



# Prevalence of laser vision correction in ophthalmologists who perform refractive surgery

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**PURPOSE:** To determine the prevalence of laser corneal refractive surgery (laser vision correction [LVC]) among ophthalmologists who perform these procedures and to assess the willingness of these ophthalmologists to recommend LVC to immediate family members.

**SETTING:** Online survey with results analyzed at Surgivision Consultants, Inc., Scottsdale, Arizona, USA.

**DESIGN:** Prospective randomized questionnaire study.

**METHODS:** The 22-question Global Survey on Refractive Surgery in Refractive Surgeons was sent by e-mail to 250 ophthalmologists randomly selected from a database of 2441 ophthalmologists known to have performed LVC at some point in the past decade. Responses were solicited by e-mail, with subsequent telephone reminders to nonresponders.

**RESULTS:** Responses were received from 248 (99.2%) of 250 queried individuals, of which 232 (92.8%) met the protocol criteria of currently working as refractive surgeons. Of the 232 subjects, 161 (69.4%) reported that they had refractive errors potentially amenable to treatment with LVC, not including presbyopia. Of the 161 ophthalmologists with treatable refractive errors, 54 (33.5%) reported they were not candidates for LVC for a variety of reasons and 107 (66.5%) reported they were candidates for LVC. Of the LVC candidates, 62.6% reported that they had an LVC procedure in their own eyes. Of the overall 232 subjects, more than 90% recommend LVC for adult members of their immediate family.

**CONCLUSIONS:** Ophthalmologists who perform LVC were significantly more likely than the general population to have LVC in their own eyes. The prevalence of refractive errors was significantly higher among ophthalmologists performing refractive surgery than in the general population.

**Financial Disclosure:** No author has a financial or proprietary interest in any material or method mentioned.

*J Cataract Refract Surg* 2015; 41:1826–1832 © 2015 ASCRS and ESCRS

Laser vision correction (LVC) has been available in the United States since the first excimer laser received U.S. Food and Drug Administration approval for photorefractive keratotomy (PRK) in 1995.<sup>1</sup> Reports of satisfaction with the procedure are high. Metaanalysis of the world's literature on laser in situ keratomileusis (LASIK)<sup>2</sup> suggests that satisfaction rates average 95.4% worldwide, ranging from 87.2% to 100%. Studies report similar rates of LVC acceptance rates among active-duty U.S. Navy aviators,<sup>3</sup> physicians,<sup>4</sup> astronauts,<sup>5</sup> and individuals likely to be driving in mesopic and high-glare conditions.<sup>6</sup>

As of 2014, estimates put the number of patients who had LVC procedures at only 16.2 million in the United States, for an overall penetration rate of 13.1% of appropriate candidates.<sup>7</sup> Reasons cited for low penetration range from general economic conditions to concerns about safety and the availability of alternate treatments for refractive errors. All these and other reasons may play a role.

Prior surveys have attempted to quantify the prevalence of LVC among members of the International Society of Refractive Surgery (ISRS)<sup>8</sup> and suggest that approximately 40% of all refractive surgeons

had refractive surgery. However, participation rates in the range of 13% in the ISRS surveys make the conclusions uncertain.

The primary purpose of this study was to establish the prevalence of LVC among currently practicing ophthalmologists who perform refractive surgery under a prospective study design with a requirement for follow-up to permit conclusive assessment. A secondary objective was to characterize attitudes and satisfaction rates among refractive surgeons who had LVC.

The motivation behind this study was to provide insight about the acceptance of LVC by those who are presumably in a position to know the most about it. Although many factors affect the decision to have LVC, such as visual needs, lifestyle, age, access to the technology, and cost, the prevalence of LVC among refractive surgeons could serve as a useful indication of the potential penetration of LVC over time.

To our knowledge, this is the first study to address these questions in the population of ophthalmologists performing these procedures in a protocol-driven randomized prospective survey and the first study to stratify results according to whether the subjects are candidates for refractive surgery.

## SUBJECTS AND METHODS

### Study Design

This is a prospective randomized survey study done via electronic media. Survey participation was conducted under a protocol that specified a starting sample size of 250 ophthalmologists without replacement.

