Inverted implantation of posterior iris-fixated intraocular lens with 23G transconjunctival vitrectomy in the management of secondary implant. Technique and stability, astigmatism and endothelial loss outcomes

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PURPOSE: To study outcomes and complications and evaluate the safety and efficacy of 23-gauge transconjunctival sutureless vitrectomy (23G PPV) to remove vitreous adhesions of dislocated or subluxated lens and in aphakia, combined with inverted implantation of posterior Artisan® iris-fixated intraocular lens.

SETTING: Ophthalmology Unit. Hospital Universitari Germans Trias i Pujol, Spain.

METHODS: 23G PPV was combined with iris-claw implantation and incision in the steepest meridian in 32 patients. Patients were followed-up for one year.

RESULTS: Complications: one bleeding in an acenocoumarol user, one intraoperative dislocation, one accidental iridotomy, five postoperative subluxations. No complications such as cystoid macular edema, retinal detachment or choroid were recorded. Refraction was measured after a mean of 59.9 days. The corrected distance visual acuity (CDVA) was 0.17 ± 0.33 logMAR (0.67 ± 0.27) and, when the six patients with poor prognosis were excluded from the group, CDVA was 0.10 ± 0.06 logMAR (0.79 ± 0.11). Visual acuity of over 0.5 was achieved in 81.25% of all patients. Spherical equivalent was 0.07 ± 0.59 D, and by vector 1.35 ± 0.57 D. There were no differences regarding incision location (p = 0.941) or the eye involved (p = 0.563). The mean endothelial cell density at baseline was 1546 ± 422 cells/mm² and the final value was 1322 ± 360 cells/mm². Total cell loss was 13.6%, in aphakia 6.2%, in replacement 11.8%, in subluxated lens 12.6%, in dislocated lens 19.7%. Only 25% of the lenses would have been further than 3 mm from the endothelium if the implant had been anterior.

CONCLUSION: This combined technique is safe, effective and predictable. Its major complication is early haptic dislocation, which is simple to resolve. The 23G PPV provides excellent treatment of the posterior cavity and prevents further complications.

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Lack of capsular support can occur in situations such as aphakia and intraocular lens dislocation (laxation to vitreous or partially subluxated lenses). The overall risk of aphakia is 0.65%¹,², but this is not planned in 87.1% of cases, resulting in a real risk of 0.49%. The main cause of aphakia is capsular rupture and loss of vitreous and a second procedure is required in two thirds of cases. In the literature, corrected distance visual acuity (CDVA) of at least 0.5 is achieved in 27.7%, which is considerable for medical specialists in training.
Late intraocular lens (IOL) dislocation has been widely reported in the literature. This occurs at a rate of between 0.05% and 0.60%, although an incidence of 1% at 10 years has been described. The most common cause in 40-66% of cases is pseudoxfoliation, but previous vitreoretinal surgery, history of ocular trauma and uveitis has also been reported. Mean CDVA achieved in these patients was 0.35 ± 0.31 logMAR (0.45 decimal), and 66.22% of them achieved visual acuity of over 0.5. It is noteworthy that late IOL displacement occurs on average 7.1–8.5 years after surgery.

There is consensus on the need for posterior vitrectomy for dislocated IOL in the vitreous cavity. The purpose is to release vitreoretinal adhesions and to reduce the risk of retinal rupture. However, in subluxated lenses, vitreous residues also remain between the capsules and haptics. Moreover, proper preparation of the vitreous base is essential in aphakia. Therefore, in the present work, the procedure included 23-gauge transconjunctival sutureless vitrectomy (23G PPV), the most recent and least invasive technique for posterior segment, thus reducing surgical trauma to the conjunctiva and sclera, shortening surgery time and producing less postoperative discomfort to the patient. Several techniques are available for implantation without capsular support: implantation in the anterior chamber, iris suture, sclera fixation, insertions in scleral tunnels with or without biological glue and iris fixation. Retropupillary implantation of an iris-claw lens (Artisan®; Ophthec, Groningen, The Netherlands) was selected, as this is considered the least invasive method and has proven effective for the treatment of aphakia after dropped nucleus, congenital cataract and ocular trauma. The effective lens position (ELP) was also calculated using the Hoffer Q formula and the measurement from the corneal apex to the anterior chamber. The effective lens position for the lens and is directly related with the accommodation of the SF (Holladay) and ACD constants. SF constant is the distance between the iris plane and the expected position for the lens and is directly related with the ACD constant (ACD = SF +3.74).

