Phakic Intraocular Lens Implantation in United States Military Warfighters: A Retrospective Analysis of Early Clinical Outcomes of the Visian ICL

MAJ Gregory D. Parkhurst, MD; LTC Maximilian Psolka, MD; Guy M. Kezirian, MD, FACS

ABSTRACT

PURPOSE: To assess short-term clinical outcomes after implantation of phakic intraocular lenses (Visian ICL, STAAR Surgical Co) in US military warfighters who are not good candidates for laser vision correction.

METHODS: A retrospective interventional consecutive case series analysis of all eyes that underwent ICL surgery during a 14-month time period was performed. Main outcome measures included indications for surgery, efficacy, predictability, and early adverse events.

RESULTS: Three-month postoperative visual data were available for 135 eyes of 69 patients who underwent ICL implantation during the study period. Indications included abnormal corneal topography (37%), thin predicted residual bed following LASIK (32%), history of dry eye (13%), thin corneal thickness (11%), or other (7%). Mean patient age was 30.9 ± 6.6 years. Mean preoperative spherical equivalent refraction was −6.00 ± 1.92 diopters (D) (range: −2.63 to −11.50 D). Three months postoperative, uncorrected distance visual acuity of 20/20 or better was found in 129/135 (96%) eyes and 91/135 (67%) were 20/15 or better. Manifest refraction and corrected distance visual acuity (CDVA) data were available for 128 eyes. Forty-two (33%) eyes had improvement of one or more lines of CDVA. One hundred fifteen eyes (90%) were within ±0.50 D of emmetropia, and predictability within ±0.75 D was found in 127/128 (99%) eyes. No significant intra- or postoperative complications were observed.

CONCLUSIONS: This retrospective analysis of 3-month outcomes suggests that Visian ICL implantation in myopic warfighters provides excellent refractive and visual results. Further study is needed to evaluate long-term results. [J Refract Surg. 2011;27(7):473-481.]

doi:10.3928/1081597X-20110106-03

The United States Army Warfighter Refractive Eye Surgery Program (WRESP) was designed to reduce the limitations posed by corrective eyewear in combat arms soldiers. Refractive surgery is offered as an elective procedure to service members. It is authorized, but in no way mandated, by military commanders.

At the Fourth Annual International Military Refractive Surgery Conference, it was reported that >160,000 service members have had successful corneal refractive excimer laser surgery from several centers across the United States Department of Defense as of 2009.1-3 Prior reports of outcomes from the US Army WRESP have shown excellent outcomes and improved overall battle readiness of service members with minimal complications or negative impact on military operations.4 However, there remains a contingent of servicemen and women requiring corrective eyewear who are not ideal candidates for laser vision correction due to thin corneal stroma, abnormal corneal topography, or history of dry eye disease. Refractive and safety results from the US Food and Drug Administration (FDA) clinical trials with the Implantable Collamer Lens (Visian ICL; STAAR Surgical Co, Monrovia, California) have been promising.5-8 This retrospective study seeks to evaluate trends in patient selection criteria and early clinical outcomes in military warfighters who...

From Carl R. Darnall Army Medical Center, Ft Hood, Texas.

The authors have not received any public or private support for this study, nor do they have any proprietary interest in the products or methods mentioned herein.

Presented at the Fourth Annual International Military Refractive Surgery Conference; January 11-13, 2010; San Antonio, Texas.

The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Army, Department of Defense, or the US Government. Opinions, interpretations, conclusions, and recommendations herein are those of the authors and are not necessarily endorsed by the US Army.

Correspondence: MAJ Gregory D. Parkhurst, MD, Carl R. Darnall Army Medical Center, 38000 Darnall Loop, Ft Hood, TX 76544-4752. Tel: 254.288.8491; E-mail: Gregory.Parkhurst@gmail.com

Received: June 1, 2010; Accepted: December 14, 2010

 Posted online: January 17, 2011

Journal of Refractive Surgery • Vol. 27, No. 7, 2011
underwent ICL surgery at one WRESP center. To our knowledge, it is the first report of myopic phakic intraocular lenses (IOLs) in a military population. Although long-term follow-up may be necessary to determine the appropriate role for phakic IOLs in warfighters, evaluation of early outcomes provides useful information about the potential for this treatment option.

