Phakic Collamer Lens (ICL) Implantation Followed by Excimer Laser Treatment (Bioptics) to Correct Hyperopia with Astigmatism

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PURPOSE: To evaluate the efficacy and safety results of excimer corneal surgery following posterior chamber phakic Implantable Collamer Lens (Bioptics) to treat hyperopia with astigmatism.

SETTING: Fernández-Vega Ophthalmological Institute, Oviedo, Spain.

METHODS: This cohort study included 62 eyes who underwent ICH V3 implantation followed by photorefractive keratectomy (PRK) and laser in situ keratomileusis (LASIK) to treat residual refractive errors (mainly astigmatism). Mean follow-up was 9.3±4.7 months after laser ablation (range 1 to 29 months).

RESULTS: Preoperatively the average manifest refractive sphere (MRSE) was 5.73±1.79 diopters (D) (range 1.50 to 11.00) and manifest refractive cylinder (MRCYL) was –2.07±1.03 D (range –4.00 to 0.00). Following ICH implantation, the mean spherical equivalent (SE) was –0.07±0.09 D (range –2.88 to 0.75 D); after laser treatment the mean MRSE was –0.01±0.08 D (range –0.5 to 0.25) and MRCYL was –0.19±0.36 D (range –1.50 to 0.00). The mean UDVA was at least 20/25 in almost 70% of laser-treated eyes; over 90% of the eyes achieved UDVA of 20/32 or better. No eye lost ≥2 lines of preoperative CDVA and a loss of 2 lines of UDVA after laser treatment compared to the CDVA after ICH implantation was noted in 4 (6.5%) eyes. After bioptics all eyes were within ±1.00 D and 60 eyes (96.8%) within ±0.50 D of SE.

CONCLUSION: Bioptics procedure combining posterior chamber phakic IOL implantation and corneal refractive surgery showed to be a safe procedure to treat hyperopia associated with astigmatism.


INTRODUCTION

The improvements in excimer laser technology made hyperopic excimer refractive surgery a valuable option for hyperopia correction. However, despite the good visual and refractive outcomes of excimer laser photorefractive keratectomy (PRK) and laser in situ Keratomileusis (LASIK) treatments, they are more effective and stable for the correction of low degrees of hyperopia than high hyperopia¹⁻⁷. Refractive regression⁸,⁹ and significant increase in ocular and corneal aberrations¹⁰,¹¹ have been reported.

The Implantable Collamer Lens (Visian ICL; STAAR Surgical, Nidau, Switzerland) is a foldable phakic intraocular lens (pIOL) designed to be placed in the posterior chamber behind the iris with the haptic zone resting on the ciliary sulcus and has demonstrated to be safe and effective among various clinical settings¹²⁻¹⁶, including hyperopia correction¹⁷⁻²⁰. Currently, toric
ICL implants to correct hyperopia with astigmatism are still not available, and therefore, the pIOL could only correct the spherical component of the refractive error and as a result coexisting astigmatic error had to be treated by either keratorefractive procedure. Combined phakic IOL implantation and corneal refractive surgery was initially described by Zaldivar et al\textsuperscript{21} who termed the use of LASIK after pIOL implantation \textit{bioptics} to treat extreme myopia and myopia combined with astigmatism. However, to our knowledge there are no reports on bioptics to treat residual refractive error after hyperopic ICL. With the present study we assessed the efficacy and safety results on bioptics with ICL implantation to treat hyperopia with astigmatism.

**PATIENTS AND METHODS**

The study population comprised 62 eyes of 35 patients who underwent PRK or LASIK for the correction of residual refractive errors after implantation of a Collamer pIOL for hyperopia correction (ICL) at the Fernández-Vega Ophthalmological Institute (Oviedo, Spain) between February 2005 and April 2009. At the time of the surgery, all patients were fully informed of the details and possible risks of the surgical procedures. Written informed consent was obtained from all patients before surgery in accordance with the Declaration of Helsinki and an institutional review board approved the study.