Calculation of IOL power

Since the constants provided by the manufacturer (A = 115.0 and ACD = 3.3) are not appropriate for retropupillary implant, a theoretical calculation was made on the basis of a Visante® study of a previous series of aphakic, pseudophakic or Artisan® implanted patients.

1. This software was used to simulate anterior and retropupillary implantations and measure the distances from the iris plane to the lens, obtaining an estimate of the SF (Holladay) and ACD constants. SF constant is the distance between the iris plane and the expected position for the lens and is directly related with the ACD constant (ACD = SF +3.74).

2. The effective lens position (ELP) was also calculated using the to the Hoffer Q formula and the measurement from the corneal apex to the anterior Artisan® implantation was compared. Retropupillary ELP was derived from measurements obtained from the simulation. Both methods produce similar values: ACD = 3.89, SF = 0.15 and A = 116.3. The manufacturer later provided an A-value of 116.8. The estimates obtained by the authors were used and the constant for immersion biometry was customized at the end of the study.

Surgical technique

23G PPV was carried out in all patients with the Constellation® console (Alcon Laboratories, Inc.) under retrobulbar anesthesia. The infusion trocar was placed in the inferior temporal position, and the remaining two trocars at 10 and 2 o’clock. Subluxated or dislocated lenses were released from vitreous adhesions by vitrectomy. Liquid perfluorocarbon was used to partially refloat the lens and protect the macula. The lens was removed by vitrectomy forceps and transferred to the anterior chamber. Complete vitrectomy was also performed in cases of aphakia. In all cases special attention was paid to the meticulous removal of the...
vitreous base. Pupillary constriction was induced with intracameral acetylcholine 1%. The incision was slightly shorter than 6 mm, compass calibrated, and always in the steepest meridian facilitated by topography. The lens was explanted using the double viscoelastic coat technique (except in the case of aphakia) and the Artisan® lens was inserted upside-down in order to avoid pupillary block. After the application of four suture stitches with 10/0 nylon, the lens was always implanted in the retropupillary position to keep it as far away from the endothelium as possible. Fixation was performed using a bimanual technique. Via a 1 mm paracentesis at 12 o’clock, the lens was held with vitrectomy forceps and moved to the retropupillary plane. Through another paracentesis located at 3 o’clock, or taking advantage of the incision if it matched the steepest meridian, a modified Sinskey hook (without its lower section) or a thin spatula was inserted, and the haptic was clamped by counterpressure, first in the 9 o’clock position and subsequently in the 3 o’clock position. The perfluorocarbon liquid, if used, and the trocars were removed. The procedure was completed with prophylactic intracameral ceftuxime and diluted 5% povidone-iodine in the conjunctival sac for 3 minutes (Figure 1).

In those cases in which the lens became unpinned, a second intervention was necessary. Our technique was simple: two 0.7 mm paracentesis are performed at 3 and 12 o’clock. The endothelium is protected with a double viscoelastic coat technique. An infusion trocar (to prevent collapse of the eye) and the trocar corresponding to the non-dislocated side were introduced. The latter was used to insert the endolight or a forceps to advance the lens so it could be grasped with the vitrectomy forceps located in the 12 o’clock paracentesis. The clamping procedure was then carried out via the 3 o’clock paracentesis. No suture is needed and the two opposing paracentesis did not affect the final astigmatism vector.

Postoperative results and analysis

Postoperative follow-up was performed the next day and after one week, with special attention to lens stability. The first suture was removed after one month depending on the induced astigmatism (SIA) quantified by topography. The remaining sutures were removed after 7 or 15 days according to the cylinder value. Refraction was measured after removal of the four suture stitches or when astigmatism was less than 1 D. Time since surgery (in days) was recorded and topography and macular OCT were performed. Six and 12 months after surgery, topography was repeated, Visante* was used to evaluate the lens position and determine anatomical measurements and an endothelial cell count was performed.

CDVA was registered in the decimal scale, but transformed to a logarithmic scale (logMAR) in order to make comparisons with the data existing in the scientific literature. SIA was calculated using the free utility software designed by doctors Saurabh Sawhney and Aashima Aggarwal, which is more effective than the subtractive method resulting from pre and postsurgical topographies (http://www.insighteyeclinic.in/SIA_calculator.php)

Incisions were classified into three groups: a) horizontal incision between 0° and 45° or 135° and 180°, b) vertical incision between 46° and 90° c) vertical incision between 91° and 134°. An incision of just under 6 mm is about 60°, so these are the possible study groups. The aim was to analyze whether the incisions in the steepest meridian compensated the effect of higher SIA induced by vertical incisions in relation to the horizontal meridian. In addition, the same data were also compared by eye to assess whether these customized incisions were affected by the proximity of the nose in the surgical field.

