Chapter

Secondary Intraocular Lens

Niranjan Manoharan and Pradeep Prasad

Abstract

Secondary intraocular lens (IOL) implantation has evolved over the past few decades. Several new techniques, lens options, and materials now exist. Careful patient selection is important to determine the optimal secondary IOL technique. Intraocular lens placement in the capsular bag is the most ideal followed by sulcus placement. However, the best option when no capsular support exists in an aphakic patient remains unclear. Surgeons should be aware of contraindications for each technique; however, there are several situations where anterior chamber intraocular lens (ACIOL), scleral-fixated intraocular lens (SFIOL), and iris fixation can all be used. In those cases, surgeon familiarity and comfort with the secondary IOL technique can determine the type of surgery performed.

Keywords: secondary intraocular lens, aphakia, scleral fixated, iris fixated, anterior chamber intraocular lens

1. Introduction

Secondary intraocular lens implantation is defined as implantation of an intraocular lens following an initial surgery that resulted in aphakia or a deficient intraocular lens. The indications for secondary intraocular lens insertion have evolved with improved surgical outcomes of modern cataract surgery. Newer surgical techniques and lenses has also advanced the field of secondary intraocular lenses. The first wave of secondary intraocular lenses to be implanted was the anterior chamber intraocular lens (ACIOL) [1]. Secondary intraocular lenses can now be implanted in a variety of anatomic locations with different techniques used to support the lens (sutured, iris claw, etc.). Specifically, sutured IOL and intrascleral fixation techniques have been gaining popularity. Szigiato et al. found a 538% increase in secondary sutured IOL techniques from 2000 to 2013 [2]. However, with the advent of several new techniques there is no clear guidance for the best technique for secondary IOL placement. This chapter aims to discuss the variety of secondary intraocular lenses, the indications for use, and surgical considerations.

2. Indications

Modern cataract surgery has evolved the role of secondary intraocular lens implantation since there is now less incidence of surgical aphakia after cataract surgery [2]. With current technology and improved cataract surgery technique, the most common reason for secondary lens implantation is IOL exchange. The rates of IOL exchange also have declined over the years with recent studies showing rates of 0.34–0.77% [2–4]. ACIOL explantation is most commonly due to corneal decompensation and inflammation [5, 6]. PCIOL explantation is most commonly due to IOL decentration and dislocation [7]. IOL dislocation can be due to zonular dehiscence from trauma, previous complicated surgery, or conditions predisposing to zonular instability such as pseudoexfoliation syndrome and Marfan's syndrome.

Uveitis-hyphema-glaucoma (UGH) syndrome is a complication of iris chafing of an IOL. Most commonly this is due to a single-piece IOL with a haptic outside of the capsular bag that comes in contact with posterior iris tissue. IOL chafing of iris tissue leads to iris transillumination defects, pigment dispersion, microhyphema/hyphema, and glaucoma. Treatment of UGH often requires IOL removal with placement of a secondary IOL although in some cases the haptic in the sulcus alone can be cut and removed.

In recent years, advancements in IOL calculations, cataract surgery technology and technique have improved refractive outcomes. Patient visual expectations after cataract surgery have increased and now, in some cases, IOL exchanges are performed for unexpected refractive outcomes, dissatisfaction with multifocal lenses, and dysphotopsias following cataract surgery. The rates of IOL exchange due to patient dissatisfaction in one study showed an increase from 7.8% in 2005 to 21% in 2014 [3]. In 2005, no patients underwent IOL exchange for unsatisfactory refractive outcomes in the absence of optical aberrations but in 2014, 42% of IOL exchanges were due to unsatisfactory refractive outcomes alone.

3. Preoperative evaluation

Prior to consideration of secondary intraocular lens implantation, a thorough pre-operative history is required. In particular, details of the prior cataract removal including intraoperative complications, type of IOL implanted, location of the IOL implant and the presence of other ocular hardware including glaucoma drainage devices are important pieces of information to gather before secondary IOL surgery. To this end, review of prior operative reports and medical records is a critical element of every preoperative evaluation.

