71 Out-of-the-Bag Implantation IOL Power

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Introduction

The lens capsular bag offers an excellent position for the intraocular lens (IOL) in cataract surgery, providing a stable and predictable location within the eye. There is no direct contact with adjacent tissues, the optical plane is similar to the natural lens and the capsular fibrosis that occurs during the first year after surgery will set a permanent axial and rotational position [1]. The postoperative in-the-bag IOL plane has a relationship with some preoperative anatomic features of the eye such as the anterior chamber depth (ACD), the lens thickness (LT), and the axial length (AL), and therefore, a predicting function can be calculated to estimate this position before surgery and calculate the IOL power for a certain refraction using Optics theory or build a predictive model to directly calculate the IOL power from those variables.

However, in several clinical situations, in-the-bag implantation will not be possible due to a lack of safe capsular support. Depending on the circumstances, the IOL will be implanted in another anatomical plane: anterior chamber, iris, ciliary sulcus, or pars plana [2]. This will change the optical effective power of the IOL, and thus, the power calculation needs to be adjusted in order to achieve an accurate refractive prediction as all the usual IOL power calculation formulas assume an in-the-bag IOL location. Moreover, some IOL models are specifically designed for another anatomical location and the IOL formula must be aware of this and adapt the calculation usually through a different IOL constant.

The most frequent out-of-the-bag implant locations and IOL designs are as follows (Fig. 71.1):

- Anterior chamber: Angle supported and iris-claw (prepupillary) IOLs
- Ciliary sulcus: Iris-claw (retropupillary) and posterior chamber (PC) IOLs. The latter can be iris-sutured and sulcus supported
- Scleral fixation: PC IOL

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J. Aramberri et al. (eds.), *Intraocular Lens Calculations*, Essentials in Ophthalmology,
https://doi.org/10.1007/978-3-031-50666-6_71

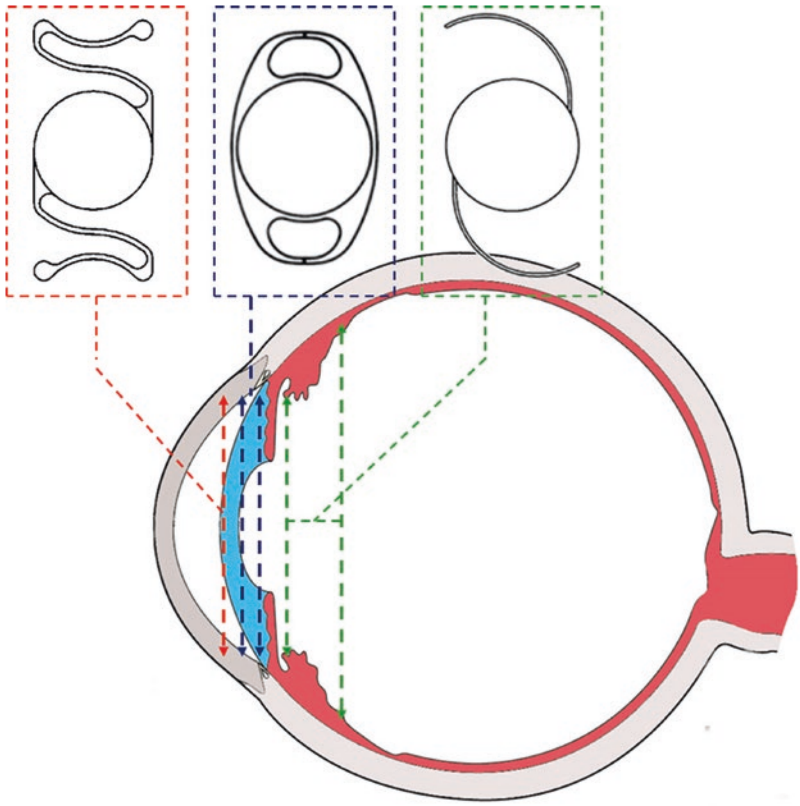

Fig. 71.1 IOL models for different out-of-the-bag implantation planes. From left to right: anterior chamber IOL, iris-claw IOL (anterior and posterior to iris), and posterior chamber IOL (iris-sutured, ciliary sulcus and pars plana fixated)

Clinical Situations

Insufficient capsular bag support can occur as a consequence of various clinical conditions. From a practical point of view, capsular and zonular damage should be distinguished.

Capsular Damage

The lens capsule can be injured in different degrees leaving some capsular support if the anterior capsule is still in place, where a PC IOL can be implanted over it, or no capsular support at all if the anterior capsule remnant is insufficient to hold the IOL in place and creating the need of an alternative IOL fixation technique.

The most usual clinical situations where the capsule is damaged are as follows:

– Capsular rupture during cataract surgery: This is a relatively frequent surgical complication with a reported incidence ranging between 0.1 and 5% depending on the series. A recent metanalysis reported 0.42% in Femto-second laser-assisted (FLACS) surgery and 0.27% in conventional phacoemulsification surgery [3]. Some related factors are surgeon's experience, cataract degree, pupil size, etc.
– Traumatic capsular rupture: It has been described in the context of blunt trauma, where the combined action of globe deformation and the shock wave can affect the capsular integrity [4], and also in perforating trauma.

Zonular Damage

Depending on the degree, there will be a partial or a total lens luxation:

– Simple ectopia lentis: Zonular damage due to genetic mutation, inherited in an autosomal dominant or recessive pattern.
– Ectopia lentis associated to systemic disease: There is a long list of associated pathologies

being the most frequent: Marfan syndrome, Weill-Marchesani syndrome, sulfite oxidase deficiency, etc. [5].

– Ectopia lentis associated to ocular disease: Several ocular morbidities are associated to luxation and subluxation of the lens: pseudo-exfoliation syndrome, high myopia, congenital glaucoma, aniridia, syphilis, retinitis pigmentosa, etc. [5].
– In-the-bag IOL dislocation: An increasing trend for the incidence of this condition has been reported. The main associated factor is pseudoexfoliation syndrome, 31–83% of cases. Less frequent are previous vitreoretinal surgery, high myopia, uveitis, etc. [6].

Out-of-the-Bag IOL Implantation

Posterior Chamber

Posterior capsular tear or rupture is a frequent and unexpected complication during cataract surgery. The risk of IOL dislocation and/or tilt runs beyond a certain degree of capsular damage in-the-bag implantation, and therefore, an alternative IOL placement must be considered. If the anterior capsule is intact with maintained zonular tension, a PC IOL can be implanted over the anterior capsule with the haptics in the ciliary sulcus. The optic is sometimes captured with the capsulorrhexis to ensure centration and stability. If there isn't enough anterior capsular support, the IOL will have to be fixated to the sclera or to the iris. Scleral fixation can be done either in the sulcus or in the pars plana. Some techniques use non-absorbable sutures while others are sutureless.

PC IOLs are usually calculated with an IOL constant value optimized for in-the-bag IOL placement. Any axial offset will change the effective power of the IOL modifying the final refraction and turning the IOL power calculation inaccurate. There will be a myopic refraction shift if the IOL is more anterior (closer to the cornea) and a hyperopic refraction shift if the IOL is more posterior (closer to the retina).

Sulcus Support

This is the easiest situation for the surgeon both from the technical and calculation point of view. The IOL is positioned over the remaining anterior capsule, and the haptics will normally sit on the ciliary sulcus.