Distance calculations and statistical analysis

Quantitative variables were analyzed statistically using the Kolmogorov-Smirnov test for normal distribution. Subsequent tests included the Student t-test for independent samples, Mann-Whitney U for non-normal distribution, ANOVA for groups and Kruskal-Wallis for comparisons with n < 30, as appropriate. Analyses were carried out using the SPSS 15.0 package.

Finally, the distance to the endothelium if the lens had been implanted in the anterior instead of retropupillary position was calculated. Coherence tomography after
one year, distance from the endothelium to the lens, lens thickness, and posterior displacement in microns relative to the angle-to-angle distance were analyzed. This new distance can be established using a mathematical formula. Finally the constant was optimized for future implants.

RESULTS

The reasons for performing the procedures are shown in Figure 2; the aphakia group was smaller than the similarly-sized groups with subluxated or dislocated lenses. Surgical complications are summarized in Table 1. During surgery, bleeding occurred when clamping the lens in a patient treated with acenocoumarol, and there was one dislocation of the lens to the vitreous. Both cases were resolved during the same intervention without further incidents. In one case, accidental iridectomy occurred with the vitreotome during vitrectomy of the vitreous base. The implant was performed without further incidents by tilting the lens and attaching it at 4 and 10 o’clock.

There was post-surgical luxation of five lenses. This always occurred in the first week post-surgery and was always caused by failure of one single haptic. Failure occurred on the right (n = 3) or the left (n = 2), so no prevalence was detected in relation to the clamping side. This complication was resolved with the simple technique described above, but required a return to the operating room. None of the patients needed to repeat the procedure more than once. None of the lenses was entirely dislocated to the vitreous during the postoperative period (failure of both haptics), and no decentering or tilting was observed (Figure 3). Macular edema was never detected, either clinically or by OCT. Complications such as choroidal hemorrhage or retinal detachment did not occur.

Corneal stability permitting final refraction after careful removal of the sutures occurred at 59.9 days on average. The first suture was never removed before one month post-surgery and the remaining

Table 1. Complications from surgery

<table>
<thead>
<tr>
<th>Complication</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleeding during lens fixation</td>
<td>1</td>
<td>3.1</td>
</tr>
<tr>
<td>Intraoperative dislocation</td>
<td>1</td>
<td>3.1</td>
</tr>
<tr>
<td>Iridectomy due to vitreotome</td>
<td>1</td>
<td>3.1</td>
</tr>
<tr>
<td>Postsurgical subluxation</td>
<td>5</td>
<td>15.6</td>
</tr>
<tr>
<td>Macular edema</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 2. Etiology of procedures carried out. This combination technique can be extended to more indications than aphakia, the condition usually reported.

Figure 3. Example of posterior stability. The implant optic is perfectly centered. Correct iris fixation prevents tilting.
were removed one a week, following the steepest meridian of the topography. Mean CDVA achieved was 0.17 ± 0.33 logMAR (0.67 ± 0.27 decimal). Six patients had poor preoperative prognosis: one patient with age-related macular degeneration, the operated eye being his only eye; one patient with corneal leukoma; and four patients with diabetic retinopathy and secondary macular photocoagulation scars. This group had a CDVA of 0.85 ± 0.25 logMAR (0.14 ± 0.07). When this group with poor preoperative prognosis was excluded, the mean CDVA improved to 0.10 ± 0.06 logMAR (0.79 ± 0.11). As many as 81.25% of patients achieved a CDVA of at least 0.5.

The final spherical equivalent was 0.07 ± 0.59 D and 87.5% achieved ± 1 D.

The mean preoperative cylinder was −1.6 ± 1 D and postoperative cylinder −2.28 ± 1.1 D. Astigmatism calculated by subtraction was 0.69 ± 0.93 D, whereas the final astigmatism by vector analysis was 1.35 ± 0.57 D (range 0.43 to 2.62). Data relating to the location of the incisions are summarized in Table 2 for clarification of the impact of the vertical and the horizontal meridian. No significant differences between these groups were found (ANOVA, p = 0.941), and no significant changes were detected when these locations were compared by left and right eye (p = 0.563 and p = 0.925, respectively).