A thorough examination of the anterior and posterior segment is required to plan for a secondary IOL implantation. The conjunctiva and scleral should be examined to identify any prior incisional glaucoma surgery or devices. Corneal health should be evaluated to determine if an ACIOL is a viable option. Specular microscopy or pachymetry can be obtained as needed to assess corneal endothelial health. Anterior chamber depth should be evaluated as a narrow/shallow chamber might preclude safe ACIOL placement. The presence of vitreous prolapse in the anterior chamber should be noted as well as the integrity of the iris and capsule. Of note, high frequency ultrasound has shown to be better than slit lamp examination in assessing capsular support for sulcus IOL implantation [8]. If there is an intraocular lens in place, the type of lens and degree of dislocation should be assessed. The optic nerve and retina should be thoroughly examined to evaluate for any other ocular comorbidities that can limit vision potential or require treatment at the time of secondary IOL implantation. Finally, vision potential with a reliable manifest refraction is important to gauge the potential benefit of secondary IOL implantation.

4. Contact lens and aphakic glasses

Aphakic spectacles are a non-invasive option for bilateral aphakia although they are a sub-optimal solution for unilateral aphakia due to induced aniseikonia.

Aniseikonia is a significant difference in the perceived size of images between the two eyes. This difference in image sizes can be as large as 30% which makes fusion impossible [9]. Other drawbacks of aphakic spectacles are that they are heavy and have poor cosmesis since the lenses are thick centrally with significant magnification. Also, patients wearing aphakic lenses may notice a ring scotoma and have to cope with objects jumping in and out of their visual field.

Extended-wear contact lenses can be an adequate option for managing binocular and monocular aphakia. Properly fitted contact lenses can be well-tolerated by patients and secondary IOL implantation can be avoided in patients who are happy with contact lens use. Some physicians argue that a trial of aphakic contact lenses should be required prior to secondary IOL implantation, especially in eyes with questionable functional visual potential.

5. Determination of anatomic location of secondary IOL

Choosing the best location and technique for secondary IOL implantation can be a difficult one. No clear guidelines are established for secondary IOL implantation. In 2003, Wagoner et al. reviewed the literature on secondary IOL implantation [10]. In this paper, the authors found no evidence to claim superiority of any one technique or anatomic location for fixation. Since 2003, secondary IOL surgery has continued to evolve dramatically and still no clear evidence exists to guide surgeons. As Wagoner's paper noted, the most important factor often is the surgeon's comfort with a secondary IOL technique.

There are however, some recommendations in ruling out certain anatomic locations for IOL fixation. For example, poor corneal endothelial status and/or abnormal angle/iris anatomy should discourage anterior chamber IOL implantation. Lack of adequate iris support would rule out other iris-fixated approaches (sutured or iris-claw). Lack of posterior capsular support or a fibrosed anterior/posterior capsule would rule out in-the-bag PCIOL placement. Sulcus intraocular lens implantation requires adequate anterior capsular support. Scleral abnormalities (i.e., Marfan's, scleral thinning, etc.) would rule out scleral fixation techniques.

In-the-bag posterior chamber intraocular lens implantation remains the best anatomic location for an intraocular lens. However, even if during secondary IOL implantation the aphakic eye has an intact posterior capsule, the anterior/posterior capsule is typically fibrosed, preventing IOL implantation inside the capsular bag. Brunin et al. evaluated the complication rates, visual acuity and refractive outcomes of different intraocular lens implantation techniques [11]. Their study noted that capsular bag implantation had the best refractive outcomes followed by sulcus IOL with optic capture and sulcus IOL without optic capture. There was no difference between transscleral-sutured IOL, iris-fixated IOLs, and ACIOLs.