This anterior IOL location entails some pathophysiological and optical consequences:

– There will be more contact between the IOL and the iris and ciliary body tissue with risk of uveitis, glaucoma, and hyphema (UGH syndrome) [7]. The ideal PC IOL for sulcus should have thin haptics to avoid excessive contact with the iris root and an adequate design to leave as much space as possible between the optic and iris to minimize iris chaffing. This means posteriorly angulated haptics and a thin optic (material with high index of refraction), preferably with rounded and smooth edges. Some 3-piece hydrophobic IOL models meet these conditions and are the preferred designs for sulcus implantation. The overall IOL diameter must be sufficiently long to enhance centration and allow for stable fixation in the sulcus (minimum of 13.0 mm) [8].
– The IOL effective power will be higher and the refraction more myopic than the in-the-bag prediction. The surgeon must convert the IOL power calculation from the bag to the sulcus plane taking into account the expected distance change.

Several studies report a mean distance of around 0.75 mm between the bag and the sulcus position. Hayashi measured with a Scheimpflug camera a mean ACD of 4.27 ± 0.25 mm in 50 eyes with in-the-bag IOL, 3.54 ± 0.48 mm in 51 eyes with sulcus IOL and 3.59 ± 0.45 mm in 50 eyes with sulcus scleral-sutured IOL [9]. Suto measured with US biometry the same distances finding a mean ACD of 3.51 ± 0.25 mm in 30 eyes with sulcus IOL and 4.26 ± 0.29 mm in the fellow eye where the IOL was in-the-bag [10]. In one personal series (non-published study), we measured a mean difference of 0.69 ± 0.17 mm (0.40–0.86 mm) in 19 eyes using the fellow eye as reference in 17 eyes and the same eye where

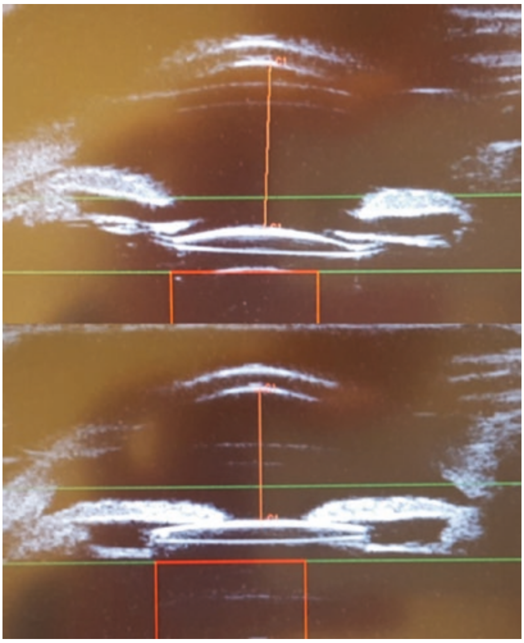

Fig. 71.2 IOL exchange in a case of negative dysphotopsia. The new IOL is implanted in the sulcus. The distance from the cornea to the anterior surface of the IOL changed from 4.35 to 3.49 mm (difference 0.86 mm)

the IOL was moved for dysphotopsia treatment in 2 cases (Fig. 71.2).

The refractive shift induced by this axial distance will be directly proportional to the power of the IOL. It can be theoretically calculated using a human eye schematic model. Suto used a Gullstrand eye to calculate an IOL power difference of 0.67 D, 1.53 D, and 2.60 D for IOL powers of 10 D, 20 D, and 30 D, respectively. The refractive change in the spectacle plane would be 0.47 D, 1.07 D, and 1.82 D [11]. We obtained very similar figures using a ray tracing thick-lens paraxial model with a constant anterior corneal radius of 7.71 mm and posterior corneal radius of 6.38 mm. A biconvex IOL with known physical features was used (SA60AT, Alcon). The spectacle plane refraction for each IOL power (from +6.00 to +34.00 D) was calculated in two different IOL positions 0.75 mm apart. A regression equation for Spectacle refraction difference as dependent variable was calculated as follows:

Table 71.1 Refractive change (Rx) induced by 0.75 mm axial movement of a biconvex IOL. Output of a regression equation (see text) based on paraxial calculations in an eye model

IOL power	Rx	IOL power	Rx	IOL power	Rx
5	0.15	15	0.77	25	1.39
6	0.21	16	0.83	26	1.45
7	0.27	17	0.89	27	1.51
8	0.34	18	0.95	28	1.57
9	0.40	19	1.02	29	1.63
10	0.46	20	1.08	30	1.70
11	0.52	21	1.14	31	1.76
12	0.58	22	1.20	32	1.82
13	0.65	23	1.26	33	1.88
14	0.71	24	1.33	34	1.94

$$Rx = -0.158 + 0.0618 * \text{IOL power}$$

Table 71.1 contains the output of this equation for IOL power ranging from +6.00 D until +34.00 D. This can be a useful tool to estimate the refractive shift induced by 0.75 mm IOL axial movement (i.e., from in-the-bag to sulcus position).

Although there is some variability, the empirically observed refractive shift generally agrees with these calculations: Hayashi et al. report a lower value, −0.39 ± 0.71 D prediction error in 51 eyes with the IOL in the sulcus against 0.08 ± 0.54 D in 50 eyes with in-the-bag IOL [9]. Suto et al. compared 30 cases where the IOL was in the sulcus in one eye and in-the-bag in the other. The refraction prediction error was −0.78 ± 0.47 D [10]. Dubey et al. analyzed a group of 36 eyes where some surgeons had subtracted 0.5 D and others 1 D to the in-the-bag IOL power. Less prediction error was found in the latter group where in normal AL (22–25 mm), it was 0.38 ± 0.20 D and in short eyes (<22 mm), it was 1.01 ± 0.32 D. In the former group, the prediction error was 1.82 ± 0.47 D, 0.86 ± 0.29 D, and 0.42 ± 0.31 D in short (<22 mm), medium (22–25 mm), and long (>25 mm) eyes, respectively [12]. Eom et al. reported a prediction error of −0.91 ± 0.74 D and −0.93 ± 0.71 D with two different IOL models using the Haigis formula [13].

There is some difference when the IOL optic is captured with the capsulorrhexis. The IOL plane will be more posterior, and the effective power of the IOL will change less from the in-the-bag position. Millar et al. found a significant difference in a group of 58 eyes where 41% had optic capture and 59% had not. The prediction error was 0.34 ± 0.75 D and −0.40 ± 0.74 D respectively. They had subtracted 0.5, 1, and 1.5 D from the in-the-bag IOL power for long, medium, and short eyes, respectively [14]. Brunin et al. optimized the IOL constants and reported some better predictability in the optic capture group (n = 29) with a standard deviation (SD) of 0.75 D versus the non-optic-capture group (n = 10) where the SD was 0.82 D [15]. Both papers conclude that whenever it is possible, the sulcus implanted IOL optic should be captured with the capsulorrhexis because it provides a more stable and safe position.