Endothelial cell loss was assessed comparing the data prior to surgery and the count after one year. Endothelial density prior to surgery was rather low, as only 6 patients had over 2000 cells/mm². This is described in Table 3 and compared with the final count.

Endothelial loss is detailed in Table 4, both by percentage and number of cells for the different study groups. There was a significant difference (p = 0.001) between interventions that required only implantation (aphakias), which show a loss of 6.2% and 76 cells in average, and interventions in which lens implantation is preceded by IOL explant (replacements, dislocated and subluxated lenses), the loss in these cases being 15.6% and 266 cells. No significant differences were found when all groups were compared (p = 0.054).

Finally, we analyzed the hypothetical final distance if, instead of the lens having been placed posteriorly, it had been placed in the anterior chamber (Figure 4). The hypothetical final distance between the front surface of the lens and the endothelium was calculated by subtraction, and found to be 2.79 ± 0.27 mm on average. Only eight lenses (25%) would have been located 3 mm from the endothelium, 18 lenses would have been placed between 2.5 and 3 mm, and 6 lenses would have been at a distance of less than 2.5 mm.

Since axial length (AXL) seems to be a criterion in the literature for posterior implant, we decided to

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Table 2. Astigmatism vector results by location

<table>
<thead>
<tr>
<th>Induced astigmatism</th>
<th>Prior cylinder</th>
<th>Cylinder after surgery</th>
<th>Induced astigmatism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>−1.6 ± 1 D</td>
<td>−2.28 ± 1.1 D</td>
<td>1.35 ± 0.57 D</td>
</tr>
<tr>
<td>Horizontal incision (between 0° and 45° or 136° and 180°)</td>
<td>−1.77 ± 1.44 D</td>
<td>−2.61 ± 1.11 D</td>
<td>1.34 ± 0.48 D</td>
</tr>
<tr>
<td>Vertical incision (between 45° and 90°)</td>
<td>−1.8 ± 1.03 D</td>
<td>−2.58 ± 1.07 D</td>
<td>1.34 ± 0.79 D</td>
</tr>
<tr>
<td>Vertical incision (between 90° and 135°)</td>
<td>−1.02 ± 0.23 D</td>
<td>−1.36 ± 0.69 D</td>
<td>1.43 ± 0.55 D</td>
</tr>
</tbody>
</table>

Table 3. Demographics by initial and final endothelial cell count

<table>
<thead>
<tr>
<th>Endothelial count (cells/mm²)</th>
<th>Patients at baseline</th>
<th>Patients at follow-up visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 2000</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>≥ 1500 and &lt; 2000</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>≥ 1000 and &lt; 1500</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>&lt; 1000</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

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analyze this parameter in our series. We quantified the ACD from endothelium to the anterior surface of the lens and found that ACD was 3.83 ± 0.32 in eyes with AXL < 24 mm, and 3.9 ± 0.27 when AXL was > 24. We found no significant difference (p = 0.553) between the two groups.

**DISCUSSION**

Implantation without capsular support is a surgical challenge and several techniques are available, such as suturing the lens to the sclera or iris, iris-embedded or intrascleral sutureless technique. The use of anterior chamber lenses with angular support has fallen significantly due to long-term complications such as endothelial decompensation, cystoid macular edema, secondary glaucoma and retinal detachment. Transscleral fixation protects the endothelium better but requires a longer surgical time, is technically difficult and complications such as tilting, decentration, choroidal hemorrhage, cystoid macular edema or retinal detachment are not uncommon. In a series comparing transscleral with posterior iris-claw (Hara et al.), the incidence of choroidal hemorrhage was 23.8% and cystoid macular edema 1%. Combination with posterior PPV allows for a proper management of the posterior cavity to avoid the risk of retinal rupture due to traction that can promote macular edema. The 23G PPV is the least invasive technique, and for this reason it was combined with the implantation.

