Ultrasound Biomicroscopic Analysis of Iris-Sutured Foldable Posterior Chamber Intraocular Lenses

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• PURPOSE: **To report ultrasound biomicroscopic (UBM) findings of iris-sutured foldable posterior chamber intraocular lenses (PCIOLs).**

• DESIGN: **Prospective, noninterventional consecutive case series.**

• METHODS: **Fifteen eyes with foldable acrylic IOL implantation using peripheral iris suture fixation in the absence of capsular support were included. UBM was used to determinate the haptic position in relation to the ciliary sulcus and ciliary body in these eyes. Additionally, anterior chamber depth, lens tilt, site of suture fixation, focal iris or angle abnormalities, and relationship of iris to lens were determined. Main outcome measures were haptic position, anterior chamber depth, and iris anatomic changes.**

• RESULTS: **Of the 30 haptics imaged, 16 (53.3%) were positioned in the ciliary sulcus. Nine (30%) haptics were found over the ciliary processes, and 5 (16.7%) were over pars plana. No patients were found to have peripheral anterior synechiae present at the haptic position. The mean (± standard deviation) depth of the anterior chamber was 3.84 ± 0.36 mm. The iris profile was altered in all patients at the iris–haptic suture fixation site. No angle abnormalities or tilted lenses were found.**

• CONCLUSIONS: **Iris-sutured PCIOL haptics were found to be in the ciliary sulcus or over the ciliary body with no significant tilt on UBM analysis. The procedure respects the angle anatomy, and no evidence of angle closure was found. The anterior chamber was deeper than has been reported previously for scleral sutured PCIOLs and was similar to that of pseudophakic eyes. This may have implications for surgical technique, IOL power calculations, and postoperative complications. (Am J Ophthalmol 2010;149:245–252. © 2010 by Elsevier Inc. All rights reserved.)**

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INTRAOCULAR APPROACHES TO CORRECT APHAKIA IN cases of inadequate capsular support include an anterior chamber intraocular lens (ACIOL), a transscleral fixated posterior chamber intraocular lens (PCIOL), or an iris-sutured PCIOL. An American Academy of Ophthalmology device review[1] concluded that all 3 options are comparably safe and effective. However, precise determination of small differences in visual outcome or complication rates requires a large prospective, randomized clinical trial.

Despite improvements in design, ACIOLs historically have been associated with angle complications, including corneal decompensation,[2] glaucoma,[3,4] and uveitis.[5,6] Scleral-sutured IOLs, although reducing some of the concerns of ACIOLs, have been associated with IOL tilt,[7] suture breakage,[7] and endophthalmitis.[8,9]

Iris-sutured IOLs have comparative advantages over the other options, including reduced inflammation, absence of suture exposure risk, and respect for angle structures.[10] With adaptation to foldable IOLs, this technique has been reported with recent enthusiasm.[11–13] However, one of the criticisms of this IOL fixation position is concern for close uveal contact and potential associated complications.

The ultrasound biomicroscope operates at a frequency of 50 MHz, producing images with a resolution of approximately 40 μm. This provides a unique ability to assess anatomic relationships between structures in the anterior segment of the eye[14] and thus is ideally suited to study iris-sutured PCIOLs. Specifically, the ultrasound biomicroscope has the ability to assess haptic position in relation to the sulcus and ciliary body, anterior chamber depth (ACD), vitreous incarceration, focal iris abnormalities, angle anatomy, and relationship of the iris to lens (straight or tilted).[15–27] The purpose of this study was to present ultrasound biomicroscopy (UBM) findings of iris-fixated foldable IOLs implanted for aphakia.

METHODS

A PROSPECTIVE UBM EVALUATION OF 15 EYES THAT UNDERwent iris suture fixation of an acrylic foldable IOL for management of aphakia was performed. Surgery was performed by 1 of 3 surgeons (I.I.K.A., C.F.K., G.P.C.), with the technique described by Condon and by Stutzman and