**PATIENTS AND METHODS**

**STUDY DESIGN AND OUTCOMES MEASURES**

This report is based on a retrospective consecutive case series analysis. Operative reports and clinical charts of 204 eyes of 104 patients who underwent unilateral or bilateral phakic IOL surgery using the Visian ICL at Carl R. Darnall Army Medical Center (Ft Hood, Texas) between June 1, 2008 and July 31, 2009, were reviewed. Eyes that underwent concurrent or sequential treatment for astigmatism were excluded from the study. Surgery was performed by two surgeons (G.D.P., M.P.) using similar techniques at one center.

Preoperative study metrics included indications for surgery and preoperative refractive characteristics. Intraoperative observations included the incidence of surgical complications, including laceration of the anterior lens capsule or placement of an inverted ICL. Postoperative safety measures included traumatic IOL decentration, need for IOL exchange, reports of glare and/or halos, residual refractive errors, loss of corrected distance visual acuity (CDVA), cataract formation, corneal decompensation, endophthalmitis, occlusion of iridotomy sites, and elevated intraocular pressure (IOP). Postoperative effectiveness measures included manifest refractive outcomes and uncorrected distance visual acuity (UDVA). Calculations for visual acuities were performed using logMAR equivalents. Refractions are reported at the spectacle plane (vertex 12.5 mm) unless specified otherwise.

Data analysis was performed using Microsoft Excel (Microsoft Corp, Redmond, Washington). Evaluation of statistical significance for continuous data was performed using the Student t test, and bivariate data were evaluated using chi-square tests. Significance was interpreted at a P level of .05.

When appropriate, comparisons using UDVA and refractive data were performed to determine clinical differences among cohorts.

**PATIENT MANAGEMENT**

All refractive surgery patients in the Darnall center are required to discontinue contact lens wear for a minimum of 3 weeks prior to preoperative evaluation. Refractive stability during the preceding 12 months, defined as change in manifest refractive spherocylinder <=0.75 diopters [D]) and change in manifest astigmatism <=0.75 D, is required for all refractive surgery candidates. Only eyes that do not qualify for corneal excimer laser surgery are considered for ICL surgery. Patients are considered for ICL surgery if they do not have a history of cataract, glaucoma, or retinal detachment. Eyes must have an anterior chamber depth of at least 3.0 mm; although in some cases during this study period, anterior chamber depth of at least 2.8 mm was considered when gonioscopy revealed a minimum Shaffer grade III angle. Laser YAG peripheral iridotomies are placed 1 to 2 weeks prior to lens implantation; however, two eyes of one patient in this series had surgical peripheral iridectomies performed at the time of IOL implantation.

Preoperative measurements recorded and analyzed in this chart review included UDVA, manifest refraction, determination of CDVA, computerized corneal topography, and anterior chamber depth using the Pentacam (Oculus Optikgeräte GmbH, Wetzlar, Germany). Visual acuity measurements were obtained using either a Snellen eye chart in a 20-foot eye lane or in a NIDEK Epic-5100 refractive station (NIDEK Co Ltd, Gamagori, Japan). Additional measurements included axial length and keratometry (IOLMaster model ce0297; Carl Zeiss Meditec, Jena, Germany) and white-to-white measurement using Orbscan Ilz (Bausch & Lomb, Rochester, New York) and a hand-held caliper. Lens powers were chosen based on predicted outcomes generated by a surgical lens calculator provided by the lens manufacturer, which takes into account axial length, keratometry, manifest and cycloplegic refraction, anterior chamber depth, and corneal thickness. In most instances, emmetropia is targeted, but age and military occupation are also taken into account when choosing lens power, which was available in 0.50-D increments. Baseline endothelial cell counts were evaluated in all cases.