**Table 4. Loss of endothelial cells (% and No.) by surgical implantation, or simultaneous explant and implant, detailed by groups.**

<table>
<thead>
<tr>
<th>Endothelial count (cells/mm²)</th>
<th>Baseline</th>
<th>Final</th>
<th>Loss %</th>
<th>Loss (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>1546 ± 422</td>
<td>1322 ± 360</td>
<td>13.6 ± 10.5</td>
<td>225 ± 221</td>
</tr>
<tr>
<td><strong>Implantation only (aphakia)</strong></td>
<td>1314 ± 274</td>
<td>1238 ± 291</td>
<td>6.2 ± 3.7</td>
<td>76 ± 49</td>
</tr>
<tr>
<td><strong>Removal + implant</strong></td>
<td>1611 ± 437</td>
<td>1345 ± 379</td>
<td>15.6 ± 10.9</td>
<td>266 ± 238</td>
</tr>
<tr>
<td><strong>Unsupported replacement</strong></td>
<td>1450 ± 185</td>
<td>1279 ± 163</td>
<td>11.8 ± 0</td>
<td>172 ± 22</td>
</tr>
<tr>
<td><strong>Subluxated IOL</strong></td>
<td>1585 ± 392</td>
<td>1389 ± 396</td>
<td>12.6 ± 8.8</td>
<td>197 ± 131</td>
</tr>
<tr>
<td><strong>Dislocated IOL</strong></td>
<td>1669 ± 526</td>
<td>1310 ± 406</td>
<td>19.7 ± 13</td>
<td>359 ± 316</td>
</tr>
</tbody>
</table>

p = 0.001 between interventions that required only implantation (aphakias) and interventions in which lens implantation is preceded by IOL explant. No significant differences were found between the groups (aphakia, unsupported replacement, subluxated IOL, dislocated IOL) p = 0.054.

Figure 4 Postoperative optical coherence tomography. Measurements analyzed in the study: pachymetry, distance from endothelium to the front surface of the lens and implant thickness.
of a retropupillary iris-claw lens in this study, and in another, currently ongoing, comparative study with the sutureless technique. Retropupillary implant was selected, as this is safer since it increases the endothelium distance. Van der Meulen et al. published favorable results of PPV with this implant and Riazi et al. combined these techniques in traumatic eyes.

In this study, as in other publications, the number of men (n = 24) was higher than the number of women (n = 8) (a proportion of 3:1 in our case). The reason for surgery was subluxated lenses in 37.5%, luxation to vitreous in 34.4%, aphakia in 21.9%, and lens replacement for which the available support was not sufficient in 6.3%. Vitreous around the lens was evident in 78%, so vitrectomy was indicated. In the case of aphakia, a partial vitrectomy had already been performed at the time of cataract extraction. This was insufficient in many cases and vitreous strands remained in the anterior chamber. The use of 23G PPV in these cases has proved very efficient. Trocar placement was simple and did not require any sclerotomy suture after the intervention. The vitreous, base included, could be completely removed, in contrast to the report by van der Meulen et al., and there was no retinal rupture. Furthermore, the placement of an active infusion trocar allows pressure to be maintained in the ocular globe.

This was closed just prior to implantation and then kept open for the rest of the procedure, depending on the surgeon's needs. Thus, the difficulties in fixation with iridodonesis mentioned by Acar et al. were resolved.

Complications after surgery with this method occurred in 6.14% of cases. Decentering or tilting problems did not occur, and the most frequent complication was subluxation of one haptic (15.6%), which always occurred within 15 days after surgery. No trend was observed for nasal or temporal location of the haptic or the eye operated. No subluxations or dislocations were observed after this period during the following year up to the scheduled follow-up visit. It was remarkable that macular edema was never detected, neither clinically nor by OCT, and complications such as choroidal hemorrhage or retinal detachment did not occur. Other authors investigating anterior implantation have reported complication rates of 6% (de Silva et al.) and 8.3% (Acar et al.). Gonnermann et al. reported rates of 8.7% in posterior implants, 13% in the case of posterior implant associated with keratoplasty, and 14.3% in children. The incidence of dislocation due to suture failure in transcleral implants ranges between 7.8 and 27.9%, and this is the cause of 57% of reinterventions. These rates appear similar, but in the case of complications, repositioning an iris-claw implant was simple, while in the case of tilting or subluxation due to scleral suture failure it was not. Repositioning can be carried out quickly and safely with the simple surgical procedure described in the Methods section.

The infusion trocar is positioned to prevent collapse of the eye, followed by the introduction of the second trocar next to the non-dislocated side. An endolight or a forceps to advance the lens is inserted through this second trocar so that it can be grasped by the vitrectomy forceps though the 0.7 mm paracentesis located in 12 o’clock position. The clamping procedure can be then carried out though the 3 o’clock paracentesis. No suture was needed and the two opposing paracentesis did not affect the final astigmatism vector.