Sulcus IOL Power

The most recommendable method would be to optimize the IOL constant for the same sulcus implanted IOL model based on the surgeon's own experience. Normally, this will not be possible except for very high volume centers. Eom et al. followed another approach modifiying the Haigis ELP prediction formula, adding the corneal radius as independent variable to the normally used AL and ACD. They found a correlation in a set of 132 eyes where the eyes with flatter corneas had more myopic error. They calculated new constants (b0, b1, b2, and b3) for this implantation plane. With this new equation, 68.1% of cases were within ±0.5 D of the prediction [13]. The most suitable option will be to subtract some power from the in-the-bag IOL following what has been exposed in the above section. Table 71.1 can provide some reference values in this sense. Several authors recommend similar figures: Dubey et al. proposed subtracting 0.5 D in low powers (<18 D), 1 D in medium powers (18 D–25 D), and 1.5 D in high powers (>25 D) [12]. Knox-Cartwright et al. proposed reducing 5% the in-the-bag power for sulcus implantation. This number came out from the back-calculated IOL power change in a series of 24 eyes and it is an easy-to-remember rule. This means that the power should be reduced 0.5 D, 1 D, and 1.5 D in 10 D, 20 D, and 30 D in-the-bag IOL powers, respectively [16].

Scleral Fixation

Transscleral fixation of a PC IOL is a popular option in the management of IOL implantation with absence of capsular support. Its main advantage over the anterior chamber or the iris plane is that the IOL stands away from these structures avoiding endothelial and angular damage or uveal contact. In 1981, Girard first described a technique of pars plana scleral fixation with sutures [17]. Some years later, Malbran et al. proposed a similar one suturing the IOL at the sulcus plane [18]. Both ciliary sulcus and pars plana fixation have pros and cons. Pars plana fixation takes the risks of retinal injury and unstable IOL fixation, while sulcus fixation can produce corectopia, pupil capture, and UGH syndrome. At this moment, there is no consensus on which one is more effective or safe [19].

The refractive results of these techniques depend significantly on the fixation technique. There has been some evolution through the years that affect the reported results. In the beginning, *ab interno* sutured scleral fixation was more popular and it was related to some complications and high variability of haptics location. Later, *ab externo* scleral fixation with the knots covered by scleral flaps and a standard distance from the limbus (i.e., 2 mm) became the rule improving the refractive precision of the surgery. In recent years, several factors have increased the reproducibility of this technique: new IOLs with closed-loop haptics that allow four points of fixations, a trend to thicker sutures (7-0 Gore-Tex and 9-0 polypropylene) to provide extended safety, the improvement in surgical skills of the surgeons, and new vitrectomy technologies [20]. Lately, several sutureless techniques have been described to avoid some complications related to sutures like long-term suture erosion and breakage. The haptic ends are inserted into scleral tunnels with or without fibrin glue to secure the fixation [21, 22]. In another recently described technique, the haptic ends are melted and thickened with a cautery creating flanges to avoid slippage through the tunnels [23].

Fixation Point

The main disadvantage of these techniques is that scleral fixation is a blind maneuver as the ciliary sulcus and pars plana cannot be directly seen during surgery. In *ab externo* techniques, the needle is passed from outside the eye while in *ab interno* techniques, this is done from the inside. Normally, a certain distance from the surgical limbus is taken as reference for the entry/exit point. Most surgeons use 1–2 mm distance for sulcus and 3 mm for pars plana. Intermediate distances should be avoided not to injure the ciliary body (with the major arterial circle) and the ciliary processes. However, several studies have shown that the accuracy of these numbers is far from perfect and there is much variability in the anatomical location of the haptics which explains the higher refractive prediction error of these cases as compared to other techniques.

The ciliary sulcus has an oval shape with a higher diameter in the vertical meridian. Biermann studied a sample of phakic young adults and reported a difference of 0.35 mm in emmetropes and 0.30 mm in myopes [24]. Petermeier found a difference of 0.27 mm in 50 pseudophakic eyes with a mean age of 72.15 years. In this paper, the mean sulcus diameter was 11.10 mm [25]. Sulcus location using the surgical limbus as reference has a limited accuracy because the correlation between the corneal diameter (so-called corneal diameter distance) and the sulcus diameter is not very high and the previously mentioned vertical-horizontal sulcus diameter relationship suffers from some variability with 5–10% of cases where the horizontal diameter is higher than the vertical [24–26]. Duffey et al. found that a straight needle perpendicular to the sclera exits in the sulcus when the distance between the limbus and the entry point was 0.83 ± 0.10 mm in the vertical meridian and 0.46 ± 0.10 mm in the horizontal meridian [27]. From this paper, many surgeons adopted 1 mm behind the limbus as guide for sulcus fixation. However, Pavlin et al. reported several cases with entry point 1.5 mm behind the limbus and haptics anterior to the sulcus deforming the iris-angle and realized that in vivo, the situation might be different: The needle trajectory is normally parallel to the iris posterior surface and consequently the outer sclera exit will be more posterior than the inner sclera entry [28]. Sewelam et al. studied 20 eyes with ab externo scleral fixation placing the sutures 1 mm posterior to the limbus. With UBM, they found that only 55% of haptics were in sulcus, while 27.5% were anterior affecting the angle and 17.5% posterior to sulcus [29].

Some methods and devices have been proposed to improve the accuracy of scleral fixation: direct visualization of the sulcus with an endoscope [30], transillumination of the sulcus area using an intraoperative endo-illuminator [31], a needle injector with a tip that matches the shape of the sulcus for *ab interno* suture [32], etc.

Sugiura et al. estimated from UBM measurements that the distance from the surgical limbus to the exit point of a straight needle in the outer scleral wall would be 2.37 mm, assuming a trajectory parallel to the posterior surface of the iris. They found a similar value in 128 eyes where endoscopy confirmed the sulcus fixation with a straight needle: 2.50 mm from the posterior surgical limbus. In 28 eyes where a curved needle had been used, this distance was shorter: 2.00 mm (Fig. 71.3) [33].

Scleral Fixated IOL Power

Most of the scleral fixated IOLs are in-the-bag designs with IOL constants calculated for such position. The calculation must take into account the optical effect of the IOL plane difference from the regular location. In the last 25 years, there are dozens of published papers about IOL scleral fixation cases and techniques but most of them are retrospective, with very heterogeneous and small samples, merging different techniques within the same study as the surgeon's experience has evolved through time, using different IOL models and very few of them analyze refractive results with an adequate methodology. Moreover, these eyes have normally lower than normal BCVA making refractions less reliable. To make it worse, these surgical techniques are more surgeon dependent than regular phacoemulsification where in-the-bag implantation guarantees a reproducible IOL location for all

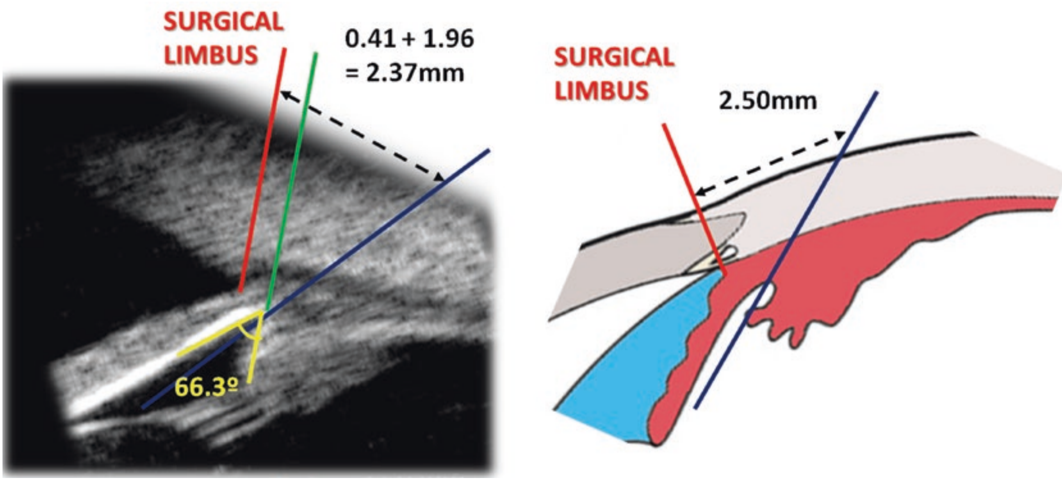

Fig. 71.3 Estimation of surgical limbus to scleral fixation straight needle exit point based on UBM image (left). In 128 eyes where the sulcus pass was checked by endoscopy, the actual distance with a straight needle was 2.50 mm [32]

cases and surgeons. Hence, the final IOL position will vary among different surgeons even for the same surgical technique and the same study. All this explains why the published results are contradictory to some extent, making it difficult to extract conclusions to provide precise recommendations.