If possible, in-the-bag implantation has the best outcomes given its closest proximity to normal anatomy. This requires a stable and intact capsular bag. If no posterior capsular exists but there is adequate anterior capsular support, sulcus IOL implantation can be performed, preferably with optic capture. However, if no capsular support exists, the guidelines for secondary IOL implantation remain controversial [12]. If a viable 3-piece IOL has been dislocated, the preference might be to reposition the lens with an iris-sutured or scleral fixation technique. Other options include ACIOL implantation, iris-fixation techniques, and scleral-fixation techniques. The following sections will explore these options in more detail.

6. Capsular bag

Secondary intraocular lens implantation into the capsular bag can only be performed in the early post-operative period before the formation of anterior–posterior capsular adhesions. Typically, this procedure is performed in the early post-cataract surgery period due to incorrect intraocular lens power or patient dissatisfaction with an IOL (i.e., dysphotopsia from a multifocal IOL). Despite advances in IOL power formulas, some of which take into account the effects of prior refractive surgery, patients can still end up with large IOL power errors that may necessitate IOL exchange. Even with small errors, premium lens patients can demand IOL removal due to higher patient expectations in this population. IOL explantation in these cases should ideally be performed within 4–6 weeks of the initial cataract surgery although in-the-bag IOL exchange months to years following cataract surgery has been reported. A needle or cannula with viscoelastic is used to dissect the anterior capsular off the lens with care to avoid damaging zonular fibers and the posterior capsule. Once the lens is mobilized and removed, the capsular stability is assessed. If good anterior and posterior capsular support is noted the capsular bag is inflated with viscoelastic and a new lens can then be placed into the capsular bag.

7. Sulcus intraocular lens

Sulcus intraocular lens implantation is the second-best option if the anterior capsule is intact and in-the-bag implantation cannot be performed. In cases with a single-piece IOL dislocation, the IOL must be removed and replaced with a 3-piece IOL in the sulcus. In cases of 3-piece IOL dislocation, the IOL can be retrieved and repositioned into the ciliary sulcus. If the capsulorhexis is intact, the optic can then be captured by pushing the optic posteriorly through capsulorhexis with the lens haptics remaining in the sulcus. Of note, most three-piece IOLs have an overall haptic to haptic diameter of 13 mm or less, which can be too short especially in long eyes. This can lead to lens decentration and tilt. Three-piece intraocular lenses with larger haptics can fit better in the sulcus and decrease chances of decentration/tilt. With optic capture, the IOL calculations remain the same as the in-the-bag calculations [10].

Single-piece acrylic IOLs should not be placed in the sulcus [13–15]. Single-piece IOLs have haptics that are as thick as the optic and can chronically chafe the posterior iris causing uveitis-glaucoma-hyphema (UGH) syndrome. Unlike three-piece IOLs, which are posteriorly vaulted, single-piece IOLs are planar in configuration, increasing the potential contact between the optic and the iris. Furthermore, single piece IOLs are shorter in overall length than 3-piece IOLs and thus are not well supported in the sulcus leading to high rates of decentration and tilt.

7.1 Technique

Viscoelastic is used to create space between the iris and anterior capsular bag. The capsular bag should be evaluated to identify areas with optimal support. Iris mobilization with a Kuglen iris manipulator or expansion with iris hooks may be necessary for adequate visualization of the capsule. The haptics should be placed in areas where the anterior capsular support is greatest. The corneal incision should be planned along the axis where IOL haptic placement is desired. The lens is then inserted with the leading haptic inserted on top of the anterior capsular bag and underneath the iris. However, if the corneal incision is not in the axis of desired haptic placement the lens can be inserted with the haptics on top of the iris. The lens is than rotated to the desired axis on top of the iris. Once in the desired axis the haptics are then placed into the sulcus. The trailing haptic is then rotated into the sulcus with a second instrument. The intraocular lens is then checked for stability and centration. If possible, the optic can be captured into the anterior capsule. There is no indication for peripheral iridotomy with sulcus intraocular lens implantation.