### Study Population

A list of 2441 ophthalmologists known to have used Surgi-Vision Datalink software products (Surgivision Consultants, Inc.) to perform surgical planning for laser vision correction since 2004 was obtained. These ophthalmologists use various laser platforms without consideration of surgical volume. From the list, 250 names were randomly selected to participate in the study using a randomization algorithm in Excel (Microsoft Corp.). No consideration was given in the selection process to subject identity, age, geographic location, knowledge of their refractive error, or other factors.

Submitted: October 29, 2014.

Final revision submitted: January 16, 2015.

Accepted: January 19, 2015.

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### Subject Eligibility

The protocol required subjects to be actively performing refractive surgery to qualify for participation. Potential subjects found to be unqualified to participate were no longer practicing, had stopped performing refractive surgery, or were deceased. These were excluded from further study and were not replaced.

### Subject Solicitation

Subjects were solicited to participate in the study using a series of communications that included e-mails and telephone calls. Solicitations were not de-identified. Communications requested the participants to complete a survey about their personal experience with refractive surgery and indicated that their responses would be included in a study for publication in a de-identified format. Institutional review board approval was not deemed necessary for this survey among colleagues.

### Survey Tool

The survey was conducted online using a commercial survey application.<sup>A</sup>

Survey questions and logic are shown in Figure 1. The survey consisted of a maximum of 22 questions administered using an electronic online commercial tool that allowed for logic to be applied to the survey, such that questions were presented according to prior responses. For example, only participants who indicated they were ever candidates for refractive surgery were asked what procedure they had.

Because the survey tool was designed to assess the self-reported prevalence of LVC among refractive surgeons, not their attitudes about refractive surgery, the survey asked questions about past events and current practice patterns rather than attitudes or impressions.

Although the survey did not undergo prior validation, it was designed to elicit information in an unbiased format. Questions were concise, objective, and presented without commentary. The survey text is provided in Figure 1.

The survey pursued 5 lines of inquiry:

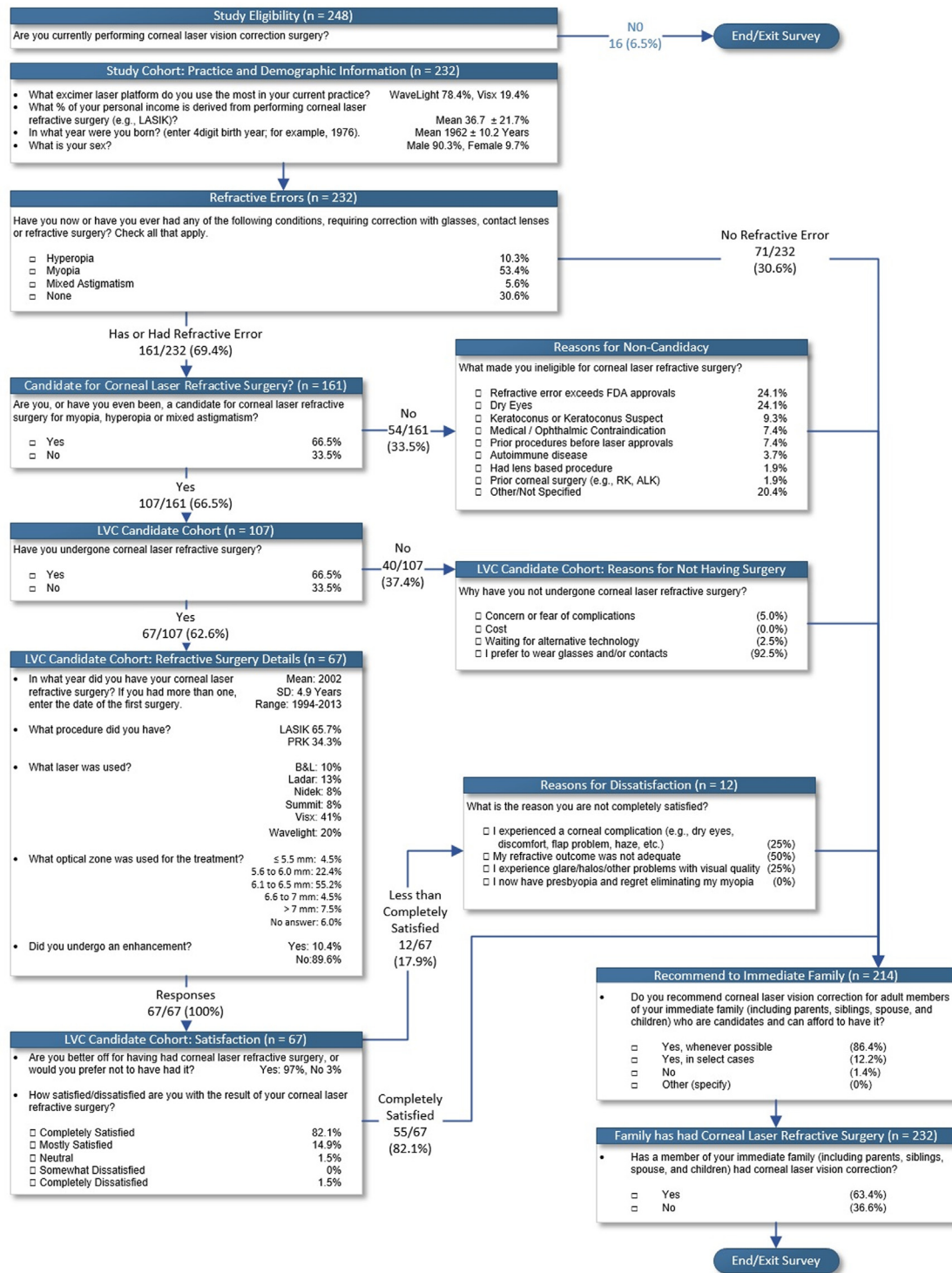
**Study Eligibility** Questions were asked to ascertain that the participant was currently practicing refractive surgery. Surgeons who indicated they were not currently practicing refractive surgery were excluded from further participation.