As it has been described above, there are two main target locations: The ciliary sulcus and the pars plana. It seems logical that in the first case, the IOL position will be anterior to the in-the-bag plane and thus refraction will shift towards myopia in a similar way and magnitude to non-fixated sulcus implantation. While in the pars plana fixation, the IOL plane might be close to the in-the-bag one. There are very few studies reporting postoperative ACD values that allow comparison with the regular surgery: Hayashi et al. measured with a Scheimplflug camera a mean ACD of 4.27 ± 0.25 mm in 50 eyes with in-the-bag IOL, 3.54 ± 0.48 mm in 51 eyes with sulcus IOL, and 3.59 ± 0.45 mm in 50 eyes with sulcus scleral-sutured IOL [9]. Yamane et al. reported a higher number with a sutureless sulcus fixation technique in 100 eyes: 4.28 mm [23]. Muth et al. measured the ACD with three different sulcus fixation techniques: 3.67 ± 1.37 mm (Gore-tex suture), 4.01 ± 0.96 mm (Prolene suture), and 3.76 ± 1.08 mm (sutureless Yamane technique) [34]. Liu et al. used UBM to measure 4.31 ± 0.29 mm in 68 eyes where sutureless scleral fixation had been done 1.75 mm from limbus [35]. This variability makes it difficult to define a distance difference from in-the-bag plane in order to calculate the dioptric difference in the IOL power. However, all reported numbers are lower than the regular ones, so some myopic refractive shift would be expected.

Refractive Results

An analysis of the published refractive results with these procedures (Table 71.2) shows again some contradictory outcomes even for similar techniques. The distance to the surgical limbus determines the implantation plane of the IOL: 1.0–2.5 mm for sulcus and 3 mm for pars plana. Therefore, more myopic shift should be expected in the former case. However, this is not always the case in the published data. Some 1.5–2.5 mm series report hyperopic prediction error like McMillin et al. in 40 eyes operated with Yamane technique (YT) [36], Randerson et al. in 109 eyes with YT [37], and Abbey et al. in 23 eyes operated with sutureless scleral fixation with, paradoxically, more hyperopic error in the 1.5 mm distance (7 cases) than in the 2 mm (15 cases) distance [42]. In 100 eyes, Rocke et al. reported nil prediction error, −0.04 ± 0.88 D, with YT (2 mm to limbus) and Barrett formula [38]. Most of the sulcus fixation studies report some myopic

Table 71.2 Refraction prediction error with different scleral fixation techniques. Formulas are reported as third and fourth generation

First author	Year	*N*	Suture fixation	IOL model	Distance to limbus (mm)	Formula	Rx prediction error (D)
McMiliin [36]	2021	40	No	ZA9003 Lucia 602	2	Third and fourth gen.	+0.48 to +0.67
Randerson [37]	2020	109	No	Lucia 602	2	Third gen	0.18 ± 1.45
Rocke [38]	2020	100	No	ZA9003	2	Fourth gen	−0.04 ± 0.88
Ohr [39]	2020	20	Yes	A060	3	Third gen	0.16 ± 0.69
Sugiura [32]	2019	128	Yes	NR-81K	2.5	n.a.	−0.63
Su [40]	2019	13	Yes	A060 MX60	2–3	Third gen	−1.35 ± 1.32
Su [40]	2019	42	Yes	A060 MX60	3	Third gen	−0.43 ± 0.71
Botsford [41]	2019	31	Yes	A060 CZ70BD	3	Third and fourth gen.	−0.19 ± 0.72
Yamane [23]	2017	50	No	X70	2	Third gen	−0.41 ± 0.98
Yamane [23]	2017	32	No	ZA9003	2	Third gen	−0.02 ± 0.93
Brunin [15]	2017	24	Yes	n.a.	n.a.	Third gen	−0.23 ± 0.79
Abbey [42]	2014	15	No	MA60AC	2	n.a.	0.32
Abbey [42]	2014	7	No	MA60AC	1.5	n.a.	0.56
Huang [43]	2013	18	Yes	P366UV CZ708D	1	Third gen	−1.66 ± 0.94
Ma [44]	2011	38	Yes	MA60BM YA60BBR	1.5	n.a.	−1.03 ± 1.82
Ma [44]	2011	56	Yes	MA60BM YA60BBR	3	n.a.	−0.88 ± 2.15
Hayashi [9]	1999	52	Yes	S62UV P336UV	1	n.a.	−0.65 ± 1.11

n.a. not available

shift ranging from −0.19 to −1.66 D. In some cases, within the same study, results depended on the IOL model. Yamane found a prediction error of −0.41 ± 0.98 D with the X70 IOL and −0.02 ± 0.93, with the ZA9003 IOL model [23]. This might be related to factors like the IOL design, the accuracy of used IOL constant, etc.

The pars plana fixation techniques normally show less myopic refractions but there are significant exceptions like the study by Ma et al. that found a myopic prediction error of −0.88 ± 2.15 D with scleral sutures 3 mm from limbus [44] and the paper by Su et al. that reported −0.43 ± 0.71 D error at the same distance [40]. In both papers, another group with sulcus fixation had a higher myopic error.

In all these published studies, the variance of the refraction prediction error is quite variable as well. This is probably related to the heterogeneity of the samples but might have some relationship with the IOL models or with surgical technique. In a subgroup of studies with YT and similar IOL models, the standard deviation of the prediction error ranges from 0.67 to 1.45 D [23, 36–38].

The recommended strategy in scleral fixation should be to use an optimized constant calculated for the same surgeon, same IOL model, and surgical technique. Randerson et al. calculated the refractive results with third-generation formulas using optimized constants for the YT and one IOL model and surgeon: They reported 32–46% of eyes with an absolute PE <0.50 D and 63.30–64.22% of eyes with an absolute PE <1.00 D [37]. Due to the fact that in many of these eyes, ACD and LT will not be available in the preoperative study, fourth-generation formulas that use these parameters will be less useful and more difficult to get enough eyes for constant optimization.

In an average volume, clinic IOL constants optimization will probably take years as these cases are not so frequent. Meanwhile, the expected refraction with in-the-bag IOL constants will be assumed to be −0.5 to −1.00 in sulcus fixation and 0.00 to −0.50 in pars plana fixation.