**SURGICAL TECHNIQUE**

Lens implantation technique was similar for both surgeons. A primary incision was placed on the steep axis of corneal cylinder, or temporally, based on surgeon preference, using a 3.0-mm keratome blade. Two percent hydroxypropyl methylcellulose (Bausch & Lomb) ophthalmic viscosurgical device (OVD) was used to protect the corneal endothelium during ICL implantation using the ICL cartridge and injector (STAAR Surgical Co). Automated irrigation and aspiration was used to remove the OVD following placement of the ICL into the ciliary sulcus. Acetylcholine chloride intraocular solution 1:100 (Novartis, Stein, Switzerland) was used to constrict the pupil once the lens was con-
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confirmed to be in the sulcus. No astigmatic treatments, such as limbal relaxing incisions, were performed.

All patients who have ICL surgery in this center have slit-lamp examination and IOP measurements performed approximately 2 hours postoperatively to ensure the anterior chamber is deep, peripheral iridotomies are patent, and that IOP is <30 mmHg. If IOP is >30 mmHg, aqueous is released from the anterior chamber via the primary incision at the slit lamp. Perioperative medications included topical moxifloxacin hydrochloride 0.5% (Alcon Laboratories Inc, Ft Worth, Texas) four times daily starting the day before surgery and continuing for 7 days; prednisolone acetate 1% (Falcon Pharmaceuticals, Ft Worth, Texas) four times daily for 5 days, tapering by one drop per day every 5 days; and topical nepafenac 0.1% (Alcon Laboratories Inc) three times daily for 3 weeks.

Patients were followed at 1 day, 1 week, and 1 and 3 months postoperative. Uncorrected distance visual acuity, manifest refraction, CDVA, ICL vault, IOP, and slit-lamp examination were measured at all postoperative visits, except as found in this chart review and noted below. A formal questionnaire was not used to elicit subjective reports. However, any complaints noted in the charts were included in this retrospective analysis.

RESULTS

COHORT CHARACTERISTICS

Mean patient age in this series was 30.9±6.6 years (range: 21 to 48 years). Twenty (29%) patients were women and 49 (71%) were men, which is statistically different from the makeup of the general Army population,10 in which 14% is female (P<.001).

The chart review revealed that indications for ICL surgery in this series included abnormal corneal topography, defined as inferior/superior (I/S) ratio >1.50 D associated with relative inferior thinning (50/135, 37%); thin predicted residual bed following LASIK <300 µm (43/135, 32%); symptoms of dry eye disease (17/135, 13%); preoperative central corneal thickness <490 µm (15/135, 11%); and other (predicted postoperative keratometry <35.00 D, history of cheloid formation, and corneal scarring) (10/135, 7%). Preoperative anterior chamber depth (ACD) averaged 3.35±0.27 mm (range: 2.78 to 3.99 mm). Thirteen (9.6%) of 135 eyes had ACD <3.0 mm. Documented informed consent regarding the potential risks, benefits, and alternatives to ICL surgery was found for all patients.

Mean preoperative spherical equivalent refraction was −6.00±1.92 D (range: −2.63 to −11.50 D). Mean preoperative astigmatism was 0.65±0.48 D (range: 0 to −2.25 D). Mean preoperative CDVA was −0.08±0.07 logMAR (range: −0.12 to 0.18) [Snellen equivalent 20/16.6±0.7 [range: 20/15 to 20/30]]. Table 1 summarizes the general preoperative characteristics of the cohort.

INTRA- AND PERIOPERATIVE COMPLICATIONS

No intraoperative complications such as laceration of the anterior lens capsule, placement of an inverted ICL, or ICL decentration were identified. Four (3%) of 135 eyes had 2-hour IOP measurement >30 mmHg requiring evacuation of aqueous via the primary incision at the slit lamp. Two (1.5%) of 135 eyes of the same patient underwent ICL exchange for human error in lens power selection. One (0.7%) eye underwent ICL exchange for vault >250% of the central corneal thickness with associated angle occlusion. No eyes developed cataract formation, corneal decompensation, endophthalmitis, occlusion of iridotomy sites, or acute angle closure glaucoma from pupillary block in the perioperative period.

POSTOPERATIVE FINDINGS

Three-month postoperative examinations were available in 135/204 consecutive eyes. Three-month postoperative refractions and CDVA were available in 128 of the 135 eyes (Fig 1). Table 2 summarizes the number of eyes available at 3-month follow-up.