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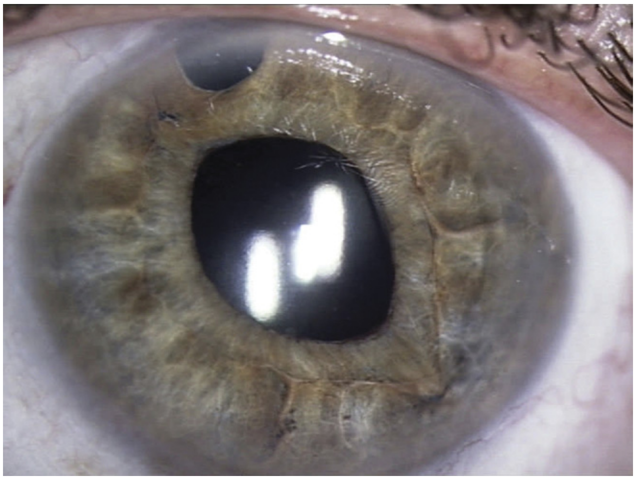

FIGURE 1. **Postoperative photograph showing that the iris sutures of the iris-sutured foldable posterior chamber intraocular lens are visible at 10 and 4 o'clock in the mid-peripheral iris.**

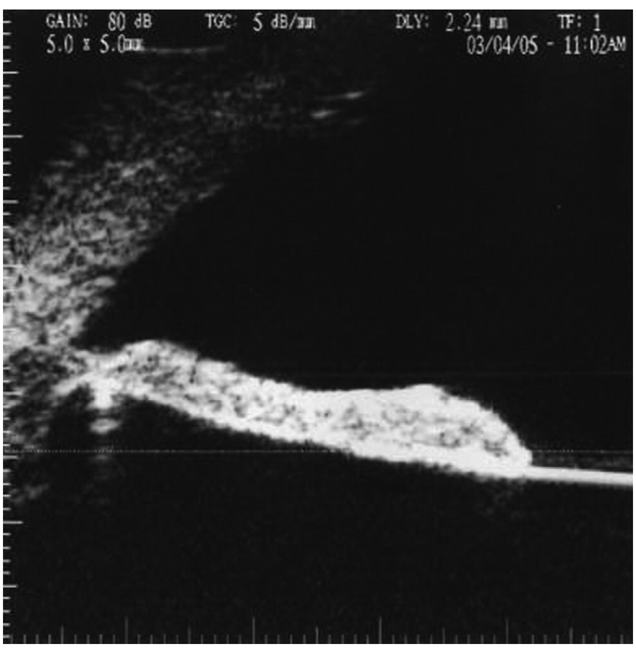

FIGURE 2. **Ultrasound biomicroscopic analysis showing the haptic of the iris-sutured foldable posterior chamber intraocular lens located in the sulcus (CS).**

Stark, which is summarized briefly below.[11,12] No intraocular complications occurred in any of the eyes enrolled.

Under topical anesthesia a 3-piece acrylic PCIOL (AcrySof MA60AC; Alcon Laboratories, Fort Worth, Texas, USA) was folded and inserted through a 3.5-mm clear corneal tunnel incision. Once in the anterior chamber (AC), both haptics were projected through the pupil while the optic was held just above the iris plane. The IOL was unfolded slowly, allowing the haptics to extend behind the posterior iris surface while the optic, supported by the spatula above the iris plane, was captured completely by the pupil and stabilized.

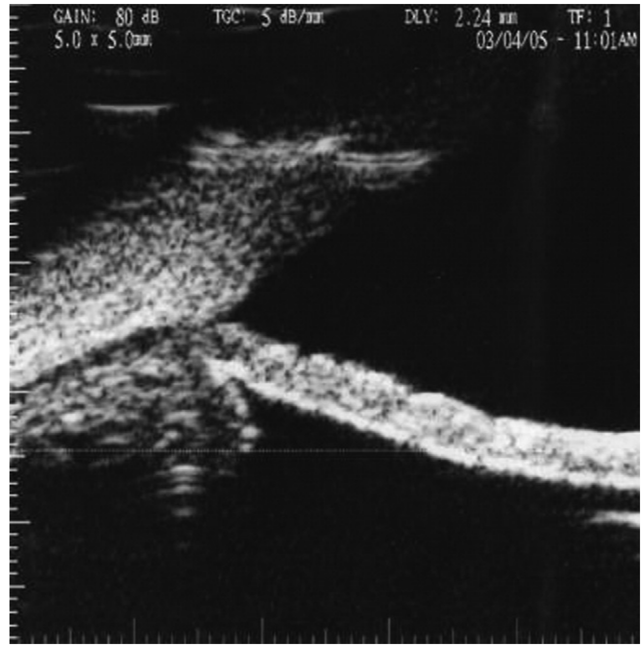

FIGURE 3. **Ultrasound biomicroscopic analysis showing the haptic of the iris-sutured foldable posterior chamber intraocular lens located over the ciliary process (CP).**