8. Iris-fixated intraocular lens

A secondary IOL can be fixated to iris tissue by suture or iris-claw enclavation. Iris-fixated secondary IOLs have the benefit of sparing scleral/conjunctival surgery in case future glaucoma surgery is needed, however normal iris anatomy is required. Iris fixation can cause iris chafing leading to inflammation and cystoid macular edema. As with all secondary IOL techniques, patient selection and counseling are key for surgical success.

A three-piece IOL can also be sutured to the iris via a variety of techniques. In one technique, the IOL is inserted into the anterior chamber such that the optic is captured by the iris with the haptics located behind the iris. A 10-0 prolene suture on a long-curved needle is used to suture the haptic to the iris with as small a bite as possible and placed as peripherally as possible. Peripheral placement avoids creating an oval iris. The suture is then tied in place and the ends trimmed. A smaller corneal incision can be used as the IOLs for this technique are foldable.

Iris-claw lenses are the most commonly used iris-fixation technique outside of the United States. Several studies have shown the safety and efficacy of this technique [16, 17]. A peripheral iridectomy is required to decrease the risk of pupillary block. Iris-claw lenses need to be carefully centered during enclavation. Studies have shown that if the iris-claw lens undergoes deenclavation, the haptics are irreversibly damaged, and the lens requires explanation [18]. These lenses can be fixated anterior or posterior to the iris. A 5-year follow-up showed no differences in astigmatism, complications or post-operative corneal endothelial cell density between anterior or posterior placement [19]. However, some prefer posterior placement with the theory that deenclavation posteriorly has less risk of corneal endothelial decompensation compared to the anterior approach [20].

9. Scleral-fixated intraocular lens

Scleral-fixated intraocular lenses have gained popularity for secondary IOL implantation in patients with aphakia. They are indicated in patients who do not wish to remain aphakic and have no capsular or iris support. However, some surgeons prefer SFIOLs even if there is iris support. In patients where an ACIOL might not be a good option such as in patients with corneal endothelial disease or glaucoma, SFIOLs or IFIOLs are both viable options.

Scleral-sutured intraocular lens implantation started in the 1980s with ab-interno and ab-externo approaches. Ab-interno approaches utilized suture passes from inside to outside the eye in a blind maneuver. This led to complications with retinal detachment, vitreous hemorrhage, and unpredictable haptic placement. Ab-externo approaches were found to be more promising with sutures passed from outside to inside the eye. This led to more reliable suture placement. Lewis popularized an ab-externo technique in 1991 [21] whereby 10-0 polypropylene suture was placed 2 mm posterior to the limbus and then “docked” into a 28-gauge straight needle 180 degrees away to externalize the needle. The suture that remained inside the eye was brought out through the corneal incision and cut. The suture ends were then tied to the IOL haptics and the IOL was inserted into the eye for sulcus placement. The external sutures were then tied down to the adjacent sclera. Ten-year follow-up of thirteen eyes showed only two eyes had minimal decentration although it did not affect final visual acuity [22].

Since Lewis described his technique, newer lenses and sutures have further improved ab-externo techniques. Lenses such as the CZ70BD (Alcon, Fort Worth, TX), enVista MX60 and the Akreos AO60 (Bausch and Lomb, Rochester, NY) have eyelets for suture fixation, which improve lens stability. Most prior scleral suture-fixed techniques used 10-0 polypropylene. However, several studies have described 10-0 polypropylene late suture breakage [23–25]. These reports show late breakage of 10-0 polypropylene suture up to 8 years post-placement. Gore-tex sutures have been used outside the eye with notable long-term stability. Studies with up to 3 years follow-up have shown Gore-tex suture durability within the eye. Similarly, 9-0 polypropylene has been shown to have improved suture stability compared to 10-0 polypropylene but with only short-term follow-up. Long-term studies are needed to further evaluate if these sutures continue to avoid suture breakage.

Bausch & Lomb Akreos AO60 hydrophilic acrylic lens contains 4 eyelets allowing 4 point fixation. However, these lenses undergo calcification and opacify when in contact with intraocular gas or air [26]. Given that aphakic patients often have coincident retinal pathology and might be at increased risk for retinal detachment repair this might be an important consideration when deciding on the optimal lens and fixation technique. The Bausch & Lomb enVista Mx60 IOL is made of hydrophobic acrylic and does not opacify when in contact with gas or air. However, it has only 2 eyelets for fixation at the haptic-optic junction.