A “lost to follow-up” analysis was done to compare eyes that were seen at 3-month follow-up to those that were not seen at 3 months. No significant preoperative differences were found for spheroequivalent refraction or astigmatism, and both groups had similar postoperative refractive outcomes at 1-month follow-up. Eyes that were not available at 3 months had mean preoperative spherical equivalent refraction of −6.90±2.30 D (range: −2.75 to −11.25 D) versus −6.00±1.92 D (range: −2.63 to −11.50 D). No significant differences in mean preoperative astigmatism (P=.135), refractive predictability within ±0.50 D at 1 month (P=.85), or mean postoperative UDVA at 1 month (P=.09) were found among eyes that were examined at 3 months and those that were not.

For all eyes with manifest refraction available at 3-month follow-up (n=128), mean postoperative CDVA was −0.13±0.06 logMAR (range: −0.3 to 0.0 logMAR) [Snellen equivalent 20/14.8±0.6 [range: 20/10 to 20/20]]. Forty-two (33%) of 128 eyes gained at least one line of CDVA, and 16/128 (13%) gained at least two lines of CDVA. One (0.8%) eye lost one line of CDVA. No eyes lost two or more lines of CDVA at 3 months.

Mean targeted spheroequivalent refraction was −0.21±0.17 D (range: −0.74 to 0.15 D) and mean sphero-
equivalent refraction achieved was $-0.19\pm0.31$ D (range: $-1.00$ to $0.75$ D) ($P=.42$). Predictability within $\pm0.50$ D was found in 115/128 (90%) of eyes, and predictability within $\pm0.75$ D was found in 127/128 (99%) of eyes.

At 3 months, mean postoperative UDVA (n=135) was $0.08\pm0.08$ logMAR (range: $-0.3$ to $0.18$ logMAR) (Snellen equivalent 20/16.6 $\pm0.8$ [range: 20/10 to 20/30]). Thirty-one (23%) of 135 eyes had postoperative UDVA better than preoperative CDVA, and 108/135 (80%) eyes had postoperative UDVA same or better than preoperative CDVA. Uncorrected distance visual acuity 20/20 or better was found in 129/135 (96%) eyes and 91/135 (67%) eyes had UDVA 20/15 or better. Six (4%) of 135 eyes did not achieve at least 20/20 UDVA, all of which had at least 1.00 D of astigmatism preoperatively. All eyes (n=111, 100%) with $\leq1.00$ D of astigmatism preoperatively had postoperative UDVA 20/20 or better, and 87/111 (78%) had UDVA 20/15 or better (Fig 2).

**POSTOPERATIVE COMPLICATIONS**

Four (3%) of 135 eyes reported halos, significant enough to require treatment with Alphagan P (Allergan, Irvine, California) to constrict the pupil, which resulted in improved symptoms in all four cases. Directions were to use one drop in each eye as needed 30 minutes before night driving. Three (2%) of 135 eyes reported glare, which was attributed by the examiner to the peripheral iridotomy in all 3 eyes because it occurred immediately following the iridotomy and persisted after ICL implantation. Glare/halos reported were considered functionally acceptable in all cases and did not require ICL explantation or therapeutic corneal tattoo. No patient with these complaints experienced loss or change of military occupation.

One (0.7%) eye developed iritis 1 month postoperatively and was treated with 4 additional weeks of topical steroid therapy. Instructions were to use prednisolone acetate 1% (Alcon Laboratories Inc) four times daily for 1 week, tapering by one drop per day every 7 days. After 8 total weeks of topical steroid, iritis resolved with no known sequelae. Two (1.5%) eyes of the same patient had subjective decrease in visual acuity in scotopic environments after ICL implantation that could not be attributed to anterior segment findings and subsequently underwent electrophysiology studies of the neurosensory retina, which were suspicious for hereditary retinal degenerative disease, but ultimately inconclusive. No vision-threatening complications such as anterior subcapsular cataract, corneal decompensation, occlusion of iridotomy sites, secondary glaucoma, or traumatic lens dislocation in service members deployed to combat zones occurred during the observation period.