**Practice and Demographic Information** Questions were limited to age and sex.

**Determination of Refractive Surgery Candidate Status** This included questions about the participant's history of ametropia and self-assessed candidacy for laser refractive surgery. Subjects who indicated they were not candidates were asked to specify the reason.

**Refractive Surgery History** Subjects who indicated they were candidates to have LVC were asked questions about whether they had LVC. If they answered yes, they were asked when they had it and what laser technology and optical zone was used. Those who indicated they were candidates but had not had a procedure were asked to indicate why they had not done so.

**Satisfaction** This included questions about whether they were "better off" for having had the procedure, sources of dissatisfaction (if any), whether they currently recommend LVC to immediate family members, and whether immediate family members had LVC.



**Figure 1.** Survey participation and data summary. The survey was conducted using an electronic tool that incorporated logic to present questions based on input data. The core 20 questions are shown here; 2 additional questions to allow the subject to validate identity and provide comments are not shown. Overall participation was 248/250 (99.2%), but 16 did not meet the study criteria of currently practicing refractive surgery. Reasons for noncandidacy and for not having surgery among candidates are shown in larger type in Tables 1 and 2.

## Data Analysis

Results are reported as raw scores with rates. The subcohort of participants who described themselves as candidates for corneal laser refractive surgery were assigned to the "LVC candidate cohort." Subsequent analysis was performed of the LVC candidate cohort to assess LVC surgical rates, as reported below.

Correlation of LVC surgical rates according to age, percentage of income derived from LVC activities, and refractive error was performed. The Student *t* test and chi-square analysis were used to evaluate for significant differences between subgroups, as appropriate.

Satisfaction rates were evaluated against reported year of the procedure, current age, whether or not an enhancement procedure was performed, and the laser technology that was used to perform the procedure.

Current practices regarding the recommendation of LVC to immediate family members was evaluated against the participant's age, percentage of income derived from LVC activities, and their own satisfaction with their procedure.

Statistical analysis was performed using Excel software. Findings with *P* values less than 0.05 were considered significant.

## RESULTS

### Solicitation Process

Subjects received up to 10 e-mail messages to solicit participation, sent weekly over a period of 10 weeks. Subjects were removed from the e-mail list as they completed the survey. At the end of 10 weeks, there were 30 outstanding nonrespondents. These surgeons received telephone calls from 1 of the authors requesting that they complete the survey. Subjects who did not complete the survey after 3 telephone call attempts were considered unresponsive.

### Cohorts Description

Survey participation and results are summarized in [Figure 1](#).

Of the 250 ophthalmologists polled, 248 (99.2%) completed the survey. Of the 248, 16 (6.5%) had retired from practicing refractive surgery or were deceased. These surgeons were excluded from the study. The remaining 232 (92.8%) of 250 qualified to participate in the overall study cohort.