The inclusion criteria for ICL implantation were corrected distance visual acuity (CDVA) of 20/50 or better, stable refraction and clear central cornea. The exclusion criteria included age <22 years, anterior chamber depth <2.8 mm, endothelial cell density (ECD) <2000 cell/mm\textsuperscript{2}, cataract, history of glaucoma or retinal detachment, macular degeneration or retinopathy, neuro-ophthalmic diseases and history of ocular inflammation. Before the ICL implantation, patients had a complete ophthalmologic examination, including manifest and cycloplegic refraction, keratometry, corneal topography and pachymetry using the Orbscan II (Bausch & Lomb, Rochester, NY), ECD (SP 3000P; Topcon Europe Medical, Netherlands), slit-lamp examination, refraction, ECD, fundus examination, intra-ocular pressure (IOP) and central separation between the lens anterior surface and the posterior surface of the ICL (Vault). For averaging, visual acuities were converted to logMAR values; then, the means and standard deviations were back calculated to Snellen acuity. Sphero-cylindrical refractive results were converted into vectors expressed by three dioptic powers: M, J\textsubscript{0}, and J\textsubscript{45}; with M being equal to the spherical equivalent (SE) of the given refractive error, and J\textsubscript{0} and J\textsubscript{45} the two Jackson crossed cylinders equivalent to the conventional cylinder. Manifest refractions in conventional script notation (S [sphere], C [cylinder], · [axis]) were converted to power vector coordinates and overall blurring strength using the formulas described by Thibos and Horner\textsuperscript{24}: M = S+C/2; J\textsubscript{0} = (–C/2)*cos (2\(\alpha\)); J\textsubscript{45} = (–C/2)*sin (2\(\alpha\)) and B = (M\textsuperscript{2} + J\textsubscript{0}\textsuperscript{2} + J\textsubscript{45}\textsuperscript{2})\textsuperscript{1/2}.

**ICL size and power calculation**

All eyes were implanted with a model ICHV3 (STAAR Surgical, Nidau, Switzerland). The ICL size was individually determined based on the horizontal white-to-white distance and anterior chamber depth (ACD) measured with Orbscan II (Bausch & Lomb, Rochester, NY) following the manufacturer’s recommendations. Power calculation for the ICL was performed using the software ICL power table provided by the manufacturer using a modified vertex formula. The ICL surgical procedure was the same as the one previously reported by the authors\textsuperscript{22,23}.

**Laser surgery**

LASIK or PRK were performed at least 3 months after ICL surgery and every eye showed a stable refraction and corneal topographic pattern for at least 3 months before performing LASIK or PRK, both surgeries were carried out by the same surgeon (JFA).

LASIK was performed in 50 eyes and PRK in 12 eyes depending on the corneal thickness and ablation depth of each patient.

In the case of myopic astigmatism, ablation was performed in the steepest meridian (negative cylinder ablation). In the case of mixed astigmatism, half of the ablation was performed in the steep meridian (negative cylinder ablation) and half in the flat meridian (positive cylinder ablation), the so-called cross-cylinder technique.

All surgical procedures were uneventful and without post-surgical complications within the follow-up time presented in this study.

**Postoperative Assessment**

Both after pIOL surgery and after LASIK/PRK all the patients fulfilled the follow-up protocol in which the examination visits were carried out at Day 1, Week 1, and Month 1, and then every 3 months as necessary. Data obtained in each postoperative follow-up visit included uncorrected distance visual acuity (UDVA), CDVA, slit-lamp examination, refraction, ECD, fundus examination, intra-ocular pressure (IOP) and central separation between the lens anterior surface and the posterior surface of the ICL (Vault). For averaging, visual acuities were converted to logMAR values; then, the means and standard deviations were back calculated to Snellen acuity. Sphero-cylindrical refractive results were converted into vectors expressed by three dioptic powers: M, J\textsubscript{0}, and J\textsubscript{45}; with M being equal to the spherical equivalent (SE) of the given refractive error, and J\textsubscript{0} and J\textsubscript{45} the two Jackson crossed cylinders equivalent to the conventional cylinder. Manifest refractions in conventional script notation (S [sphere], C [cylinder], · [axis]) were converted to power vector coordinates and overall blurring strength using the formulas described by Thibos and Horner\textsuperscript{24}: M = S+C/2; J\textsubscript{0} = (–C/2)*cos (2\(\alpha\)); J\textsubscript{45} = (–C/2)*sin (2\(\alpha\)) and B = (M\textsuperscript{2} + J\textsubscript{0}\textsuperscript{2} + J\textsubscript{45}\textsuperscript{2})\textsuperscript{1/2}.