Finally, a slight ovalization of the pupil occurred in 12.5% of our cases. Gonnermann et al. described this in 13% in posterior implants, and in 24.8% of adults, considered by the authors to be an acceptable complication considering the severity of the initial process. Hsing et al. report an incidence of 18.75% in posterior implant. It is noteworthy that ovalization ensures better clamping of the lens, and we have never observed dislocation in these eyes. Dislocations began to occur after the eighth patient, when we began to try to minimize ovalization. The key to achieving adequate fixation without ovalization is to use a very thin instrument. In our case, this is a Sinskey hook without the inferior section or a conventional spatula of the least possible thickness. Retropupillary fixation was then simple as it was affected by pressure.

No cases of macular edema were observed in this study. Thickening greater than 250 microns or individual increases of 50 microns were not detected either clinically or by serial tomography. Acar et al. also did not find increases in central macular thickness when PPV had been carried out before. Gonnermann et al. reported an incidence of 4.3% associated with keratoplasty and 8.7% in the case of aphakia. Van der Meulen et al. reported a rate of macular edema of 7.69% with PPV but the authors specified that the vitreous base had not been removed. De Silva et al. observed an incidence of 7.7%, and Shingleton et al. reported an incidence of 6.2%, always in cases with lens replacement. In the latter study, anterior vitrectomy was performed until no vitreous remained in the anterior chamber, and PPV was carried out only in cases with replacement of an IOL dislocated to vitreous. Lastly, the incidence of macular edema after lens sutured to sulcus may reach 7.69%. The difference in our series compared to published studies may be due to the careful removal of the vitreous, including the base. Technically, 23G PPV was the procedure of choice because it was less traumatic and very effective in terms of the tightness of the sutureless sclerotomy.

As for other complications, the main incidents reported by Shingleton et al. were hypotonia without leaking wounds, and a 4.9% incidence of choroidal detachment (CD). For their part, Riazi et al. also described a 5.5% incidence of CD, despite previous PPV. Rufer et al. reported a 20% incidence hypotony,
10% CD, and 10% hemovitreous. Chen et al. mentioned a retinal detachment rate of 2.78% in their series of iris-claw anterior implant, with a follow-up up to three years. De Silva et al. found an incidence of retinal detachment of 0.8%. Transscleral posterior chamber fixation is not without risks, such as vitreous hemorrhage and retinal ruptures.

However, these complications did not occur in our series. The combination of 23G PPV permits manipulations to be carried out in a closed space without globe distortions and without vitreous traction. Visualization of the posterior segment and peripheral retina was excellent, without the drawback of the iris-claw lens limiting mydriasis. In the opinion of the authors, the ability to control intraocular pressure by 23G PPV infusion is essential for managing this situation, as this control of the ocular tone was maintained at all times. Therefore, this should be a complementary procedure to implantation, and not just an option, when vitreous is visualized in the anterior chamber.

The incision for Artisan® lens implantation was just under 6 mm in length. This needs four corneal nylon 10/0 sutures and if these are carefully removed, astigmatism can be modulated. These sutures naturally lengthen the postoperative period. The average time to achieve wound stabilization and obtain final refraction was 59.9 days, and we believe that a foldable implant requiring a smaller incision may shorten this time significantly.

The average CDVA achieved was 0.17 ± 0.33 logMAR (0.67 ± 0.27 decimal). Excluding patients with poor previous prognosis, as described in the Results section, increased post-surgical CDVA to 0.10 ± 0.06 logMAR (0.79 ± 0.11). This outcome has been reported in several studies using different techniques that showed various degrees of success depending on the population and the technique. The results presented here are in line with the 0.17 logMAR (0.67 decimal) obtained in aphakic subjects by De Silva et al.

When eyes with previous pathology were excluded, these authors found an improvement in their results to 0.09 logMAR (0.81 decimal). Other studies, reported a CDVA of 0.24 logMAR (0.58 decimal), and 0.38 ± 0.31 logMAR (0.42 decimal). Acar et al. in their series with anterior implant after PPV, reported CDVA 0.37 ± 0.26 (0.43 decimal), while Chen et al. achieved 0.27 ± 0.18 logMAR (0.54 decimal). A series of children with posterior aphakias who received posterior implant achieved 0.13 ± 0.17 (0.74 decimal). Cleary et al., also in children, but with anterior implant, reported 0.04 ± 0.09 logMAR (0.91 decimal), and Kodjikian et al. achieved 0.1 logMAR (0.79 decimal) in adults with PPV and implant.