Not all surgeons provided their age. The mean age of the 215 (92.7%) of 232 who did provide their age was 51.6 years  $\pm$  10.2 (SD) (range 32 to 73 years).

All respondents indicated their sex. The distribution was overwhelmingly men, with 24 (9.7%) women in this sample.

Most surgeons in this study reported they currently use an Alcon Wavelight laser platform (182 of 232, 78.4%) followed by Visx (45, 19.4%). The remaining 5 surgeons (2.2%) reporting using the Zeiss, Nidek, or "other" laser platforms. Nearly all surgeons in this

survey (225, 96.9%) reported that they practice in the United States.

### Distribution of Refractive Errors in the Overall Cohort

Of the 232 surgeons who qualified to participate in the study, 161 (69.4%) self-reported that they had refractive errors not including presbyopia, and 71 (30.6%) reported they were emmetropic. Some level of myopia was reported in 123 (53.4%) of 232 respondents. Only 24 respondents (10.4%) reported they had hyperopic refractive errors, and 13 (5.6%) indicated that they had mixed astigmatism.

There were no significant differences in age and sex distribution between surgeons who reported they had refractive errors and those who reported they were emmetropic.

### Laser Vision Correction Candidate Cohort

Of the 161 ophthalmologists with refractive errors, 107 (66.5%) of 161 answered affirmatively to the question, "Are you, or have you ever been, a candidate for corneal laser refractive surgery for myopia, hyperopia or mixed astigmatism?"; 11 (6.8%) of 161 did not respond to this question. The 107 surgeons who indicated they were candidates were designated as the LVC candidate cohort.

Reasons for noncandidacy were provided by 43 (79.6%) of 54 surgeons who reported they had refractive errors but indicated they were not a candidate for corneal refractive surgery ([Table 1](#)).

As can be inferred from above, the LVC candidate cohort comprised 107 (46.1%) of 232 subjects in the overall study cohort and 107 (66.5%) of 161 of those with refractive errors.

### Rates of Laser Vision Correction

Of the 107 respondents in the LVC candidate cohort, 67 (62.6%) of 107 reported they had LVC.

**Table 1.** Reasons reported for the 54 (33.5%) of the 161 ophthalmologists who indicated they have refractive errors but were "ineligible for corneal laser refractive surgery."

Reason	n	%
Refractive error exceeded FDA approval	13	24.1
Dry eyes	13	24.1
Keratoconus or keratoconus suspect	5	9.3
Medical/ophthalmic contraindication	4	7.4
Prior procedure before lasers were approved	4	7.4
Autoimmune disease	2	3.7
Had a lens-based procedure	1	1.9
Prior corneal surgery	1	1.9
Not specified	11	20.4

FDA = Food and Drug Administration

**Table 2.** Reasons reported log the 49/116 (42%) surgeons in the LVC candidate cohort who were candidates for LVC but reported they had not had a procedure.

Reason	n	%
Concern or fear of complications	2	5.0
Waiting for alternate technology	1	2.5
Prefer to wear glasses and/or contacts	37	92.5

The procedure of choice for two thirds (44 of 67, 65.7%) was LASIK, whereas one third (23 of 67, 34.3%) chose PRK. Those having refractive surgery represented 67 (28.9%) of 232 in the overall survey regardless of refractive errors.

The 40 (37.4%) of 107 surgeons in the LVC candidate cohort who did not have LVC provided reasons for not having surgery as listed in Table 2. Most responded that they “just preferred to wear glasses or contact lenses.” No respondent reported cost as a barrier.

Grouping all subjective reasons together (concerns, waiting, and those who prefer glasses and/or contacts) suggests 40 (37.4%) of 107 refractive surgeons who were candidates for LVC chose not to have surgery even though they considered themselves to be candidates for a procedure (Figure 2).

### Satisfaction Rates

All 67 ophthalmologists who reported they had LVC responded to the questions about satisfaction rates. Overall, 65 (97%) of 67 responded they were “better off for having had corneal laser refractive surgery” and 55 (82.1%) of 67 reported they were “completely satisfied” with their results. Ten (14.9%) of 67 reported they were “mostly satisfied.” One surgeon (1.5%) rated satisfaction as neutral, and 1 (1.5%) was “completely dissatisfied.” This surgeon reported he had gone on to develop corneal ectasia.