9.1 Scleral fixation of IOL with Gore-tex suture technique

Typically, conjunctival peritomies are performed where the sclerotomy sites are planned, 180 degrees apart. Sclerotomy placement at horizontal, oblique and vertical orientations are all acceptable. A toric lens marker is used to mark the axis of the lens within the peritomy. Sclerotomy sites are marked, 3 mm posterior to the limbus and 4–5 mm apart from each other in each scleral bed. One of the suture sclerotomy sites can be used for the vitrectomy trocar. The trocar sclerotomy should be made perpendicularly without tunneling to facilitate suture knot insertion. The lens is pre-threaded with a suture on each side and inserted into the eye. The sutures are then externalized using forceps through the sclerotomies taking care not to tangle the sutures. To avoid suture tangling and disorganization, the sutures can be inserted into the eye and externalized prior to lens insertion. The sutures are then tied down permanently with care taken to make sure the suture tension allows the lens to be appropriately centered. The knot is then buried into the sclerotomies to avoid knot erosion through the conjunctiva. The conjunctiva is sewn in place over the sclerotomies and sutured. Long term follow-up results are yet to be determined. Two-year results have shown good lens and suture stability with the Gore-tex suture. Complications include hypotony (up to 10%) with and without serous choroidal detachment. This is thought to occur from leakage from the sclerotomy sites. Vitreous hemorrhage and hyphema have also been reported. Published studies have not reported persistent post-operative inflammation, endophthalmitis or suture erosion/breakage at 2 years [27]. With in-the-bag calculations for the IOL, a recent study showed that 2 mm sclerotomies resulted in a more myopic post-operative outcome than 3 mm sclerotomies [28]. Other studies have shown acceptable refractive outcomes with this technique and 3 mm from the limbus sclerotomies with in-the-bag IOL calculations [29].

9.2 Sutureless scleral fixation intraocular lens implantation

Sutureless techniques have also been developed to avoid potential complications that can rise from suture fixation including knot erosion, endophthalmitis, and suture breakage. Agarwal described scleral fixation with glued haptic fixation [30]. Scleral flaps are created 180 degrees apart and a sclerotomy is made within the flap. The haptics of a 3-piece IOL are then externalized via the sclerotomy and glued into place with the flap closing over the haptic. Several complications can occur with the haptic including extrusion, dislocation, and breakage. Haptic-related complications seen include haptic extrusion, haptic dislodgement, broken haptic and subconjunctival haptic. Most of the haptic-related complications are due to improper scleral tucking [31].

Yamane et al. described a technique whereby three-piece IOL haptics are passed through a 27 gauge needle which guides the haptic through a tunneled sclerotomy [32]. The externalized haptic is than cauterized to create a bulb at the tip of the haptic to allow for improved stability within the scleral tunnel. Short-term outcomes from Yamane's initial study reported no IOL dislocation at 1.5 years. Reported complications include optic capture of the iris (8%), vitreous hemorrhage (5%) and cystoid macular edema (1%). It is important to note that the Yamane technique utilizes the EC-3 PAL three-piece intraocular lens, which has more durable and malleable haptics compared to the 3-piece IOLs commonly used in the United States. Higher rates of IOL dislocation have been reported with the Yamane technique when non-EC-3 PAL 3-piece IOLs are used. Several modified Yamane techniques have been since described including the use of 27 gauge trocars instead of a needle to externalize the haptics. Long-term follow-up has yet to be presented since these techniques have only been introduced in the past decade.