Data analysis was performed using SPSS for Windows version 16.01 (SPSS Inc. Chicago, IL). Normality of data was checked by Kolmogorov-Smirnov test and analyzed using the Wilcoxon rank sum test, or analysis of variance with multiple comparisons correction where appropriate, to explore statistical differences for refractive and visual acuity scores.
among different follow-up visits. Bivariate correlations between attempted versus achieved refraction were analyzed using a non-parametric (Spearman’s coefficient) correlation analysis. Differences were considered to be statistically significant when the $p$ value was $<0.05$.

**RESULTS**

The mean age of the 35 patients, 19 women (54.3%) and 16 men (45.7%), was 27.6 years ± 4.3 (SD) (range 20 to 40 years). The mean interval between ICL surgery and LASIK /PRK was 4.9± 3.9 months (range 3 to 19 months). Fifty-one eyes had residual myopia or myopic astigmatism, 11 eyes had mixed astigmatism after ICL surgery. Mean follow-up after laser treatment was 9.7±7.4 months (range 3 to 27 months). Table 1 shows the preoperative patient demographics and ICL characteristics.

**Refractive outcomes**

The overall change in manifest refraction is shown in Figure 1. Prior to ICL implantation, the mean manifest refractive sphere was 5.73±1.79 D (range 1.50 to 11.00 D) and the mean manifest refractive cylinder was $-2.07±1.03$ (range $-4.00$ to 0.00 D). At the latest follow-up visit following laser treatment the mean manifest refractive sphere was $-0.01±0.08$ (range $-0.50$ to 0.25 D) and manifest refractive cylinder was $-0.19±0.36$ (range $-1.50$ to 0.00 D). The distribution of the refractive components after vector conversion before and after the different laser treatments is shown in table 2. No statistically significant differences existed in the M, $J_0$ or $J_{45}$ components among patients undergoing either laser procedure. The power vector magnitude was reduced either after ICL surgery or after different laser treatments and the mean value in all components of refraction after laser surgery were neither clinically nor statistically significant between the different laser procedures ($P>0.05$, Kruskal-Wallis test for all vector components of refraction). Figure 2 shows the astigmatic components of the power vector as represented by the 2-dimensional vector plot ($J_0$, $J_{45}$). The dispersion

![Figure 1. Time course of the Manifest refractive sphere (MRSE) and cylinder (MRCYL) in diopters (D) after laser surgery.](image)

**Table 1.** Descriptive statistics for demographic data of patients and characteristics of implanted Hyperopic Implantable Collamer Lens

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Mean SD</th>
<th>Range [Min, Max]</th>
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<tbody>
<tr>
<td>Refractive sphere (D)</td>
<td>5.73 1.79</td>
<td>[1.50,11.00]</td>
</tr>
<tr>
<td>Refractive cylinder (D)</td>
<td>$-2.07$ 1.03</td>
<td>[$-4.00$,0.00]</td>
</tr>
<tr>
<td>Flat keratometry</td>
<td>41.2 1.9</td>
<td>[36.5,45.8]</td>
</tr>
<tr>
<td>Steep keratometry</td>
<td>43.3 2.0</td>
<td>[39.0,47.8]</td>
</tr>
<tr>
<td>ICL size (mm)</td>
<td>12.00 0.30</td>
<td>[11.5,12.5]</td>
</tr>
<tr>
<td>ICL sphere (D)</td>
<td>8.4 2.7</td>
<td>[3.0,14.0]</td>
</tr>
<tr>
<td>ECC (cells/mm²)</td>
<td>2775 313</td>
<td>[2105,3377]</td>
</tr>
<tr>
<td>White-White (mm)</td>
<td>11.9 0.4</td>
<td>[11.0,12.9]</td>
</tr>
<tr>
<td>ACD (mm)</td>
<td>3.0 0.2</td>
<td>[2.8,3.4]</td>
</tr>
<tr>
<td>CCT (µm)</td>
<td>538 54</td>
<td>[410,640]</td>
</tr>
</tbody>
</table>

D: diopters; ICL: Implantable Collamer Lens; ACD: anterior chamber depth; ECC: endothelial cell count; CCT: central corneal thickness.