Sulcus Fixation IOL

Recently, a new IOL specifically designed for sutureless sulcus fixation has been marketed: FIL SSF Carlevale (Soleko Inc). It is a 1-piece foldable acrylic IOL with T-shaped haptics that will be externalized through the sclera with a forceps at two points 180° apart and 2 mm from limbus. Therefore, it can be defined as sutureless sulcus transcleral fixation.

The IOL constant is calculated for this implantation site and therefore should be quite accurate. The manufacturer provided IOL constants for optical biometry are A constant = 119.1 for SRK/T, SF = 1.9 for Holladay 1, a0 = 0.051, a1 = 0.140 and a2 = 0.197 for Haigis and pACD = 5.68 for Hoffer Q and Holladay 2. With this, A constant two different studies found very similar prediction errors, both in terms of mean and SD values: Rouhette et al. reported −0.30 ± 0.70 in 70 cases [45] and Barca et al. found −0.24 ± 0.81 D in 32 cases [46]. Vaiano et al. optimized the IOL constants for the third-generation formulas using a selected sample of 25 cases: values for SRK/T, Hoffer Q, and Holladay 1 were 118.92, 5.48, and 1.75, respectively. The SD of the prediction error with these constants was 0.89 for SRK/T, 0.94 for Holladay 1, and 0.95 for Hoffer Q. The percentage of eyes within ±0.50 D and ±1.00 D were 56% and 72% for SRK/T, 64% and 68% for Holladay 1 and 60% and 72% for the Hoffer Q formula [47].

Iris Plane

The iris can be used as a IOL supporting anatomical structure in the case of absence of capsular support. There are two different options: The iris-claw IOL design which is specifically designed for iris fixation and a PC IOL with the haptics sutured to the mid-perypheral iris.

Iris Claw IOL

The first iris claw IOL was designed by Jan Worst in 1978 to optically correct aphakia after intracapsular surgery [48]. A later evolution of that lens is still in use today: The Artisan aphakia 205 IOL (Ophtec). This is a 1-piece PMMA IOL 8.5 mm long (7.5 mm for pediatric patients) with an optical zone of 5.0 mm. The haptics have a claw shape design in order to pull a small section of iris through it securing the lens to the mid-peripheral iris. It can be implanted in the anterior chamber with a posterior to anterior iris enclavation maneuver or in the posterior chamber enclavating the iris in the opposite sense. Both techniques are considered to be safe and effective but the last years, the retropupilar implantation seems to be more popular, especially in younger patients, due to a lower endothelial damage risk [49].

Iris Claw IOL Power

The Artisan IOL power is calculated as any pseudophakic IOL using normally a third-generation theoretical formula. Most of the published studies use the SRK/T formula. These formulas employ the AL and K value as effective lens position predictors. This could be considered to be senseless as there is no in-the-bag IOL position to predict. The manufacturer recommended A constant values are: 116.8 (US) and 116.9 (optical) for retropupillary (RP) placement and 115.0 (US) and 115.7 (optical) for prepupillary (PP) implantation (Table 71.3).

The reported outcomes can be generally considered better than those obtained with scleral fixated IOLs, and this is probably one of the reasons that explains the increasing popularity of this surgical technique in the correction of aphakia. Very few papers report the refraction prediction error (PE): Choi et al. studied 103 eyes with RP position and found a PE of −0.56 ± 0.98 D. 71.8% of eyes had <0.50 D absolute PE [50]. Gonnermann et al. analyzed 137 eyes calculated with the SRK/T formula. The final refraction was 0.00 ± 1.21 D. At last visit, 75.9% of eyes where within ±1.00 D [51].

Table 71.3 Manufacturer recommended IOL constants for Artisan aphakia 205 IOL

	Constants	Prepupillary	Retropupillary
US biometry	SRK/T	115.0	116.8
Optic biometry	SRK/T (A)	115.7	116.9
	Holladay 1 (SF)	−0.08	0.54
	Hoffer Q (pACD)	3.62	4.34
	Haigis a0	−0.16	−0.25
	Haigis a1	0.4	0.4
	Haigis a2	0.1	0.1
	Barrett (LF)	0.15	0.78

https://es.ophtec.com/productos/cirugia-de-cataratas/lios/artisan-afaquia. Accessed 9 Sept. 2021

Vounotrypidis et al. studied 40 eyes and reported a PE of −0.11 ± 1.06 D. The eyes that were aphakic preoperatively had slightly lower PE than those who were pseudophakic: −0.09 ± 1.18 D and −0.12 ± 0.98 D, respectively. However, 36% of eyes were within ±0.50 D of prediction and 52% within ±1.00 D [52]. In a prospective randomized study of IOL reposition vs exchange with RP iris claw implantation, Dalby et al. reported a PE of +0.29 ± 0.86 D in 50 eyes [53]. Baykara et al. studied 32 eyes operated by one surgeon and reported a PE of −0.13 ± 0.28 D [54]. Choragiewicz et al. analyzed 47 eyes with RP Artisan/Verysyse. They used the Haigis formula with these constants: a0: −0.25, a1: 0.4 and a2: 0.1. The prediction error was −0.27 ± 1.28 D and 61% of eyes where within ±1.00 D of the prediction [55].

There is some variability in these mean values and their variances than can be explained, as in other aphakia treatment modalities, by the difference among treated clinical conditions.

The main drawback of this IOL is that it is non-foldable, and therefore, it demands a large wound size which will induce more astigmatism than other techniques where foldable IOLs are implanted. This can be improved using a tunneled scleral incision instead of a corneal one. Lajoie et al. report a surgically induced astigmatism (SIA) of 1.67 D × 176° in 21 cases of PP implantation and 1.19 D × 11° in 51 cases of RP IOL placement. This difference was not significant [56]. Seknazi et al. found higher induced astigmatism with the Artisan, 1.72 ± 0.96 D than with the Carlevale, 0.72 ± 0.52 D, in 22 and 20 cases ,respectively [57].

Iris Sutured

A PC IOL can be suturede to the mid-perypheral iris with 10/0 polypropylene sutures. The IOL is implanted in the anterior chamber placing the haptics posteriorly in the sulcus, and then, two sutures are passed from limbus to limbus engaging the haptics and the iris. Finally, the optic is gently pushed behind the pupil. This technique was first proposed by McCannel in 1976 and gained quick popularity especially when combined with penetrating keratoplasty as it was easy to perform in sky-open surgery [58, 59]. When performed with a closed chamber, first McCannel suturing was used tying the knot from a paracentesis located above the haptic but Condon related the incidence of haptic slippage and IOL dislocation to the intrinsic difficulty of this technique in cinching correctly the knot and defended the Siepser technique tying the knot outside a lateral paracentesis and then sliding it by opposite pulling without any haptic countertraction [60]. Chang reported eight cases of successful iris sutured IOLs using the Siepser knot [61].

In this technique, the IOL optic will be located in the sulcus plane, maybe slightly more anterior than the sulcus supported IOL, but probably with no significant optical effect. Mura et al. reported a mean ACD of 3.84 ± 0.36 mm (range 3.17–4.5 mm) in 15 cases measured with UBM. The haptics were found to be in sulcus in 53.3%, over the ciliary processes in 30% and over pars plana in 16.7% of the cases. No haptic was found anteriorly placed pushing the iris root [62].

The IOL model selection should follow the same recommendations for any iris-touching model: 3-piece IOL with thin haptics and optic and haptic-optic posterior angulation if only to release some pressure on the iris.

