomy sites. A standard 3-piece IOL is then inserted into the eye and the haptics are externalized in turn through the sclerotomy incisions and fed into the scleral tunnels, leaving only a small portion of each haptic exposed between the scleral tunnel and the sclerotomy site.^{86,87}

Since their original description of the SIS technique, other surgeons have modified the method by using vitreoretinal instruments to create the sclerotomies. For example, Prenner and colleagues used a microvitreoretinal blade and 23 gauge trocars to fashion the sclerotomies and scleral tunnels through which the haptics of a 3-piece IOL may be inserted.⁸⁸ The one-year results with this technique were good, with a mean improvement of visual acuity from approximately 20/400 to 20/70 at one year. However, three of the reported 24 cases (12.5%) developed IOL dislocation.⁸⁹ Abbey and coworkers subsequently

described a similar technique for SIS that did not require a conjunctival peritomy.⁴³ With this approach, 25-gauge trocars are used to create 3 mm transconjunctival scleral tunnels that are 180 degrees apart from each other. The cannulas are left in the tunnels and sclerotomies, and then one of the haptics of a 3-piece IOL is inserted into the eye through a limbal incision. Next, the tip of the haptic is grasped with a 25-gauge forceps that has been inserted through one of the cannulas. The cannula is subsequently advanced up the shaft of the forceps, and the haptic is pulled through the sclerotomy and scleral tunnel. The same procedure is repeated for the haptic 180 degrees away. After a mean follow-up of one year, none of the haptics had eroded through the conjunctiva and none of the 15 cannula-fixation eyes had experienced an IOL dislocation. Mean visual acuity improved from approximately 20/300 pre-operatively to 20/50 post-operatively. As the haptics remain covered by the conjunctiva, the risk of exogenous endophthalmitis in the post-operative period should be minimized. We have recently described a variation of this technique using 27-gauge fixating trocars that may form a tighter tunnel around the haptics and thus potentially reduce the risk of post-operative hypotony (Digital Supplement, Video 2).⁹⁰

Another adaptation of the SIS technique was recently described by Yamane and coworkers.⁹¹ After inserting a 3-piece IOL into the anterior chamber, they used a 27-gauge needle to create a scleral tunnel at a distance of 1.7 mm from the limbus. Next, microforceps were used to feed one haptic into the lumen of the 27-gauge needle. This same process was then repeated 180 degrees away for the other haptic and scleral tunnel. The 27 gauge needles are simultaneously removed from the eye to allow the haptics to rest in the scleral tunnels. After a mean follow-up interval of 10 months in 35 eyes, the authors had no cases of retinal detachment, endophthalmitis, IOL dislocation, or vitreous hemorrhage. However, ocular hypertension was present in two eyes and optic capture occurred in three eyes.

In place of sutures, fibrin glue has also been used to secure the haptics of an IOL to the sclera. This technique was first described in 2008 by Agarwal and colleagues and involves the creation of two scleral flaps 180 degrees apart.⁹² Sclerotomies are made within the flaps and, after introduction of the IOL into the eye, the haptics are grasped through the sclerotomies with forceps and externalized. Next, fibrin glue is applied to the bed of the flap, and the outer portion of the scleral flap is folded over the haptic, sealing the scleral flap. In a recent study of 25 eyes that underwent fibrin glue-assisted SIS fixation, IOL decentration occurred in only one eye (4%) after one year of follow-up.⁹³ Long-term studies regarding the safety and efficacy of this technique are lacking, but haptic erosion through the scleral bed has been reported in one study, as well as vitreous hemorrhage and intraocular pressure elevation.⁹⁴

SUTURED VS. SUTURELESS SFIOLS

There have been relatively few studies directly comparing one type of SFIOL technique with another. Ganekal and colleagues compared sutured SFIOL (n = 25) with fibrin-glue assisted SFIOL (n = 25) implantation and found that postoperative visual acuity was similar between the two groups.⁹⁵ However, the sutured IOL group experienced significantly more complications compared to the fibrin glue group (56% vs 28%, respectively, p = 0.045). Higher rates of post-operative glaucoma and inflammation occurred in the sutured IOL

group compared to the fibrin glue group. Another study compared sutured SFIOL surgery using the Hoffman pockets (n=31) to the Scharioth SIS technique (n=11) in patients with post-traumatic or post-operative aphakia with a mean follow up time of 14.5 months.⁷⁵ A single surgeon performed all of the procedures in both groups. The authors did not find any difference in postoperative visual acuity between the two groups ($p = 0.161$). However, two eyes in the SIS group had IOL dislocations while no eyes in the sutured pocket fixation group had an IOL dislocation. Conclusions of superiority of one technique cannot be drawn without longer-term studies with more enrolled patients.