**DISCUSSION**

Refractive surgery in the US military has been important to service members due to unique occupational demands such as landing aircraft on small landing strips, meeting performance standards for marksmanship, and visually identifying harmful suspicious materials that may harbor enemy weaponry. This often occurs where exposure to extreme temperatures,
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<table>
<thead>
<tr>
<th>Avg K (D)</th>
<th>Axial Length (mm)</th>
<th>ACD (µm)</th>
<th>ECC (cells/mm²)</th>
<th>White-to-White (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>43.80±1.27 (41.32 to 46.02)</td>
<td>25.61±0.95 (23.74 to 27.85)</td>
<td>3.38±0.28 (2.78 to 3.90)</td>
<td>3292±697 (2600 to 4398)</td>
<td>11.87±0.52 (11.10 to 13.10)</td>
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<tr>
<td>44.49±1.56 (41.49 to 48.02)</td>
<td>26.07±1.22 (24.04 to 28.76)</td>
<td>3.36±0.27 (2.82 to 3.99)</td>
<td>3226±657 (2416 to 4229)</td>
<td>11.87±0.44 (11.00 to 12.60)</td>
</tr>
<tr>
<td>44.60±1.53 (41.20 to 46.15)</td>
<td>25.39±1.13 (24.11 to 27.34)</td>
<td>3.28±0.22 (2.97 to 3.71)</td>
<td>2861±241 (2599 to 3435)</td>
<td>11.70±0.31 (11.20 to 12.10)</td>
</tr>
<tr>
<td>43.99±1.15 (41.68 to 45.67)</td>
<td>25.53±1.08 (24.04 to 27.71)</td>
<td>3.25±0.21 (2.82 to 3.63)</td>
<td>3228±528 (2803 to 4453)</td>
<td>11.88±0.47 (11.20 to 12.60)</td>
</tr>
<tr>
<td>43.03±2.70 (39.74 to 46.50)</td>
<td>26.26±1.31 (29.44 to 28.15)</td>
<td>3.29±0.34 (2.98 to 3.76)</td>
<td>3155±627 (2626 to 4476)</td>
<td>12.00±0.23 (11.80 to 12.30)</td>
</tr>
<tr>
<td>44.22±1.60 (39.74 to 48.02)</td>
<td>25.79±1.15 (23.74 to 28.76)</td>
<td>3.35±0.27 (2.78 to 3.99)</td>
<td>3191±635 (2416 to 4476)</td>
<td>11.84±0.45 (11.00 to 13.10)</td>
</tr>
</tbody>
</table>

ultraviolet light, and the potential for ocular trauma with resulting vision loss exists.11 Appliances such as spectacles may present risks in these environments, as they may become damaged, ineffective, or in the way of protective gear worn as part of the uniform.

One alternative to spectacle correction is contact lens wear. However, contact lens wear is not authorized in combat zones due to the potential for poor access to proper hygiene and the associated risk of contact lens–related keratitis.12-14 For these reasons, many service members request refractive surgery to improve their ability to accomplish military operations. Excellent uncorrected visual function often is vital to job performance and even survival. Similar visual function performance considerations may apply to other occupations such as law enforcement, emergency response personnel, and professional athletes.

To date, >160 000 service members have undergone some form of refractive surgery.1-3 The most common procedure performed is photorefractive keratectomy (PRK), followed by LASIK.15,16 Known potential complications of corneal excimer surgery, such as PRK-associated stromal haze, postoperative laser vision correction ectasia, especially in patients with forme fruste keratoconus, and concern about risk of LASIK-associated flap trauma, have prevented some service members from undergoing refractive surgery in the past.17 Phakic IOL surgery is currently being investigated in patients considering refractive surgery in the US Army and Navy. To date, Army Special Forces, Army Aviators, and US Air Force personnel are not authorized to undergo ICL surgery.

This retrospective study of early (3 month) outcomes suggests that phakic IOLs can provide excellent visual and refractive results, with few early complications, in eyes deemed unsuitable for laser refractive surgery. Long-term follow-up is required to determine the appropriate role of phakic IOLs in eyes that are not candidates for laser vision correction in the military setting. The most common indications for phakic IOL surgery in this cohort were abnormal topography (37%), predicted residual stromal thickness <300 µm (32%), ocular surface disorders (13%), preoperative corneal thickness <490 µm (11%), and other (7%, including predicted postoperative keratometry <35.00 D, history of cheloid formation, and corneal scarring).