In the results presented in this study, as many as 81.25% of patients achieved a CDVA of at least 0.5. It was noteworthy that this outcome is rather variable in the literature and has steadily improved since the study by Güell et al. published in 2005, with percentages ranging from 31.25% to 87.5%, and several rates in between. In a study by Rao et al., a rate of 80% of patients achieving CDVA ≥ 0.5 rose to 85.3% if previous pathology was excluded. Finally, the comparative study of Farrahi et al. in which PPV followed by anterior or sulcus-sutured Artisan® lens implant was carried out, reported a CDVA of 0.24 ± 0.17 logMAR (0.58 decimal) in the iris-claw group versus 0.41 ± 0.22 logMAR (0.39 decimal) in the transscleral group. Furthermore, CDVA over 0.5 was achieved in 75% of the iris-claw patients versus 38% for the suture group. Menezo also reported better visual results with Worst implants than with sutured lenses. These results are encouraging and merit comparison with a sutureless method under the same protocol.

In this study, the final mean spherical equivalent was 0.07 ± 0.59 D and 87.5% of patients were in the range of ± 1 D. Riazi et al. reported 94.1% with a range of ± 2 D, and, Chen et al. achieved 0.24 ± 0.17 logMAR (0.58 decimal) in the iris-claw group versus 0.41 ± 0.22 logMAR (0.39 decimal) in the transscleral group. Furthermore, CDVA over 0.5 was achieved in 75% of the iris-claw patients versus 38% for the suture group. Menezo also reported better visual results with Worst implants than with sutured lenses. These results are encouraging and merit comparison with a sutureless method under the same protocol.

The refractive effect of a large incision of about 6 mm must be properly assessed. Kodjikian et al. reported 0.58 ± 0.99 D by the subtractive method, and the result obtained was 0.69 ± 0.93. This method may give an oversimplified interpretation of its real impact, and vector analysis of astigmatism may be more exact. In this respect, the vector of the mean SIA was 1.35 ± 0.57 D. It is important to indicate that in our study the incision was performed in the steepest meridian and not in the 12 o’clock position, as other authors have done. When the incision is customized, it should be carried out in the retropupillary direction and to fix it definitively via the paracentesis at 3 o’clock. Thus, the work here reported has been carried out in closed chamber, with pressurization of the eyeball as needed by 23G PPV infusion.

Upper incisions at 12 o’clock induce more astigmatism than horizontal incisions. The SIA was studied in three different angular locations as described in Methods. Since no significant differences between the different vertical, horizontal locations or the eye under study were found, it was considered that the formal and methodical incision in the steepest meridian, although technically more difficult, was more effective for neutralizing the effect of inducing greater SIA in vertical meridians. Compared with our phacoemulsification SIA (SIA induced by 3.2 mm...
incisions is 0.8 ± 0.61 D, 0.67 ± 0.38 D by 2.8 mm, and 0.42 ± 0.17 D with MICS and 1.7 mm incision) the final vector was acceptable. We hope that a foldable implant that allows a shorter corneal incision will soon be available, so our results can be balanced out.

Endothelial cell density of these patients was not very high, as they had already undergone at least one previous surgical procedure. Mean density was 1546 ± 422 cells/mm² and six patients (18.75%) had less than 1000 cells/mm². Therefore the use of double viscoelastic coat techniques is crucial. Despite this effort, the loss was 13.6% and 225 cells on average. This result is in line with the levels reported by Jehan et al. (23.87%) and Kodjikian et al. for simultaneous PPV and anterior implant (14% ± 16 per year). There was a significant difference between interventions that require implantation only (aphakias) and interventions that include IOL explantation and lens implantation, the loss being higher in the latter. Cell loss increased steadily over the four groups, from aphakia to replacement, subluxation and dislocation. This suggests that aphakia is the best scenario, although no significant differences were found between the groups, probably because too many subdivisions were made.

The better performance of the aphakia group may be attributed to less manipulation, because only implantation was carried out in this group, while the rest required lens removal followed by implantation in the same procedure. Most implants without capsular support reported in the literature were performed in aphakia and the addition of 23G PPV should not impact the outcome. Endothelial cell loss in aphakia has been widely quantified. Güell et al. reported a loss of 7.78% in the first year with anterior implantation. Gonnermann et al. found a loss of 6.4% in posterior implantation in children. Ravalico et al. reported a greater loss in patients who required a second procedure compared to those with primary implantation. Riazi et al. reported a loss of 8.1%. This group performed PPV in all their trauma patients, and implantation took place after a minimum of six months. Chen et al. described a loss of 8.38% after one year and 9.78% after three years of follow-up, while Rao et al. found a loss of 8.1% at six months, and Koss et al. 10.5% at 22 months. Also in this line, Cleary et al. reported an average of 14.2% loss at 28 months, and Siddiqui et al. 17.1% at nine months. Endothelial loss in transcleral IOL fixation has been found to be 11.7% at three months.