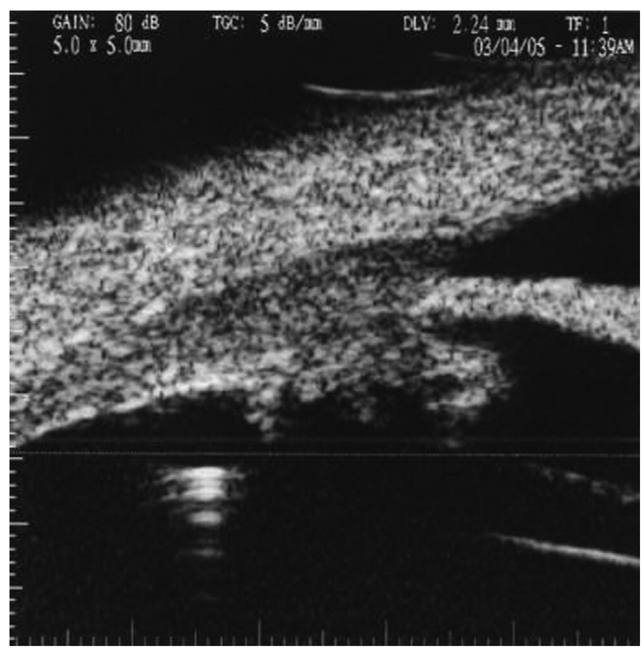

FIGURE 4. **Ultrasound biomicroscopic analysis showing the haptic of the iris-sutured foldable posterior chamber intraocular lens located over the pars plana (PP).**

To fixate each haptic to the peripheral iris, a 10–0 polypropylene suture on a long curved CIF-4 needle (Ethicon, Inc, Somerville, New Jersey, USA) or PC-7 needle (Alcon Laboratories) was passed through peripheral

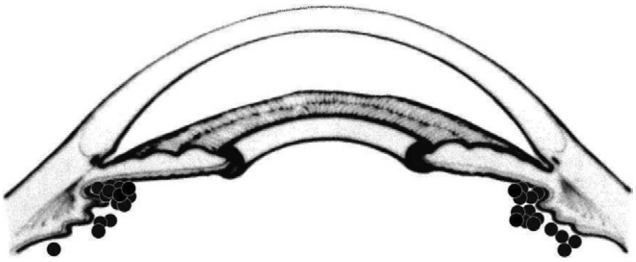

FIGURE 5. Diagram summarizing of all 30 haptic positions of the iris-sutured foldable posterior chamber intraocular lens imaged by ultrasound biomicroscopy in 15 eyes.

TABLE 1. Anterior Chamber Depth and Haptic Positions of the Iris-Sutured Foldable Posterior Chamber Intraocular Lenses

Patient No.	ACD	Haptic 1		Haptic 2		Site of Suture
1	4.05	CS	1:00	CP	7:00	Mid periphery
2	3.17	CP	6:00	CP	12:00	Mid periphery
3	3.61	CS	1:00	CS	7:00	Mid periphery
4	3.40	CS	12:00	CP	6:00	Mid periphery
5	4.50	CP	6:00	PP	12:00	Mid periphery
6	3.59	CS	6:00	CS	12:00	Mid periphery
7	3.89	CS	3:00	CS	9:00	Mid periphery
8	3.75	CS	10:00	PP	4:00	Mid periphery
9	3.70	CS	11:00	PP	5:00	Mid periphery
10	3.96	CS	3:00	CS	9:00	Mid periphery
11	4.33	CP	11:00	CP	7:00	Mid periphery
12	3.67	CS	12:00	CP	6:00	Mid periphery
13	4.20	PP	3:00	PP	9:00	Mid periphery
14	3.63	CS	2:00	CS	7:00	Mid periphery
15	4.22	CS	12:00	CP	6:00	Mid periphery

ACD = anterior chamber depth; CP = ciliary process; CS = ciliary sulcus; PP = pars plana.
Clock hour position of each haptic shown.

iris, behind the haptic, and out through the iris and peripheral cornea. The Siepser slipknot technique[28,29] or microtying forceps (Ahmed Microtying Forceps; Micro-Surgical Technology, Redmond, Washington, USA) were used to tie the suture. The second haptic was secured in the same manner. The optic then was prolapsed into the posterior chamber (Figure 1). When it was required, anterior or posterior vitrectomy, or both, was performed to clear the retropupillary space before IOL implantation.