Postoperative ectasia is a potential complication of LASIK. Meta-analyses have been done to develop risk scoring systems to help predict the risk of ectasia after LASIK.18-21 In the Randleman system, predicted residual stromal thickness >300 µm increases the overall ectasia risk factor score according to a graduated scale. This added risk, when also taking into account corneal topography and age, disqualifies some patients from LASIK. It should be noted that three eyes that received ICLs in this retrospective analysis had predicted residual stromal bed >300 µm because the contralateral eye had a predicted residual bed <300 µm and these patients desired to have the same refractive procedure performed on each eye.

Prior reports by Sanders and Vukich22,23 have shown ICL implantation to be safer and more effective than conventional LASIK in treating low, moderate, and high myopia. To our knowledge, this is the first case
Figure 1. Refractive surgery outcomes in 128/135 eyes at 3-month follow-up after Implantable Collamer Lens implantation.
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A series of myopic phakic IOLs in a military population, and results compare favorably to an early report of 3-month outcomes in 16,111 eyes from the WRESP using laser vision correction, in which 85.6% of eyes achieved UDVA 20/20 or better. In the present study, no eye lost two or more lines of CDVA, and only one eye lost one line of CDVA (from CDVA 20/15 preoperatively to 20/20 postoperatively). Refractive predictability within ±0.50 D at 3 months was found in 115/128 (90%) of eyes, and predictability within ±0.75 D was found in 127/128 (99%) of eyes. Uncorrected distance visual acuity of at least 20/20 was found in 129/135 (96%) of eyes and UDVA of at least 20/16 was found in 91/135 (67%) of eyes. All patients who underwent surgery in this series returned to active military duty.

Intra- or perioperative complications occurred in 7/135 (5%) eyes and postoperative complications occurred in 10/135 (7%) eyes within the 3-month follow-up period of the study. One patient had bilateral ICL implantation of incorrect lens power due to human error in the operating room. This error was discovered several minutes postoperatively, and the patient underwent bilateral ICL exchange the same day achieving UDVA 20/15 in each eye with CDVA 20/12.5 in each eye at 3 months postoperatively. All complications were recognized and treated without any apparent long-term sequelae.

In addition to visual performance, the stability of the lens is another important consideration, especially in a military setting. The first report of combat trauma involved a 31-year-old male soldier with bilateral ICLs with orbital shrapnel and blunt globe trauma after a grenade explosion. The soldier underwent bilateral ICL implantation 8 months prior to this event and was wearing full battle gear, including ballistic-tested sunglasses, when the grenade went off. Despite the injuries sustained by the explosion, both ICLs remained stable, and no deterioration of visual acuity was observed. Lens opacities have also been a concern with ICLs due to their close position to the crystalline lens. Opacities were a significant complication with the V3 ICL design, which has been discontinued. The currently used V4 design was developed to have an additional 0.13 to 0.21 mm of anterior vault height, depending on the dioptric power. In a prospective study of 61 eyes in 40 Chinese patients who received the V4 design, 1 (1.6%) cataract occurred, and this was due to inadequate vaulting over the crystalline lens because the ICL was too small. Kamiya et al implanted the V4 design into 56 eyes of 34 patients with myopic refractive errors of −4.00 to −15.25 D. One (1.8%) eye developed a clinically significant symptomatic anterior subcapsular cataract 1 year postoperatively. Six (11%) eyes developed an asymptomatic anterior subcapsular cataract, of which 5 (9%) showed no change in CDVA; 1 (1.8%) eye lost one line of CDVA.

In the FDA trial, in which 87 eyes received the V3 design and 523 received the V4 design, anterior subcapsular opacities were observed in 2.9% of the V4 group. However, 2 of the 19 participating surgeons accounted for most of the opacities in this series, suggesting that surgeon trauma may have had a significant impact on these results. A similar effect was seen in the 3-year follow-up of the FDA trial, in which 1 surgeon implanted 12% of the ICLs but was associated with 43% of the anterior subcapsular opacities in the trial that graded trace or greater. A recent update on this population showed that 31 (5.9%) of 526 eyes developed symptomatic and asymptomatic anterior subcapsular cataract.