<table>
<thead>
<tr>
<th>Table 2. Mean values and standard deviation (SD) of components of vectorial decomposition of refraction before and at different follow-up times after surgery</th>
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<tbody>
<tr>
<td><strong>Pre-operatively</strong></td>
</tr>
<tr>
<td>M</td>
</tr>
<tr>
<td>LASIK</td>
</tr>
<tr>
<td>4.9±1.6</td>
</tr>
<tr>
<td>3.8±2.0</td>
</tr>
<tr>
<td>PRK</td>
</tr>
<tr>
<td>0.085</td>
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SD: Standard deviation.
* Independent-Samples Kruskall-Wallis Test.
of preoperative data and its concentration around the origin (0,0 coordinates) is apparent at the last follow-up visit after Laser treatment. Sixty eyes (96.8%) were within ±0.50 D for the M component and all eyes were within ±1.00 D of the desired refraction ($r^2=0.99$ for attempted vs. achieved correlation analysis), while for astigmatic components, 56 (90.3%) and 60 (96.8%) eyes were within ±0.50 D and 61 (98.4%) and 62 (100%) were within ±1.00 D, for $J_0$ ($r^2=0.95$) and $J_{45}$ ($r^2=0.98$), respectively, as shown in Figure 3.

**Visual Outcomes**

The change in uncorrected (UCVA) and corrected (CDVA) distance visual acuity (decimal notation) is summarized in Figure 4. Mean preoperative UDVA was $0.39\pm0.22$ Snellen lines and it was 20/200 or better in all 62 eyes. Following phakic IOL implantation it significantly improved in all but 1 eye ($P<0.01$, Wilcoxon Test); the mean UDVA was $0.67\pm0.28$ with 91% eyes achieving at least 20/63 or better (Figure 5). Following excimer laser treatment the UDVA improved in all eyes. It was at least 20/40 in 58 (93.5%) eyes and 20/25 or better in 43 (69.4%) eyes ($P<0.01$, Wilcoxon Test). Preoperative mean CDVA was $0.84\pm0.21$ and it was equal to or better than 20/40 in 58 eyes (93.5%) and equal to or better than 20/20

![Figure 2. Scatter plot of the astigmatic vectors ($J_0$ and $J_{45}$) before and after Biopics treatment. The more central location of postoperative data represents the reduction of preoperative astigmatism.](image)

![Figure 3. Plots of achieved against attempted correction (predictability) as spherical equivalent (M) and the astigmatic components ($J_0$ and $J_{45}$) in diopters (D) at the last follow-up visit after biopics treatment. Coefficients of determination ($r^2$) are 0.99, 0.95 and 0.98 for M, $J_0$ and $J_{45}$, respectively.](image)

![Figure 4. Changes in mean decimal visual acuity over the entire follow-up period after ICL implantation and laser surgery.](image)

![Figure 5. Preoperative cumulative UDVA Snellen acuity versus postoperative UDVA after pIOL implantation and after Laser surgery.](image)
in 25 eyes (40.3%) (Figure 6). Following phakic IOL implantation the mean CDVA was 0.81±0.20 Snellen acuity and it was equal to or better than 20/40 in 59 (95.2%) eyes and 20/20 or better in 20 (32.3%) of eyes. After laser treatment the mean CDVA was 0.84±0.18 (p=0.632, Wilcoxon Test) and it was at least 20/25 in 45 (72.6%) eyes and 20/20 or better in 21 (33.9%) eyes. Changes in CDVA (safety) over the follow-up and the changes of CDVA after IOL implantation when compared with UDVA after laser treatment are shown in Figure 7. After phakic IOL implantation 1 (1.6%) eye had lost more than 2 lines of CDVA, 6 eyes (9.7%) had lost 2 lines, 17 eyes (27.4%) had lost 1 line and 38 eyes (61.3%) had no change or improved CDVA from preoperatively. After laser treatment, no eyes lost more than 2 lines of preoperative CDVA, 5 (8.1%) eyes lost 2 lines and 10 eyes (16.1%) lost 1 line while 47 (75.8%) eyes maintained or gained lines of visual acuity. Both the safety index (ratio of postoperative CDVA to the preoperative CDVA) and the efficacy index (ratio of postoperative UDVA to the preoperative CDVA) significantly improved after laser treatment (P>0.05, Wilcoxon Test for both indexes); they were 1.04±0.21 and 0.99±0.20, respectively.

Despite the improvement in UDVA after laser treatment, when compared with CDVA after ICL implantation a loss of >2 lines of visual acuity was noted in 1 (1.6%) eye. Furthermore, a gain of 1 line was noted in 13 (21%) eyes and a gain of 2 lines was observed in 5 (8.1%) laser treated eyes.