Iris Sutured IOL Power

There are very few reports regarding IOL power calculation in PC IOL sutured to iris. Most of them focus on technique and safety and outcomes are normally expressed in terms of number of eyes over certain UCVA and BCVA. There is no paper with a detailed IOL power calculation methodology description. Dzhaber et al. studied 117 eyes operated by one surgeon with the same IOL model and found a myopic refraction of −1.3 ± 1.4 D (n = 43) with a prediction error of 0.8 ± 0.7 D (n = 38) (sic) [63]. Soiberman et al. reported a postoperative refraction of −0.88 ± 1.91 D in 27 eyes operated by one surgeon with the same IOL model [64]. Condon et al. found −0.36 ± 1.00 D final refraction in 46 eyes, but again with no calculation method description [65].

The recommended IOL power calculation method therefore is not based on data supported evidence but on the knowledge of the produced IOL plane shift. The guidelines have been described above in this chapter for sulcus supported IOLs: Conversion of the in-the-bag IOL power taking into account the IOL power value and the distance shift from in-the-bag to sulcus plane. The figures should be very similar, and therefore, the suggested methods should apply similarly for iris sutured PC IOLs. As soon as experience provides actual outcomes, these calculations can be fine-tuned optimizing an adequate IOL constant for this plane.

Anterior Chamber

Anterior chamber (AC) IOLs can be angle supported or iris supported. As the iris supported IOLs (iris claw) have been covered in a previous section of this chapter, here we will refer exclusively to angle supported IOL models.

After a long evolution since the first AC implantation in 1952 (Baron), the present day models are 1-piece lenses with open-loop flexible haptics. Most designs are based on the Kelman Multiflex IOL with 5.5 mm optic and different longitudinal sizes where selection will depend on the horizontal corneal diameter. The recommended rule is to add 1 mm to the measured horizontal corneal diameter distance. Correctly sized, there will be some anterior optic vaulting avoiding contact with the iris and decreasing the risk of endothelial damage (Fig. 71.4). Most of these IOLs are PMMA made and hence non-foldable. Thus, the large incision size will induce more astigmatism than other techniques where foldable IOLs can be implanted.

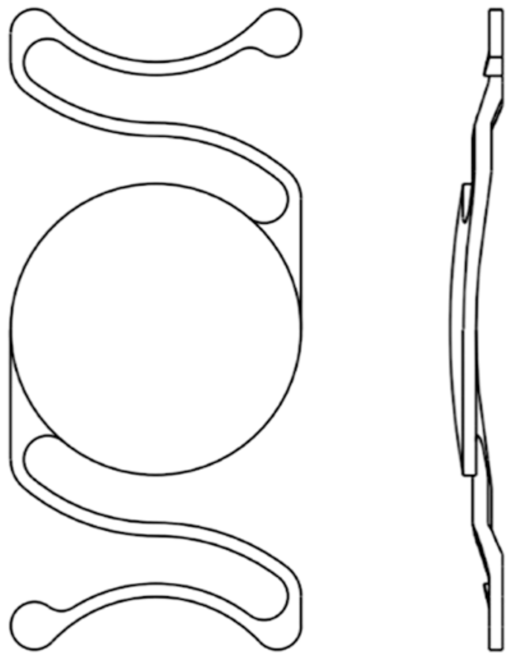

Fig. 71.4 Anterior chamber angle supported IOL. Open-loop haptics with some anterior angulation to provide anterior vaulting of the optic. Model Kelman Multiflex III (Alcon)

The implantation technique is simple and the learning curve is short. A protocoled surgery will allow a safe procedure. There are several complications that have been traditionally associated to angle supported IOLs: corneal decompensation, glaucoma, pupil ovalization, uveitis, etc. [66]. However, the incidence decreased since the first closed-looped IOLs and a recent report by the American Academy of Ophthalmology concluded that the evidence shows no superiority of any single implantation technique in the absence of capsular support [2].

Anterior Chamber IOL Power

Angle supported IOLs are calculated by means of an IOL power calculation formula and a model-specific IOL constant that will take into account the IOL features and the IOL position within the eye, which is much closer to the cornea than any other IOL type. As it happens with the iris fixated IOLs, it is not logical to use a formula that estimates the IOL position with an algorithm calculated for the in-the-bag IOL plane. A lower outcomes spread could be expected with an anterior chamber specific IOL position algorithm. The IOL constant adjusts the calculation to this new IOL plane with a lower value. Cooke et al. calculated an optimized A constant of 115.7 ± 0.39 D for the MT*UO IOL model (Alcon) and the SRK/T formula with a dataset of 52 eyes. They highlighted that this was an increase of 0.4 over the manufacturer's labeled value, just as the median A constant increase of optimized values of most IOLs in ULIB website [67].

The published results suggest better accuracy than scleral fixated IOLs but it should be remarked that nearly all studies are retrospective, with small samples, without detailed calculation methodology description and significant differences in the clinical context: primary vs secondary implantation, aphakia, IOL exchange, etc.: Gore et al. studied 41 eyes and reported a refraction prediction error of 0.37 ± 0.89 D. 71.2% and 40.4% of the eyes were within ±1.00 D and ±0.50 D of the target, respectively [68]. Negretti et al. report a prediction error of −0.23 ± 1.31 D in a sample of 271 eyes [69]. Brunin et al. found a similar value in their series where 30 eyes with anterior chamber IOLs were analyzed: −0.22 ± 0.86 D. After IOL constant optimization, the mean absolute prediction error was 0.62 ± 0.58 D [15]. Harrison et al. studied 35 eyes and reported a prediction error of 0.31 ± 1.00 D. However, 69% and 37% of the eyes were within ±1.00 D and ±0.50 D of the target, respectively [70].

References

1. Oetting TA, Hilary Beaver H, Johnson T. Intraocular lens design, material and delivery. [aut. libro] Henderson BA. Essentials of cataract surgery. Thorofare: Slack Incorporated. pp. 167–182.
2. Shen JF, Deng S, Hammersmith KM, Kuo AN, Li JY, Weikert MP, Shtein RM. Intraocular lens implantation in the absence of zonular support: an outcomes and safety update: a report by the American Academy of Ophthalmology. Ophthalmology. 2020;127(9):1234–1.
3. Kolb CM, Shajari M, Mathys L, Herrmann E, Petermann K, Mayer WJ, Priglinger S, Kohnen T. Comparison of femtosecond laser-assisted cataract surgery and conventional cataract surgery: a meta-analysis and systematic review. J Cataract Refract Surg. 2020;46(8):1075–85.
4. Liu X, Wang L, Du C, Li D, Fan Y. Mechanism of lens capsular rupture following blunt trauma: a finite element study. Comput Methods Biomech Biomed Engin. 2015;18(8):914–21.
5. Nelson LB, Maumenee IH. Ectopia lentis. Surv Ophthalmol. 1982;27(3):143–60.
6. Kristianslund O, Dalby M, Drolsum L. Late in-the-bag intraocular lens dislocation. J Cataract Refract Surg. 2021;47(7):942–54.
7. Chang DF, Masket S, Miller KM, Braga-Mele R, Little BC, Mamalis N, Oetting TA, Packer M, ASCRS Cataract Clinical Committee. Complications of sulcus placement of single-piece crylic intraocular lenses: recommendations for backup IOL implantation following crylic intraocular lenses: recommendations for backup IOL implantation following. J Cataract Refract Surg. 2009;35(8):1445.
8. Werner L. Intraocular lenses: overview of designs, materials, and pathophysiologic features. Ophthalmology. 2021;128(11):e74–93, S0161-6420(20)30626-6.
9. Hayashi K, Hayashi H, Nakao F, Hayashi F. Intraocular lens tilt and decentration, anterior chamber depth and refractive error after trans-scleral suture fixation surgery. Ophthalmology. 1999;106:878–82.
10. Suto C, Hori S, Fukuyama E, Akura J. Adjusting intraocular lens power for sulcus fixation. J Cataract Refract Surg. 2003;29:1913–7.
11. Suto C. Sliding scale of IOL power for sulcus fixation using computer simulation. J Cataract Refract Surg. 2004;30(11):2452–4.
12. Dubey R, Birchall W, Grigg J. Improved refractive outcome for ciliary sulcus-implanted intraocular lenses. Ophthalmology. 2012;119(2):261–5.
13. Eom Y, Song JS, Kim HM. Modified Haigis formula effective lens position equation for ciliary sulcus-