Two physicians (C.J.P., H.I.), using a commercial version of the ultrasound biomicroscope (Humphrey Instruments; San Leandro, California, USA), conducted all UBM examinations. UBM imaging procedures have been described elsewhere.[14]

The central ACD, iris profile, iris-haptic fixation sites, AC angle, IOL optic tilt and position, and haptic position were examined with the UBM in all eyes. Haptic position was designated as CS if located in the ciliary sulcus, CP if located over the ciliary processes, and PP for haptics located over the pars plana.

RESULTS

THE MEAN AGE OF ENROLLED PATIENTS RANGED FROM 20 to 86 years; mean (± standard deviation) was 51.8 ± 21.8 years. There were 4 eyes from females and 11 from males. Follow-up duration ranged from 3 to 33 months; the mean (± standard deviation) follow-up was 10.5 ± 9.7 months.

Fourteen eyes improved their best-corrected visual acuity (BCVA), whereas 1 eye maintained BCVA. The mean preoperative BCVA was 0.72 ± 0.47 logarithm of the minimal angle of resolution units, and the postoperative BCVA was 0.38 ± 0.19 logarithm of the minimal angle of resolution units (P = .001).

UBM analysis was performed on 15 eyes. UBM examination found that 16 haptics (53.3%) were located in the ciliary sulcus (Figure 2), 9 haptics (30%) were over the ciliary processes (Figure 3), and 5 haptics (16.7%) were over pars plana (Figure 4). No haptics were found anterior to the sulcus region. Figure 5 summarizes the actual position of all haptics imaged. The location and relative position of haptics (clock hours) are detailed in Table 1. We did not find any alteration in angle anatomic features, nor any peripheral anterior synechiae nor any degree of angle closure. The mean ACD was 3.84 ± 0.36 mm (range, 3.17 to 4.5 mm).

All the IOLs were in a planar position; no IOL tilt was found in any patient. No synechia or vitreous incarceration was evident during UBM examination. At the point of iris–haptic suture fixation, there was a focal acute alteration in the iris profile (Figure 6). Other than the point of iris–haptic fixation, there was no further contact of the IOL optic or haptic to the posterior iris.

DISCUSSION

IRIS-SUTURED PCIOLS HAVE DEMONSTRATED SAFETY IN several studies,[1,13,30–32] with results at least as favorable as those with ACIOLs and transscleral sutured PCIOLs. A review from the American Academy of Ophthalmology[1] reaffirmed this. Of 43 articles selected on the basis of relevance and design and published between 1980 and 2002, 8 were related to iris-sutured IOLs and 5 of those were in the setting of aphakic correction during penetrating keratoplasty (PKP). Evaluating IOL results (visual outcome, glaucoma incidence, cystoid macular edema [CME] prevalence) in the setting of PKP is difficult and is masqueraded by the PKP itself. This is compounded by the relatively low incidence of aphakia, making a randomized prospective study on appropriate IOL choice difficult. In the only randomized prospective study comparing the 3