CONCLUSION

Ocular trauma, diseases causing zonular weakness, and zonular trauma after complex cataract surgery can disrupt the anterior and posterior lens capsule, thus prohibiting placement of an IOL in the capsular bag. In these cases, most patients do not wish to remain aphakic and choose to undergo surgery with implantation of an ACIOL, IFIOL, or SFIOL. Evidence shows that implantation of any of these IOLs will lead to good visual acuity outcomes. Placement of an SFIOL is the only option for patients whose eyes lack both iris and capsular support.

SFIOLs are broadly categorized as either sutured or sutureless. Sutured SFIOL techniques vary according to the type of suture used, the type of IOL used, the maneuvers used to place the sutures, and the way in which suture knots are placed. Complications associated with sutured SFIOLs include suture breakage and lens dislocation and severe complications such as retinal detachment, suprachoroidal hemorrhage, and suture-related endophthalmitis. Sutureless techniques attempt to avoid suture-related complications by burying the IOL haptics in scleral tunnels or scleral flaps; however, these IOLs can still dislocate, and long-term data regarding IOL stability and severe complication rates is lacking.

Surgical techniques for SFIOLs are improving as innovative surgeons attempt modifications of existing techniques. Methods to reduce the perioperative complications associated with inaccurate suture placement and to decrease the risk of IOL decentration and dislocation merit additional study. As industry improves suture material options and IOL designs, surgeons will have more options to improve SFIOL placement while minimizing postoperative complications. Long-term data comparing the various techniques used to place SFIOLs will be crucial to identify optimal strategies for SFIOL implantation.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

SIS	sutureless intrascleral fixation
PPV	pars plana vitrectomy
PPL	pars plana lensectomy
IOL	intraocular lens
SFIOL	scleral-fixated intraocular lens
ACIOL	anterior chamber intraocular lens
IFIOL	iris-fixated intraocular lens

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Figure 1.

The Lewis technique for implanting a sutured IOL is portrayed. Two small conjunctival peritomies are performed 180 degrees apart from one another, and then two triangular partial thickness scleral flaps are created. A straight needle on a polypropylene suture is inserted 2 mm posterior to the limbus through the bed of a scleral flap and docked into a 28 gauge needle 180 degrees away (A). The two needles are externalized, and the central line of suture is pulled through a corneal wound or scleral tunnel (B). After the suture is externalized, it is

cut and the ends are tied to each haptic of the IOL (**C**). The IOL is inserted into the eye each suture end is tied to a neighboring suture (**D**).

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TABLE 1

Method of Scleral Fixation			Potential IOLs		References for Surgical Techniques	
Sutured	1	10-0 polypropylene	1	CZ70BD (Alcon)	1	Malbran ES, et al. <i>Int Ophthalmol.</i> 1986;9(2-3):151-160
	2	9-0 polypropylene	2	Akreos AO60 (Bausch and Lomb)	2	Lewis JS. <i>Ophthalmic Surg.</i> 1991;22(11):692-695
	3	7-0 Gore-Tex			3	Mittelvieffhaus H, et al. <i>Ophthalmic Surg.</i> 1993;24(10):698-701
					4	Hoffman RS, et al. <i>J Cataract Refract Surg.</i> 2006;32(11):1907-1912
					5	Szurman P, et al. <i>Br J Ophthalmol.</i> 2010;94(2):167-169.
					6	Khan MA, et al. <i>Br J Ophthalmol.</i> 2016;100(5):638-643
Sutureless	1	Sutureless intrascleral fixation	1	MA60AC (Alcon)	1	Scharioth GB, et al. <i>J Cataract Refract Surg.</i> 2010;36(2):254-259
			2	ZA9003 (Tecnis)	2	Prenner JL, et al. <i>Retina.</i> 2012;32(4):853-855
	2	Fibrin glue assisted			3	Abbey AM, et al. <i>Graefes Arch Clin Exp Ophthalmol.</i> 2015;253(1):1-5
					4	Agarwal A, et al. <i>J Cataract Refract Surg.</i> 2008;34(9):1433-1438
					5	Yamane S, et al. <i>Ophthalmology.</i> 2014;121(1):61-66

The main indication for SFIOL implantation is the absence of adequate iris and capsular support in a patient who does not wish to remain aphakic. Methods for fixating an IOL to the scleral can be classified as sutured or sutureless. The 2005 review by Por and colleagues nicely summarizes many of the techniques used for SFIOL implantation.

Abbreviations: IOL, intraocular lens.