Among the 12 (17.9%) of 67 surgeons who were less than “completely satisfied” with the result of their corneal laser refractive surgery, 3 (25%) reported they had experienced “corneal complications,” 6 (50.0%) reported they were dissatisfied with the refractive outcome, and another 3 (25%) reported they were not satisfied with the visual quality. All 12 who reported they were not completely satisfied with their results were men.

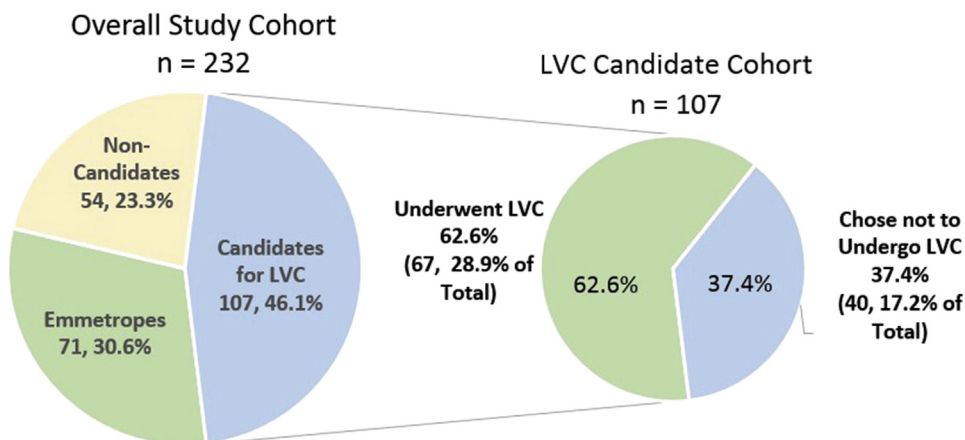
Of interest, 2 of the 12 surgeons who were not completely satisfied did not actually have laser refractive surgery. One had conductive keratoplasty in 2004 and stated in the comments section that “in retrospect, I wish I had LASIK.” The other reported he had radial keratotomy in 1991. Of the remaining 10 surgeons in the “not completely satisfied with LVC” group, all but 1 had their surgery prior to 2005. The 1 surgeon who had surgery in 2011 experienced a “corneal complication.”

No significant relationship was found between satisfaction rates and surgeon age, year of the procedure, percentage of income derived from LVC surgery, or refractive error, using a Student *t* test, regression analysis, and chi-square analysis.

### Practices for Recommending Refractive Surgery for Immediate Family Members

All survey participants were asked “Do you recommend corneal laser vision correction for adult members of your immediate family who are candidates and can afford to have it, including parents, siblings, spouse, and children?” Most (214 of 232, 92.2%) responded to this question, whereas the remaining 18 (7.8%) did not.

Answers among the 214 respondents were overwhelmingly positive: 211 (98.6%) of 214 recommend corneal LVC to their immediate family, either “when-ever possible” (185, 86.4%), or “only in select cases



**Figure 2.** Breakdown of the overall study cohort and LVC cohort.

(eg, occupational demands or sports)" (26, 12.2%). Three participants (1.4%) answered "no" to this question.

All 232 survey participants answered the question "Has a member of your immediate family (including parents, siblings, spouse, and children) had corneal laser vision correction?" The response "yes" was selected by 147 (63.4%) of 232; 85 (36.6%) selected "no." Of the ophthalmologists who had LVC themselves, 56 (83.6%) of 67 reported that a family member had surgery, compared with 91 (55.2%) of 165 surgeons who had not had LVC ( $P < .01$ , chi-square test). Note that this question was asked without attempting to qualify whether the surgeon had a family member who was considered a candidate for corneal laser refractive surgery.

Current practices regarding recommending immediate family members to have LVC were correlated against the participant's age, percentage of income derived from LVC activities, laser platform used, and their own satisfaction with their procedure (as appropriate). No significant correlations were identified.

## DISCUSSION

This prospective randomized protocol-driven survey of 232 ophthalmologists who offer LVC gathered information about personal refractive surgery history using a self-reported format. Findings indicate that more than 62.6% of refractive surgeons who consider themselves to be candidates for LVC have had a procedure, and more than 90% recommend LVC to their immediate family members.