**Adverse Events**

There were no intraoperative complications. No ICL required explantation or repositioning, and no ICL was decentred. There were no cases of pupillary block or anterior subcapsular cataract. No eye had chronic increased postoperative intraocular pressure (IOP); 1 eye had a mild, transient increase in IOP up to 25 mmHg that did not require treatment. We did not observe dislocation or decentration of the ICL and no dehiscence of the ICL incision due to laser treatment was observed either.

**DISCUSSION**

In this prospective study with 62 eyes, high levels of safety, efficacy and predictability were achieved for the combined use of a posterior chamber phakic IOL and LASIK or PRK (biopics) in eyes with hyperopia and astigmatism. After laser treatment, all eyes were within ±1.00 D of the predicted correction and nearly 97% were within ±0.50 D. Hyperopia and astigmatism was reduced from a mean +5.73 ± 1.79 D and –2.07±1.03 D to –0.01 ± 0.08 D and –0.19±0.36 D, respectively, and astigmatic components (J0, J45) showed values over 95% within ±1.00 D in all eyes (Figure 3 middle and bottom). Moreover, we have observed good visual outcomes in relation to the safety index (over 1.00) and the efficacy index (about 1.00) with about 75% of eyes maintaining or gaining several lines of CDVA.

In 1999, Zaldívar et al21 presented the results of combining ICL implantation and LASIK in 67 myopic eyes with SE of at least –18.00 D or with high levels of astigmatism. Fifty-seven eyes (85%) were within ±1.00 D of emmetropia and 45 (67%) within ±0.50 D; fifty-one (76%) eyes gained 2 or more lines of CDVA and no eyes lost 2 or more lines of CDVA after ICL implantation. Three months after LASIK or PRK, the mean SE was within ±1.00 D in 97.2% of eyes and within ±0.50 D in 83.7%. Arne et al26 report a series of 32 eyes of 28 patients, (preoperative SE was
astigmatism surgically induced after ICL implantation.

Similar results following ICL implantation; a significant improvement was seen in 2 eyes (8%) and postoperative CDVA was seen in 2 eyes (8%) and 20/40 or better in 15 eyes (63%). In the U.S. Food and Drug Administration’s (U.S. FDA) trials, a Phase I study was initially published in 1999 including 10 hyperopic patients with hyperopia who had implantation of an ICL. Preoperatively, the mean SE was +5.78 ± 2.54 D; it was within ±0.50 D in 81% of eyes, within ±1.00 D in 96%, and within ±1.50 D in 100% and 86.5% had a change in SE refraction within ±0.50 D during follow-up. The CDVA was reduced by 1 Snellen line in 8.3% of eyes and the UCVA was 20/20 or better in 49.8% of eyes, 20/40 or better in 87.6%, and 20/70 in 100%. In the present study, we obtained similar results following ICL implantation; a significant reduction in the manifest refractive sphere, nearly emmetropia and a reduction of about 0.57 D in astigmatism that may be explained by the change in corneal astigmatism surgically induced after ICL implantation.

In the present study we observed that after ICL implantation, 17 (27.4%) eyes lost at least 1 line of CDVA; 6 (9.7%) lost 2 lines and 1 (1.6%) eye lost more than 2 lines (Figure 6). However, this effect has been partially corrected after LASIK or PRK and it returned to the preoperative levels after laser enhancement (Figure 6); at the end of the biopics procedure, 5 (8.1%) eyes lost 2 lines of CDVA but no eye lost 2 or more lines. The loss of CDVA after ICL implantation observed in this study could be explained by the decrease in the size of the retinal image that is produced in eyes with high hyperopia corrected by pIOLs in addition, a cornea with high astigmatism causes greater distortion of the retinal image than a cornea with low astigmatism. When LASIK or PRK is performed for the correction of astigmatism, it is common to observe an increase in CDVA after surgery. Thus, a reduction in the amount of astigmatism through corneal refractive procedures such as LASIK/PRK can be also successfully used in eyes with high hyperopia and astigmatism.