There are also concerns that ICL implantation could lead to endothelial cell loss. Published results thus far have varied. For example, four different studies showed different rates of endothelial cell loss at 3 to 4 years postoperatively (range: 3.7% to 9.7%). Variance in patient demographics, sample size, and other factors

### Table 2

<table>
<thead>
<tr>
<th>Demographic</th>
<th>N</th>
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</thead>
<tbody>
<tr>
<td>All eyes having ICL during study period</td>
<td>204</td>
</tr>
<tr>
<td>Eyes available at 3 months</td>
<td>135</td>
</tr>
<tr>
<td>Eyes at 3 months with manifest refraction and CDVA</td>
<td>128</td>
</tr>
<tr>
<td>Eyes lost to follow-up (deployment)</td>
<td>69</td>
</tr>
</tbody>
</table>

CDVA = corrected distance visual acuity
may help explain these differences, warranting further research to better assess these outcomes. It should be noted that the product labeling for the ICL specifies that anterior chamber depths ≤3.0 mm are a contraindication for its use. Thirteen eyes in this series had anterior chamber depths ≤3.0 mm, each of which had preoperative gonioscopy revealing an open angle of at least Shaffer grade III.32 As postoperative endothelial cell counts were not performed in this study of early outcomes, no assessment can be made regarding endothelial cell loss in these eyes. The decision to implant the ICL in this series was made with consideration of the broader safety issues for combat personnel. This should not be interpreted as a recommended practice and should not be generalized beyond this population without further study. Endothelial cell counts are assessed at annual intervals in our center for eyes with ICLs. Should endothelial cell counts indicate that cell loss exceeds the expected values listed in the product labeling, the ICLs will be removed.

Presently, ICL surgery in the general population is more commonly used for higher degrees of myopia than in the current study patient cohort, which has lower degrees of myopia due to military entrance standards that prohibit high myopes from entrance into active service.6,7,29-31 The average spherical equivalent refraction in this group was −6.00 D, whereas the average spherical equivalent refraction of patients in the overall ICL database is −10.00 D (Fig 3).

One limitation of this study, which consisted of a retrospective chart review, was that 69/204 (34%) eyes that underwent ICL implantation during the study period were unavailable for examination 3 months post-operatively due to deployment and will receive ongoing care elsewhere. A comparison of these eyes to those that were examined at 3 months showed a small difference in preoperative spherical equivalent refraction (−6.90±2.30 D versus −6.00±1.90 D [P=.005]). However, comparison of 1-month refractive predictability within ±0.50 D (P=.85), postoperative CDVA (P=.10), and postoperative UDVA (P=.09) outcomes were not significant. Nevertheless, it is possible that selection bias exists in this cohort. It is also important to note that product labeling for the ICL recommends documented refractive stability within ±0.50 D for 1 year prior to surgery. In our center, a wider range of ±0.75 D/year is used to define refractive stability to qualify patients for surgery. This is done in recognition of the young patient population being treated, where assessment of refractive stability can be complicated by the use of overminused corrections, and in consideration of the overall risk:benefit analysis of decreased spectacle dependence in the combat setting. It should not be interpreted as recommended practice for other centers.

This study suggests that phakic IOLs may provide an alternative treatment modality for eyes that are not considered ideal for corneal excimer laser surgery due to corneal irregularities, thin corneal thickness, or dry eyes, particularly in the US military population where occupational requirements for spectacle independence may influence the short- and long-term risk:benefit analysis. More studies are needed to determine rates of potential long-term complications in a young myopic patient population such as traumatic lens dislocation, cataract, endothelial cell decompensation, and retinal detachment.

**AUTHOR CONTRIBUTIONS**

Study concept and design (G.D.P.); data collection (G.D.P., M.P.); analysis and interpretation of data (G.D.P., G.M.K.); drafting of the manuscript (G.D.P., G.M.K.); critical revision of the manuscript (G.D.P., M.P., G.M.K.); statistical expertise (G.M.K.); administrative, technical, or material support (G.D.P.); supervision (G.D.P., M.P.)

**REFERENCES**