Compared with our phacoemulsification data, where endothelial loss at one year after cataract surgery of LOCS3 grade 4-5 cataracts with coaxial technique was 24.6 ± 13.4, and 16.3 ± 10.9 when the surgical technique was bimanual MICS, the impact of secondary implant without capsular support is similar to that of phacoemulsification of hard cataracts. However, it is necessary to keep in mind that these patients have undergone a previous procedure and endothelial cell count is lower than in naïve eyes.

It seems that the most severe endothelial deterioration occurs during surgery but Saxena et al. demonstrated a significant negative correlation between cell loss and the ACD constant in phakic eyes, this loss being maintained over time. Furthermore, the Doors model for phakic implants predicts endothelial loss related to the distance between the lens and the endothelium, showing that the lens was safer the further away it was from the endothelium. Kim et al. reported a significant decrease in the superior endothelial cell density relative to the central area, just where the distance between the lens and endothelium was shorter. This occurs when the changes associated with the incision have already been compensated and suggests long-term chronic damage.

In order to fix the lens as far as possible from the endothelium, the option has been the retropupillary implant. However, there is interest in knowing the hypothetical distance to the endothelium if it had been placed anteriorly. In the interesting study by Sminia et al. in anterior implants in children, long-term endothelial density was comparable in groups of the same age. However, wide disparity was found, and it may be suspected that the distance between lens and endothelium was not quantified. In the present case, this was determined using Visante®, and the distance to the lens, its thickness and the crystalline lens rise distance from the angle-to-angle line were analyzed and determined for each case. This is the same procedure used by Koss et al. for their determinations in 18 cases of anterior implant; determined by Visante®, the average distance from the endothelium to the lens was 2.87 ± 0.34 mm, temporal distance was 2.34 ± 0.29 mm, and nasal distance 2.38 ± 0.3 mm. As stated in the Results section, it was found the hypothetical final distance to be 2.79 ± 0.27 mm on average, and only eight lenses (25%) would have been placed 3 mm or further from the endothelium, 18 between 2.5 and 3 mm and six lenses at less than 2.5 mm. These measurements were from the lens to the central corneal endothelium and the peripheral distance is smaller. Obviously, each surgeon will assess the distance that affords sufficient safety, although retropupillary fixation to the endothelium is more conservative and this choice is not deterred by technical complications.

In a series of 16 cases, Koss et al. suggest that eyes with AXL shorter than 24 mm have a smaller ACD, and this could be a criterion for posterior implant. In our series of 32 cases, a slightly higher ACD in eyes with AXL > 24 mm (3.9 ± 0.27) was found. However, the difference compared to eyes with AXL > 24 mm (3.83 ± 0.32) was not significant, so we do not believe that AXL is a criterion for deciding on anterior or posterior implant.
Finally, we customized the A-constant according to our data. Gonnermann et al.\textsuperscript{25} assumed a constant of $A = 117.0$ for retropupillary implant and quoted the manufacturer's constant as $A = 116.9$. Mohr et al.\textsuperscript{21} used $A = 116.8$ and Hsing et al.\textsuperscript{20} $A = 117.0$. The calculations obtained with the two methods used to simulate retropupillary ELP, indicated the following: $SF = 0.15$ and $A = 116.3$. Currently, we use this value for immersion biometry according to the customization method reported elsewhere.\textsuperscript{54}

In conclusion, and pending the results of a comparative study with sutureless transscleral lenses, the technique described here is safe, effective and predictable. Its major complication is early dislocation of one haptic and, although this is easy to solve, it also requires additional surgery. Combination with transconjunctival sutureless vitrectomy provides excellent treatment of the posterior cavity, and no macular edema or other major complications occurred. Endothelial cell loss equals that of phacoemulsification of hard cataracts. Refractive results were better than those initially expected; since an incision close to 6 mm would cause a greater astigmatism vector. However, a foldable lens implanted through a smaller incision would be a breakthrough in this surgical solution to the range of situations of aphakia and dislocated lens.

REFERENCES