The safety and efficacy of ICL implantation to correct hyperopia was well established in several published studies. Davidorf et al in 1998 described the implantation of the Visian ICL lens in 24 hyperopic eyes with a mean SE of +6.51 ± 2.08 D (range, +3.75 to +10.50 D). After a mean follow-up of 8.4 months, the postoperative SE was –0.39 ± 1.29 D (range, +1.25 to –3.88 D), with 79% (19 eyes) within ±1.00 D and 58% (14 eyes) within ±0.50 D of emmetropia. One eye lost 2 or more lines of CDVA due to a progressive neovascular glaucoma, which was precipitated by an episode of postoperative pupillary block, while a gain of two or more lines of CDVA was seen in 2 eyes (8%) and postoperative UDVA was 20/20 or better in 2 eyes (8%) and 20/40 or better in 15 eyes (63%). In the U.S. Food and Drug Administration’s (U.S. FDA) trials, a Phase I study was initially published in 1999 including 10 hyperopic eyes with a SE range of +2.50 to +10.875 D. Six months postoperatively, the SE was +0.20 ± 0.61 D (range, –0.50 to +1.50 D). Eight out of 10 eyes (80%) were within ±0.50 D of emmetropia, 9 eyes (90%) were within ±1.00 D. There were no complications reported, with all eyes seeing 20/40 or better UDVA. In 2002, as part of the U.S. FDA Phase III clinical trial, Bloomenstein et al reported on 20 eyes, (preoperative SE of +5.55 D), and postoperatively, the mean SE was +0.06, with more than 80% of the eyes having an uncorrected visual acuity of 20/40 or better. Recently Pesando et al reported the results of a 10-year follow-up study on 59 eyes of 34 patients with hyperopia who had implantation of an ICL. Preoperatively, the mean SE was +5.78 ± 2.54 D (range +2.50 to +11.75 D). At 10 years, the mean SE was +0.0 ± 0.54 D; it was within ±0.50 D in 81% of eyes, within ±1.00 D in 96%, and within ±1.50 D in 100% and 86.5% had a change in SE refraction within ±0.50 D during follow-up. The CDVA was reduced by 1 Snellen line in 8.3% of eyes and the UCVA was 20/20 or better in 49.8% of eyes, 20/40 or better in 87.6%, and 20/70 in 100%. In the present study, we obtained similar results following ICL implantation; a significant reduction in the manifest refractive sphere, nearly emmetropia and a reduction of about 0.57 D in astigmatism that may be explained by the change in corneal astigmatism surgically induced after ICL implantation.

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Studies of hyperopic PRK and hyperopic LASIK surgery showed similar outcomes in terms of residual ametropia (<1.00 D), and predictability (about 50% within ±0.50 D; about 70% within ±1.00 D). Sources of variability between them may include differences in the ablation zone parameters and the ablation profile between the lasers; differences in the nomograms used may account for the variation in the reported results. A similar behavior regarding predictability and regression of refractive effect is also observed, with acceptable efficacy for corrections up to +4.00 D, but limited predictability for higher dioptric corrections, and a modest hyperopic regression of about 0.50 D during follow-up. In the present study we observed better results of predictability with the biopics approach when compared with similar studies using hyperopic PRK or LASIK. This may be explained by the fact that to calculate the power of the phakic IOL to be implanted, we considered only the spherical part of the refraction with the cylinder in negative sign, as astigmatism was corrected by laser in a second step. Doing this, after phakic IOL implantation, most eyes in this study presented myopic or mixed astigmatism that was corrected by myopic LASIK/PRK, which is superior to hyperopic LASIK/PRK in efficacy and predictability as well as having a perfect centration that is also even more critical in hyperopic LASIK.

Increased intraocular pressure, pupillary block, and cataract formation, have been the most documented safety concerns related to ICL implantation. Allegedly, the risk is higher in hyperopic eyes than in myopic eyes because of the more crowded anterior segments. However, the incidence rate seems to be lower in hyperopic ICLs. In the present study, there were no cases of chronic elevated postoperative IOP or cataract development. Furthermore, LASIK and PRK did not cause dislocation or decentration of the ICL and there was no dehiscence of the ICL incision.
The goal of refractive surgery is to achieve emmetropia through any corrective procedure and therefore the existence of toric IOLs became a need. However, while hyperopic toric ICLs are not available, bioptics using the hyperopic ICL followed by LASIK or PRK offers a safe and effective method for correcting moderate to high hyperopia with or without astigmatism. Bioptics reduced preoperative spherical and astigmatic errors with high predictability and safety. However, more time and investigation are needed to draw conclusions about the mechanisms of cataract formation and refractive regression in ICL implanted hyperopic eyes.

REFERENCES