10. Anterior chamber intraocular lens

Baron was the first to implant an anterior chamber IOL in 1952 [33]. Several other ACIOLs followed during the 1950s but were limited by their design and anterior vault that led to high rates of corneal decompensation. Closed loop ACIOLs gained popularity in the 1970s due to their various flexible designs that were thought to alleviate problems with sizing. However, the sharp edges of the closed-loop ACIOL haptic eroded uveal tissue, released inflammatory mediators, and led to multiple complications including uveitis-glaucoma-hyphema syndrome, corneal decompensation, and cystoid macular edema [34–37]. Open-loop ACIOL designs were introduced in the 1980s and their design continued to be improved with its use peaking in the 1990s. These modern open-loop ACIOL designs appear to have less associated complications.

A peripheral iridectomy is required as ACIOLs can cause pupillary block glaucoma. Compared to other IOL techniques, the ACIOL requires a larger six-millimeter incision. Typically, a scleral tunnel is formed in order to minimize astigmatism from a clear corneal incision. Contraindications for anterior chamber intraocular lens include corneal decompensation, angle abnormalities with or without glaucoma, and lack of iris support. Complications associated with ACIOL implantation include endothelial failure with corneal edema, chronic intraocular inflammation, and/or uveitis glaucoma hyphema. The angle to angle measurement measured by a UBM or OCT is the most accurate option for fitting an ACIOL. More commonly however the white-to-white distance is measured intraoperatively with calipers and 1 mm is added to size the ACIOL. The white-to-white distance is not always a reliable equivalent to the actual angle to angle distance.

Many of the complications of ACIOL implantation can be prevented with an appropriately-sized lens, however, limited sizes are available. An overly small lens can be mobile and cause damage to the corneal endothelium leading to corneal decompensation. A small lens can also cause trauma to iris tissue leading to inflammation and cystoid macular edema. Similarly, an overly large lens can cause inflammation, cystoid macular edema and corneal endothelial failure. A large lens can be noted if the iris is distorted or ovalized during placement. This is due to the footplates not being seated well in the angle. Since the vertical and horizontal angle to angle dimensions are different the lens can be rotated to see if it fits better at a different meridian.

10.1 Anterior chamber intraocular lens implantation technique

A scleral tunnel is created in either a frown or linear configuration. This can be placed temporally or superiorly based on surgeon preference. A corneal incision is avoided to minimize astigmatism however can be used if needed. The benefits of a corneal incision include preserving conjunctiva/sclera for potential glaucoma interventions. Miosis is induced and viscoelastic is then injected. The ACIOL is then inserted with or without a use of a lens glide. The purpose of the lens glide to secure placement of the ACIOL across the pupil so as not to get the lens or haptic caught on the iris at the pupillary margin. The ACIOL is then positioned such that the footplates of the IOL are well-seated in the angle and the pupillary margin is round. Gonioscopy can be performed to confirm appropriate placement of the ACIOL footplates. Once the ACIOL is positioned, a peripheral iridectomy is created and the scleral or corneal incision is closed.

11. Conclusion

Ophthalmology has seen an evolution in secondary intraocular lens implantation. Particularly, in the past decade, the implantation of scleral-fixated intraocular lenses has gained popularity along with ACIOL implantation [36]. Careful patient selection is critical to determine the optimal secondary IOL technique. When possible, placement of the secondary intraocular lens in the capsular bag is preferred, followed by placement in the sulcus with optic capture. When capsular support is absent, ACIOL implantation, iris fixation and scleral fixation of a secondary intraocular lens can be considered. The variety of surgical options with respect to secondary IOL implantation illustrates the lack of an optimal consensus technique. Indeed, several studies have compared these techniques with no clear favorite [38–41]. In most cases, patient ophthalmic history and anatomic considerations in addition to surgeon familiarity and comfort with the secondary IOL technique may determine the type of surgery performed.