implanted intraocular lenses. Am J Ophthalmol. 2016;161:142–9.
14. Millar ER, Allen D, Steel DH. Effect of anterior capsulorhexis optic capture of a sulcus-fixated intraocular lens on refractive outcomes. J Cataract Refract Surg. 2013;39(6):841–4.
15. Brunin G, Sajjad A, Kim EJ, Montes de Oca I, Weikert MP, Wang L, Koch DD, Al-Mohtaseb Z. Secondary intraocular lens implantation: complication rates, visual acuity, and refractive outcomes. J Cataract Refract Surg. 2017;43(3):369–76.
16. Knox Cartwright NE, Aristodemou P, Sparrow JM, Johnston RL. Adjustment of intraocular lens power for sulcus implantation. J Cataract Refract Surg. 2011;37(4):798–9.
17. Girard LJ. Pars plana phacoprosthesis (aphakic intraocular implant): a preliminary report. Ophthalmic Surg. 1991;109:1754–8.
18. Malbran ES, Malbran E Jr, Negri I. Lens guide suture for transport and fixation in secondary IOL implantation after intracapsular extraction. Int Ophthalmol. 1986;9(2–3):151–60.
19. Forlini M, Bedi R. Intraocular lens implantation in the absence of capsular support: scleral-fixated vs retropupillary iris-claw intraocular lenses. J Cataract Refract Surg. 2021;47(6):792–801.
20. Stem MS, Todorich B, Woodward MA, Hsu J, Wolfe JD. Scleral-fixated intraocular lenses: past and present. J Vitreoretin Dis. 2017;1(2):144–52.
21. Prenner JL, Feiner L, Wheatley HM, Connors D. A novel approach for posterior chamber intraocular lens placement or rescue via a sutureless scleral fixation technique. Retina. 2012;32(4):853–5.
22. Agarwal A, Kumar DA, Jacob S, Baid C, Agarwal A, Srinivasan S. Fibrin glue-assisted sutureless posterior chamber intraocular lens implantation in eyes with deficient posterior capsules. J Cataract Refract Surg. 2008;34(9):1433–8.
23. Yamane S, Sato S, Maruyama-Inoue M, Kadonosono K. Flanged Intrascleral intraocular lens fixation with double-needle technique. Ophthalmology. 2017;124(8):1136–42.
24. Biermann J, Bredow L, Boehringer D, Reinhard T. Evaluation of ciliary sulcus diameter using ultrasound biomicroscopy in emmetropic eyes and myopic eyes. J Cataract Refract Surg. 2011;37:1686–93.
25. Petermeier K, Suesskind D, Altpeter E, Schatz A, Messias A, Gekeler F, Szurman P. Sulcus anatomy and diameter in pseudophakic eyes and correlation with biometric data: evaluation with a 50 MHz ultrasound biomicroscope. J Cataract Refract Surg. 2012;38(6):986–91.
26. Reinstein DZ, Archer TJ, Silverman RH, Rondeau MJ, Coleman DJ. Correlation of anterior chamber angle and ciliary sulcus diameters with white-to-white corneal diameter in high myopes using Artemis VHF digital ultrasound. J Refract Surg. 2009;25:185–94.
27. Duffey RJ, Holland EJ, Agapitos PJ, Lindstrom RL. Anatomic study of transsclerally sutured intraocular lens implantation. Am J Ophthalmol. 1989;108:300–9.
28. Pavlin CJ, Rootman D, Arshinoff S, Harasiewicz K, Foster FS. Determination of haptic position of transsclerally fixated posterior chamber intraocular lenses by ultrasound biomicroscopy. J Cataract Refract Surg. 1993;19(5):573–7.
29. Sewelam A, Ismail AM, El Serogy H. Ultrasound biomicroscopy of haptic position after transscleral fixation of posterior chamber intraocular lenses. J Cataract Refract Surg. 2001;27(9):418–22.
30. Jürgens I, Lillo J, Buil JA, Castilla M. Endoscope-assisted transscleral suture fixation of intraocular lenses. J Cataract Refract Surg. 1996;22(7):879–81.
31. Horiguchi M, Hirose H, Koura T, Satou M. Identifying the ciliary sulcus for suturing a posterior chamber intraocular lens by transillumination. Arch Ophthalmol. 1993;111(12):1693–5.
32. Sugiura T, Kaji Y, Tanaka Y. Ciliary sulcus suture fixation of intraocular lens using an auxiliary device. J Cataract Refract Surg. 2019;45(6):711–8.
33. Sugiura T, Kaji Y, Tanaka Y. Anatomy of the ciliary sulcus and the optimum site of needle passage for intraocular lens suture fixation in the living eye. J Cataract Refract Surg. 2018;44(10):1247–53.
34. Muth DR, Wolf A, Kreutzer T, Shajari M, Vounotrypidis E, Priglinger S, Mayer WJ. Safety and efficacy of current sclera fixation methods for intraocular lenses and literature overview. Klin Monatsbl Augenheilkd. 2021;238(8):868–74.
35. Liu J, Fan W, Lu X, Peng S. Sutureless Intrascleral posterior chamber intraocular lens fixation: analysis of clinical outcomes and postoperative complications. J Ophthalmol. 2021;16:8857715.
36. McMillin J, Wang L, Wang MY, Al-Mohtaseb Z, Khandelwal S, Weikert M, Hamill MB. Accuracy of intraocular lens calculation formulas for flanged intrascleral intraocular lens fixation with double-needle technique. J Cataract Refract Surg. 2021;47(7):855–8.
37. Randerson EL, Bogaard JD, Koenig LR, Hwang ES, Warren CC, Koenig SB. Clinical outcomes and lens constant optimization of the Zeiss CT Lucia 602 lens using a modified Yamane technique. Clin Ophthalmol. 2020;14:3903–12.
38. Rocke JR, McGuinness MB, Atkins WK, Fry LE, Kane JX, Fabinyi DCA, Yeoh J, Chiu D, Essex MBiostat RW, Roufail E, Sheridan AM, Allen PJ, Edwards TL. Refractive outcomes of the Yamane flanged Intrascleral haptic fixation technique. Ophthalmology. 2020;127(10):1429–31.
39. Ohr MP, Wisely CE. Refractive outcomes and accuracy of IOL power calculation with the SRK/T formula for sutured, scleral-fixated Akreos AO60 intraocular lenses. Graefes Arch Clin Exp Ophthalmol. 2020;258(10):2125–9.
40. Su D, Stephens JD, Obeid A, Borkar D, Storey PP, Khan MA, Hsu J, Garg SJ, Gupta O. Refractive outcomes after pars plana vitrectomy and scleral fixated intraocular lens with Gore-Tex suture. Ophthalmol Retina. 2019;3(7):548–52.