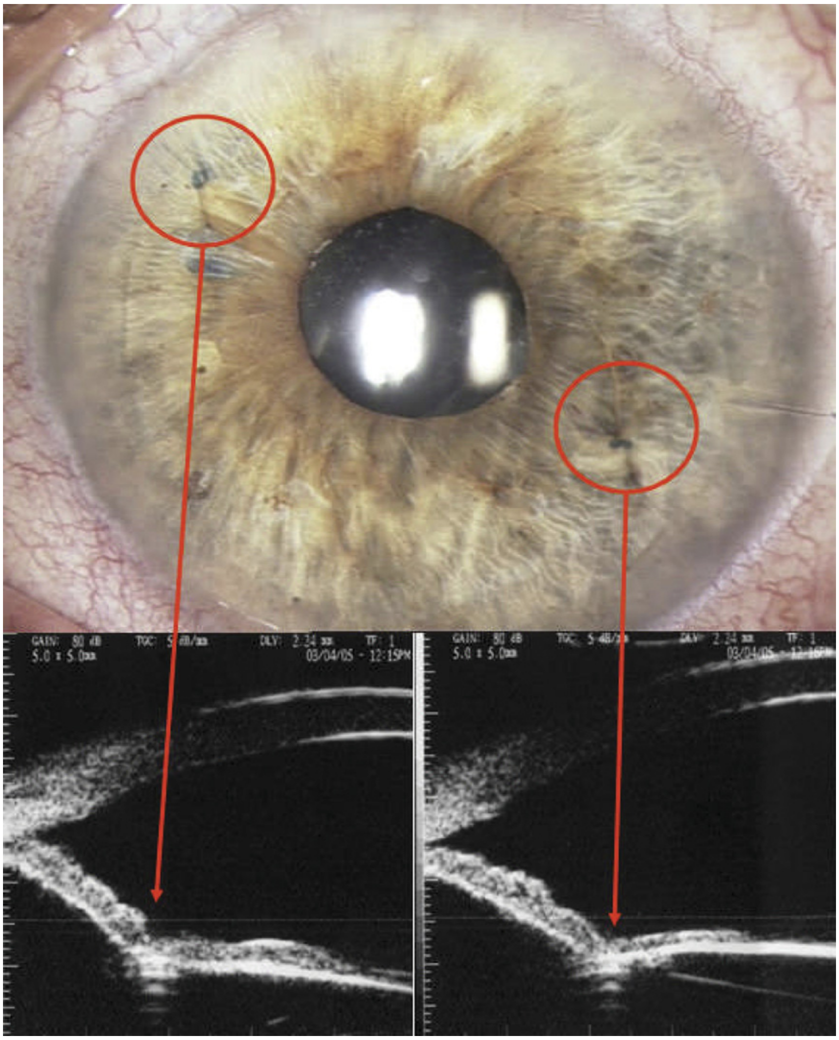

FIGURE 6. Photograph showing mid-peripheral positioning of sutured haptics of the iris-sutured foldable posterior chamber intraocular lens, with corresponding ultrasound biomicroscopic images showing the altered iris profile.

options for IOL fixation in the absence of capsular support, iris-fixated IOLs were found to have a statistically lower incidence of CME, although postoperative visual acuity was similar among the groups.[10]

ACIOL implantation is technically easier, but even with flexible open-loop designs, angle-related concerns persist. Close proximity of the lens haptics to the cornea creates concern for corneal decompensation, glaucoma escalation, and chronic inflammation.[2–6] Correct sizing for anterior chamber angle width is critical to prevent IOL rotation, corneal contact, or both or iris entrapment and chronic inflammation. Traditionally, surgeons have used the corneal white-to-white measurement +1 mm as a guide for correct ACIOL sizing. However, recent imaging studies with high-speed optical coherence tomography have demonstrated poor correlation with this measurement, with relatively inaccurate sizing of implanted ACIOLs.[33]

A long-term Norwegian study (93.8 months) demonstrated that secondary implantation of ACIOLs raised the intraocular pressure by 3.2 mm Hg from baseline.[2] Biro found that in 4.6% and 0.9% of eyes, glaucoma developed after secondary implantation of flexible ACIOLs versus scleral-fixated PCIOLs, respectively.[4] Bellucci and associates found corresponding frequencies of 3% and 0% after a follow-up of 12 to 44 months.[3] These studies suggest that ACIOLs should be used with caution in glaucomatous eyes.

Scleral-sutured sulcus PCIOL implantation, although technically more demanding, has the advantages of avoiding some of the angle-related problems with ACIOLs. However, this technique necessarily involves transscleral blind needle passes to approximate the ciliary sulcus and risks intraocular hemorrhage. Further concerns include IOL tilt, optic capture, peripheral anterior synechiae, external suture erosion and breakage, and suture tract infection[34] or endophthalmitis.[8,9]

TABLE 2. Summarized Published Anterior Chamber Depth and Haptic Positions as Reported for Various Posterior Chamber Intraocular Lens Fixation Strategies