Author details

Niranjan Manoharan and Pradeep Prasad*
Stein Eye Institute, University of California, Los Angeles, CA, United States

*Address all correspondence to: prasad@jsei.ucla.edu

References

[1] Rattigan SM et al. Flexible open-loop anterior chamber intraocular lens implantation after posterior capsule complications in extracapsular cataract extraction. Journal of Cataract & Refractive Surgery. 1996;**22**(2):243-246

[2] Szigiato A-A, Schlenker MB, Ahmed IIK. Population-based analysis of intraocular lens exchange and repositioning. Journal of Cataract & Refractive Surgery. 2017;**43**(6):754-760

[3] Jones JJ, Jones YJ, Jin GJC. Indications and outcomes of intraocular lens exchange during a recent 5-year period. American Journal of Ophthalmology. 2014;**157**(1):154-162

[4] Jin GJC, Crandall AS, Jones JJ. Changing indications for and improving outcomes of intraocular lens exchange. American Journal of Ophthalmology. 2005;**140**(4):688-694

[5] Solomon KD et al. Complications of intraocular lenses with special reference to an analysis of 2500 explanted intraocular lenses (IOLs). European Journal of Implant and Refractive Surgery. 1991;**3**(3):195-200

[6] Marques FF et al. Longitudinal study of intraocular lens exchange. Journal of Cataract & Refractive Surgery. 2007;**33**(2):254-257

[7] Leysen I et al. Surgical outcomes of intraocular lens exchange: Five-year study. Journal of Cataract & Refractive Surgery. 2009;**35**(6):1013-1018

[8] De Silva DJ, Nischal KK, Packard RB. Preoperative assessment of secondary intraocular lens implantation for aphakia: A comparison of 2 techniques. Journal of Cataract & Refractive Surgery. 2005;**31**(7):1351-1356

[9] Repka MX. Visual rehabilitation in pediatric aphakia. Pediatric Cataract. 2016;**57**:49-68

[10] Wagner M, Cox T, Ariyasu R. Intraocular lens implantation in absence of capsular support. Ophthalmology. 2003;**110**:840-859

[11] Brunin G et al. Secondary intraocular lens implantation: Complication rates, visual acuity, and refractive outcomes. Journal of Cataract & Refractive Surgery. 2017;**43**(3):369-376

[12] Dalby M, Kristianslund O, Drolsum L. Long-term outcomes after surgery of late in-the-bag intraocular lens dislocation: A randomized clinical trial. American Journal of Ophthalmology. 2019;**207**:184-194

[13] Kemp PS, Oetting TA. Stability and safety of MA50 intraocular lens placed in the sulcus. Eye (London, England). 2015;**29**(11):1438-1441

[14] Chang DF, Masket S, Miller KM, Braga-Mele R, Little BC, Mamalis N, et al. Complications of sulcus placement of single-piece acrylic intraocular lenses recommendations for backup IOL implantation following posterior capsule rupture. Journal of Cataract and Refractive Surgery. 2009;**35**(8):1445-1458

[15] Mohebbi M, Bashiri SA, Mohammadi SF, Samet B, Ghassemi F, Ashrafi E, et al. Outcome of single-piece intraocular lens sulcus implantation following posterior capsular rupture during phacoemulsification. Journal of Ophthalmic & Vision Research. 2017;**12**(3):275-280

[16] Anbari A, Lake DB. Posteriorly enclavated iris claw intraocular lens for aphakia: Long-term corneal endothelial

safety study. European Journal of Ophthalmology. 2015;**25**(3):208-213

[17] Schallenberg M et al. Aphakia correction with retropupillary fixated iris-claw lens (Artisan)—Long-term results. Clinical Ophthalmology (Auckland, NZ). 2014;**8**:137

[18] Tandogan T et al. Material analysis of spontaneously subluxated iris-fixated phakic intraocular lenses. Journal of Refractive Surgery. 2016;**32**(9):618-625

[19] Toro MD et al. Five-year follow-up of secondary iris-claw intraocular lens implantation for the treatment of aphakia: Anterior chamber versus retropupillary implantation. PloS one. 2019;**14**(4):e0214140

[20] Lajoie J et al. Assessment of astigmatism associated with the iris-fixated ARTISAN aphakia implant: Anterior fixation versus posterior fixation, study of postoperative follow-up at one year. Journal Francais D'Ophtalmologie. 2018;**41**(8):696-707