To our knowledge, this is the first study to report the incidence of refractive surgery that stratifies results according to preexisting refractive errors and candidacy for surgery. Of the 107 (46.1%) of 232 subjects who indicated they were candidates for LVC, 62.6% reported that they had corneal LVC. This compares with an overall penetration of LVC of 13.1% among persons with refractive errors in the United States in 2013<sup>7</sup> ( $P < .01$ , chi-square test). In other words, ophthalmologists who perform refractive surgery are nearly 4 times more likely to have LVC than the general U.S. population. Similarly, nearly two thirds (63.4%) of the refractive surgeons in this study reported that immediate family members had LVC.

In contrast, 37.4% of ophthalmologists who reported they were candidates for LVC reported they had not had surgery. Of these, all cited some subjective reason for not having surgery (concern or fear of complications, waiting for alternate technology, and those who prefer glasses and/or contacts).

Satisfaction rates were high among subjects who reported having LVC, with 97% reporting they were either "completely satisfied" or "mostly satisfied" with

their results. This agrees well with the 2013 report by Pasquali et al.<sup>4</sup> of 95% long-term satisfaction with LVC among general physicians.

Most ophthalmologists (86.4%) reported that they recommend LVC "whenever possible" to "immediate family who are candidates and can afford to have it, including parents, siblings, spouse, and children," whereas 12.1% answered, "Yes, but only in select cases (eg, occupational demands or sports)." Only 3 (1.4%) of 214 selected "no" for an answer to this question; 7.8% of the surgeons did not respond to this question. Even if all of the 7.8% nonrespondents were grouped with the "no" answers, 90.2% of the ophthalmologists who participated in this study recommend LVC to their immediate family members.

The study design attempted to minimize bias by sampling ophthalmologists known to have done some refractive surgery on a prospective randomized basis. To avoid response bias, the protocol relied on high participation rates to be valid. The 22-question survey was sent by e-mail to 250 ophthalmologists who were randomly selected from a database of 2441 ophthalmologists who were known to have done at least some refractive surgery in the past decade. Responses were received from 248 (99.2%) of 250 queried individuals, which exceeded the 90% threshold established in the protocol and compares favorably with other physician surveys.<sup>3,9</sup>

The results in this study generally agree with those in previously published surveys of the members of the ISRS<sup>8</sup> as reported by Duffey and Leaming. Their 2014 survey,<sup>8</sup> although challenged by a response rate of 15%, reported that 40% of all refractive surgeons had refractive surgery. This compares with 28.9% found in the current study.

The rate of ametropia among the participants in this study was high. The prevalence of myopia is 53.4% and of refractive errors overall was 69.4%. This compares with a prevalence of refractive errors of approximately 42% in the general U.S. population<sup>7</sup> ( $P < .01$ , chi-square test). Most of the subjects in this study practiced in the United States. The protocol did not capture information about national, ethnic, or racial backgrounds. Nevertheless, it is interesting that this finding agrees with a prior study that evaluated the incidence of refractive errors in Norwegian ophthalmologists,<sup>10</sup> in which 72.0% were found to be ametropic. A surprisingly high proportion (33.5%) of subjects who reported they had refractive errors considered themselves ineligible for refractive surgery.

This study does have limitations. Nearly all (96.9%) of the surgeons in this study practice in the United States, so the results cannot be generalized to other parts of the world. The study responses were not audited, and the survey tool had not been validated

for reproducibility or reliability. The degree to which the surgeons in this study can be considered representative of all refractive surgeons is not known. Although difficult to overcome, these limitations should be considered in any interpretation of the study results.

The high rates of participation in this survey suggest that surgeons are willing to disclose their personal experiences with refractive surgery. Future studies should be conducted to evaluate ophthalmologist acceptance of other ophthalmic procedures and to compare these rates against age- and income-matched controls from the general population.

#### WHAT WAS KNOWN

- The prevalence of refractive errors amendable to LVC is approximately 42% in the general U.S. population, and approximately 13.1% of the eligible U.S. population has had LVC. Satisfaction rates average 95.4% worldwide, ranging from 87.2% to 100%.

#### WHAT THIS PAPER ADDS

- Refractive surgeons were approximately 4 times more likely to have LVC than the general population. Between 90.2% and 98.6% recommended LVC to their immediate family members. The incidence of ametropia among ophthalmologists performing refractive surgery was significantly higher than in the general population. The prevalence of myopia was 53.4% and of refractive errors overall was 69.4%.

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