	ACD (mm)	Haptic Position (% of Haptics)				
		Capsular Bag	Anterior to Sulcus	Ciliary Sulcus	Ciliary Process	Pars Plana
Phakic	2.86[25] 2.86[23] 2.63[19]	N/A	N/A	N/A	N/A	N/A
PCIOL in-the-bag after phacoemulsification and CCC	3.72[25] 3.61[19] 3.86[17] 4.06[20]	100%	N/A	N/A	N/A	N/A
PCIOL after ECCE and linear capsulotomy[17]	3.64	79.4%	5.9%	11.8%	2.9%	0%
PCIOL in sulcus supported by capsular remnant[17,21]	3.14	16.7%	0%	68.1%	9.7%	4.2%
PCIOL scleral sutured[a,18]	3.47	N/A	N/R	N/R	N/R	N/R
PCIOL scleral sutured[22]	N/R	N/A	N/R	37.2%	33.7%	11.6%
PCIOL scleral sutured[26]	N/R	N/A	27.5%	55.0%	17.5% (posterior to sulcus)	
PCIOL scleral sutured[24]	N/R	N/A	38.2%	38.2%	23.5% (posterior)	
PCIOL scleral sutured (ab externo/interno)[16]	N/R	N/A	35% 29%	31% 29%	44% 29% (posterior to sulcus)	
PCIOL iris sutured[27]	N/R	N/A	0%	11.5%	3.8%	26.9%
PCIOL (foldable) iris sutured (current study)	3.84	N/A	0%	53.3%	30%	16.7%

ACD = anterior chamber depth; CCC = continuous curvilinear capsulorrhexis; ECCE = extracapsular cataract extraction; N/A = not applicable; N/R = not reported; PCIOL = posterior chamber intraocular lens.

[a]Using A-scan ultrasonography.

Using the peripheral iris as support for fixation of a PCIOL retains the normal anatomic position of the IOL and does not require transscleral suture passes or an externalized suture. Previously described techniques were primarily used with an open-sky approach, using a specially designed 4-positioning hole optic during PKP, with favorable results.[30–32] Limbal approaches were cumbersome and technically difficult.[32] However, with recent innovations using a foldable acrylic IOL, small incisions, and modified iris suturing techniques, iris fixation has become increasingly popular.[11,12,28]

One of the critical aspects in evaluating IOL selection in the absence of capsular support (ACIOL, scleral-sutured PCIOL, or iris-sutured PCIOL) is the anatomic relationship between the lens implant and surrounding ocular tissue. The UBM, with a resolution of 40 μm and depth of penetration of 4 to 5 mm, provides excellent real-time imaging of the anterior segment, including the anterior chamber, angle, iris, ciliary body, and zonules.[14] Assessment of IOL position, haptic location, and tilt thus can be performed precisely. UBM has been used to assess anterior segment changes after phacoemulsification and endocapsular IOL implantation, extracapsular cataract extraction and IOL implantation, sulcus IOL implantation supported by anterior capsular shelf in cases of capsular rupture, scleral-sutured IOLs, and iris-fixated IOLs (Table 2).[16–27]

When unable to be placed within the capsular bag, PCIOL haptic position is located ideally in the ciliary sulcus. The ciliary sulcus is a space that may be variable, particularly in a patient with an absent capsule. The ciliary processes may be shorter, adhesions may be present, and the sulcus is narrower than expected.[35] Furthermore, with no direct view, an attempt to fixate an IOL within the sulcus is essentially a blind procedure.

PCIOL haptic location has significant clinical implications. An excessively anterior haptic position may result in iris impingement and uveitis, as well as peripheral anterior synechiae.[24] Posterior positioning within the ciliary processes may result in uveal irritation and inflammation. Furthermore, asymmetric haptic fixation may cause IOL tilt. Haptic position also has implications for ACD and hence preoperative IOL calculations and postoperative refraction.

Scleral-sutured PCIOLs have been evaluated with several UBM studies,[16,22,24,26] which show between 29% and 55% of haptics in the ciliary sulcus position. Sewelam and associates and Pavlin and associates noted that 27.5% and 38.2% of haptics, respectively, were located anterior to the sulcus, accompanied by a variable degree of angle closure.[24,26] Furthermore, the ACD in scleral-sutured IOLs has been found to be shallower[22] than that in endocapsular PCIOLs.