[21] Lewis JS. Ab externo sulcus fixation. Ophthalmic Surgery. 1991;**22**(11):692-695

[22] Cavallini GM, Volante V, De Maria M, et al. Long-term analysis of IOL stability of the Lewis technique for scleral fixation. European Journal of Ophthalmology. 2015;**25**(6):525-528

[23] Assia EI, Nemet A, Sachs D. Bilateral spontaneous subluxation of scleral-fixated intraocular lenses. Journal of Cataract and Refractive Surgery. 2002;**28**(12):2214-2216

[24] Bading G, Hillenkamp J, Sachs HG, Gabel VP, Framme C. Long-term safety and functional outcome of combined pars plana vitrectomy and scleral-fixated sutured posterior chamber lens implantation. American Journal of Ophthalmology. 2007;**144**(3):371-377

[25] 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;**28**(7):741-746

[26] Kalevar A, Dollin M, Gupta RR. Opacification of scleral-sutured akreos AO60 intraocular lens after vitrectomy with gas tamponade: Case series. Retinal Cases & Brief Reports. 2017:1-4

[27] Khan MA et al. Scleral fixation of intraocular lenses using Gore-Tex suture: Clinical outcomes and safety profile. British Journal of Ophthalmology. 2016;**100**(5):638-643

[28] Su D et al. Refractive outcomes after pars plana vitrectomy and scleral fixated intraocular lens with gore-tex suture. Ophthalmology Retina. Jul 2019;**3**(7):548-552

[29] Botsford BW et al. Scleral fixation of intraocular lenses with Gore-Tex suture: Refractive outcomes and comparison of lens power formulas. Ophthalmology Retina. Jun 2019;**3**(6):468-472

[30] Narang P, Narang S. Glue-assisted intrascleral fixation of posterior chamber intraocular lens. Indian Journal of Ophthalmology. 2013;**61**(4):163

[31] Kumar DA, Agarwal A. Glued intraocular lens: A major review on surgical technique and results. Current Opinion in Ophthalmology. 2013;**24**(1):21-29

[32] Yamane S, Inoue M, Arakawa A, Kadonosono K. Sutureless 27-gauge needle-guided intrascleral intraocular lens implantation with lamellar scleral dissection. Ophthalmology. 2014;**121**(1):61-66

[33] Anterior chamber intraocular lenses. Survey of Ophthalmology. 2000;**45**:S131-S149

[34] Apple DJ et al. Anterior chamber lenses. Part II: A laboratory study. Journal of Cataract & Refractive Surgery. 1987;**13**(2):175-189

[35] Apple DJ et al. Anterior chamber lenses. Part I: Complications and pathology and a review of designs. Journal of Cataract & Refractive Surgery. 1987;**13**(2):157-174

[36] Apple DJ, Olson RJ. Closed-loop anterior chamber lenses. Archives of Ophthalmology. 1987;**105**(1):19-20

[37] Apple DH et al. Intraocular lenses: Evolution, Designs, Complications, and Pathology. Archives of Ophthalmology. 1991;**109**(2):189

[38] Madhivanan N et al. Comparative analysis of retropupillary iris claw versus scleral-fixated intraocular lens in the management of post-cataract aphakia. Indian Journal of Ophthalmology. 2019;**67**(1):59

[39] Nehme J et al. Secondary intraocular lens implantation with absence of capsular support: Scleral versus iris fixation. Journal Francais D'Ophtalmologie. 2018;**41**(7):630-636

[40] Kim EJ, Brunin GM, Al-Mohtaseb ZN. Lens placement in the absence of capsular support: Scleral-fixated versus iris-fixated IOL versus ACIOL. International Ophthalmology Clinics. 2016;**56**(3):93-106

[41] Kim KH, Kim WS. Comparison of clinical outcomes of iris fixation and scleral fixation as treatment for intraocular lens dislocation. American Journal of Ophthalmology. 2015;**160**(3):463-469