41. Botsford BW, Williams AM, Conner IP, Martel JN, Eller AW. Scleral fixation of intraocular lenses with Gore-Tex suture: refractive outcomes and comparison of lens power formulas. Ophthalmol Retina. 2019;3(6):468–72.
42. Abbey AM, Hussain RM, Shah AR, Faia LJ, Wolfe JD, Williams GA. Sutureless scleral fixation of intraocular lenses: outcomes of two approaches. The 2014 Yasuo Tano Memorial Lecture. Graefes Arch Clin Exp Ophthalmol. 2015;253(1):1–5.
43. Huang YC, Tseng CC, Lin CP. Myopic shift of sulcus suture-fixated posterior chamber intraocular lenses. Taiwan J Ophthalmol. 2013;3(9):95–7.
44. Ma DJ, Choi HJ, Kim MK, Wee WR. Clinical comparison of ciliary sulcus and pars plana locations for posterior chamber intraocular lens transscleral fixation. J Cataract Refract Surg. 2011;37(8):1439–46.
45. Rouhette H, Meyer F, Pommier S, Benzerroug M, Denion E, Guigou S, Lorenzi U, Mazit C, Mérité PY, Rebollo O. FIL-SSF Carlevale intraocular lens for sutureless scleral fixation: 7 recommendations from a serie of 72 cases. MICA study (Multicentric Study of the Carlevale IOL). J Fr Ophtalmol. 2021;44(7):1038–46.
46. Barca F, Caporossi T, de Angelis L, Giansanti F, Savastano A, Di Leo L, Rizzo S. Trans-scleral plugs fixated IOL: a new paradigm for sutureless scleral fixation. J Cataract Refract Surg. 2020;46(5):716–20.
47. Vaiano AS, Hoffer KJ, Greco A, Greco A, D'Amico G, Pasqualitto V, Carlevale C, Savini G. Accuracy of IOL power calculation using the new carlevale sutureless scleral fixation posterior chamber IOL. J Refract Surg. 2021;37(7):472–6.
48. Worst JGF. Iris claw lens [letter]. Am Intraocular Implant Soc J. 1980;6:166–167.
49. Liang IC, Chang YH, Hernández Martínez A, Hung CF. Iris-Claw intraocular lens: anterior chamber or retropupillary implantation? A systematic review and meta-analysis. Medicina (Kaunas). 2021;57(8):785.
50. Choi EY, Lee CH, Kang HG, Han JY, Byeon SH, Kim SS, Koh HJ, Kim M. Long-term surgical outcomes of primary retropupillary iris claw intraocular lens implantation for the treatment of intraocular lens dislocation. Sci Rep. 2021;11(1):726.
51. Gonnermann J, Klamann MK, Maier AK, Rjasanow J, Joussen AM, Bertelmann E, Rieck PW, Torun N. Visual outcome and complications after posterior iris-claw aphakic intraocular lens implantation. J Cataract Refract Surg. 2012;38(12):2139–43.
52. Vounotrypidis E, Schuster I, Mackert MJ, Kook D, Priglinger S, Wolf A. Secondary intraocular lens implantation: a large retrospective analysis. Graefes Arch Clin Exp Ophthalmol. 2019;257(1):125–34.
53. Dalby M, Kristianslund O, Drolsum L. Long-term outcomes after surgery for late in-the-bag intraocular lens dislocation: a randomized clinical trial. Am J Ophthalmol. 2019;207:184–94.
54. Baykara M, Ozcetin H, Yilmaz S, Timuçin OB. Posterior iris fixation of the iris-claw intraocular lens implantation through a scleral tunnel incision. Am J Ophthalmol. 2007;144(4):586–91.
55. Choragiewicz T, Rejdak R, Grzybowski A, Nowomiejska K, Moneta-Wielgoś J, Ozimek M, Jünemann AG. Outcomes of sutureless Iris-Claw lens implantation. J Ophthalmol. 2016;2016:7013709.
56. Lajoie J, Glimois V, Petit T, Amelie R, Varenne F, Fournie P, Pagot Mathis V, Malecaze F, Wargny M, Gallini A, Soler V. Assessment of astigmatism associated with the iris-fixated ARTISAN aphakia implant: anterior fixation versus posterior fixation, study of postoperative follow-up at one year. J Fr Ophtalmol. 2018;41(8):696–707.
57. Seknazi D, Colantuono D, Tahiri R, Amoroso F, Miere A, Souied EH. Secondary sutureless posterior chamber lens implantation with two specifically designed IOLs: Iris Claw lens versus sutureless trans-scleral plugs fixated lens. J Clin Med. 2021;10(1):2216.
58. McCannel MA. A retrievable suture idea for anterior uveal problems. Ophthalmic Surg. 1976;7(2):98–103.
59. Price FW Jr, Whitson WE. Visual results of suture-fixated posterior chamber lenses during penetrating keratoplasty. Ophthalmology. 1989;96(8):1234–9.
60. Condon GP. Iris-fixated posterior chamber intraocular lenses. J Cataract Refract Surg. 2006;32(9):1409.
61. Chang DF. Siepser slipknot for McCannel iris-suture fixation of subluxated intraocular lenses. J Cataract Refract Surg. 2004;30(6):1170–6.
62. Mura JJ, Pavlin CJ, Condon GP, Belovay GW, Kranemann CF, Ishikawa H, Ahmed II. Ultrasound biomicroscopic analysis of iris-sutured foldable posterior chamber intraocular lenses. Am J Ophthalmol. 2010;149(2):245–52.
63. Dzhaber D, Mustafa OM, Tian J, Cox JT, Daoud YJ. Outcomes and complications of iris-fixated intraocular lenses in cases with inadequate capsular support and complex ophthalmic history. Eye (Lond). 2020;34(10):1875–82.
64. Soiberman U, Pan Q, Daoud Y, Murakami P, Stark WJ. Iris suture fixation of subluxated intraocular lenses. Am J Ophthalmol. 2015;159(2):353–9.
65. Condon GP, Masket S, Kranemann C, Crandall AS, Ahmed II. Small-incision iris fixation of foldable intraocular lenses in the absence of capsule support. Ophthalmology. 2007;114(7):1311–8.
66. Por YM, Lavin MJ. Techniques of intraocular lens suspension in the absence of capsular/zonular support. Surv Ophthalmol. 2005;50(5):429–62.
67. Cooke DL, Otto B. Lens constants for anterior chamber intraocular lenses. J Cataract Refract Surg. 2021;47(8):1094–5.
68. Gore DM, Wilkins MR. Refractive outcomes in anterior chamber intraocular lenses. Int Ophthalmol. 2013;33(5):453–4.
69. Negretti GS, Lai M, Petrou P, Walker R, Charteris D. Anterior chamber lens implantation in vitrectomised eyes. Eye (Lond). 2018;32(3):597–601.
70. Harrison BM, Idrees S, DiLoreto D, Chung M, Ramchandran R, Kuriyan AE. Refractive outcomes of anterior chamber intraocular lens implantation. Invest Ophthalmol Vis Sci. 2020;61(7):1683.