In our current study, iris-sutured IOL haptic position was found to be in the ciliary sulcus in 53.3% of cases. We did not find any haptics positioned anterior to the ciliary sulcus, nor related angle anatomic changes or development of synechia. Nearly 47% of haptics were posterior to the anatomic sulcus, implying either a lack of sulcus or haptic entrapment posteriorly. Compared with UBM analysis in scleral-sutured PCIOLs, we found a greater number of haptics posterior to the sulcus than anterior to it (Table 2). This is likely because of the overall diameter of the IOL and the fact the haptics are unfolded posteriorly (in the anterior vitreous cavity) and may have a tendency to catch or become entrapped posterior to the sulcus (i.e., within or posterior to the ciliary processes). Furthermore, in these cases, the IOL is implanted without the limiting effect of the lens capsule, which otherwise would cause the IOL to be positioned more forward. Although we found no negative effects of such posterior haptic positioning, to address this we recommend lifting the haptics (with overlying iris) at the conclusion of the case to obtain sulcus positioning, avoiding the capture of the haptics behind the head of the ciliary processes. This may be performed with microforceps. Correspondingly, to reduce this type of posterior luxation, we suggest avoiding overinflating the eye with BSS at the conclusion of the procedure, that is, corneal hydration for wound closure, and instead use corneal sutures to obtain watertight wounds. One also may consider a shorter-diameter PCIOL. Despite these maneuvers, we cannot comment on the likelihood of maintaining haptic positioning within the sulcus after surgery.

Walther and associates reported UBM findings in a series of 13 patients with iris-sutured rigid PCIOLs 2 days after surgery.[27] They found 57.7% of haptics had no contact with intraocular structures. As in our current study, they also found that a significant number of haptics (30%) were posterior to the ciliary sulcus. They did not provide data about ACD.

UBM findings in scleral-sutured PCIOLs have found that nearly 50% of haptics had some degree of vitreous incarceration.[22] We did not find vitreous incarceration in our series of iris-sutured PCIOLs, likely because of differences in needle passage and suture placement.

ACD, a function of IOL and haptic position within the anterior segment, has implications for postoperative refraction, and risk for optic capture, iris chafing, or both. UBM studies have shown sulcus-fixated PCIOLs supported by an anterior capsule remnant have shorter ACDs (3.14 mm) compared with endocapsular PCIOLs (3.61 to 4.06 mm). The mean ACD in our series of iris-sutured foldable PCIOLs (3.84 mm) was deeper compared with that of phakic eyes (values from 2.63 to 2.86 mm)[19,23,25] and that of scleral-sutured PCIOLs[21] (3.47 mm) and similar to that of in-the-bag pseudophakic[17,19,20,25] eyes (3.61 to 4.06 mm). This has important implications for preoperative IOL calculations. Based on our UBM and clinical findings, we did not make adjustments on in-the-bag IOL power calculations for iris-sutured PCIOL implantation.

Using UBM evaluation, optic tilt has been found to be a problem in anterior capsule-supported PCIOLs placed in the sulcus in 56% of cases in one series,[21] as well as in scleral-sutured PCIOLs, with up to 11.5% having severe optic tilt.[36] We found no cases of IOL tilt in our series of iris-sutured PCIOLs.

Midperipheral iris suture position was found in all the patients, which is important considering the risk of bleeding. If we review the blood supply of the iris, the major arterial circle is near to its root. At the site of the suture, the blood vessels are radial to the pupil, encapsulated, and smaller in diameter, providing a low risk of hemorrhage. Importantly, other than iris contact at the point of haptic suture fixation, there were no other areas of posterior iris contact with the IOL in our case series, thus indicating the low risk of pigment dispersion with this fixation technique.

Our UBM findings for iris-sutured foldable PCIOLs using a standardized technique appear favorable compared with scleral-sutured PCIOLs. We found similar or better haptic positioning with no optic tilt or vitreous incarceration, and thus a lower theoretical risk of chronic inflammation, hemorrhage, or CME. Interestingly, in the only randomized study comparing techniques, iris-fixated IOLs had lower CME than scleral-sutured IOLs.[10] Furthermore, we found iris-sutured PCIOLs were found to be optically closer to in-the-bag implantation.

In summary, UBM analysis after iris-suture fixation of foldable acrylic PCIOLs found favorable anatomic placement relative to intraocular structures, with preservation of angle anatomic features and avoidance of vitreous incarceration. Because of either narrowing of the ciliary sulcus or haptic entrapment, haptic placement tended to be somewhat posterior in nearly half of the cases. Optic tilt was not an issue, and ACD was similar for endocapsular PCIOL fixation. This study confirms the safety of small-incision iris-sutured foldable PCIOL techniques.

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