



# Three-Year Longitudinal Survey Comparing Visual Satisfaction with LASIK and Contact Lenses

Marianne O. Price, PhD,<sup>1</sup> David A. Price, BS,<sup>1</sup> Frank A. Bucci, Jr., MD,<sup>2</sup> Daniel S. Durrie, MD,<sup>3</sup> William I. Bond, MD,<sup>4</sup> Francis W. Price, Jr., MD<sup>5</sup>

**Purpose:** To assess patient satisfaction and perceived outcomes with different methods of refractive error correction through annual surveys administered over a 3-year period.

**Design:** Prospective, longitudinal, parallel-group, multicenter survey.

**Participants:** A total of 1800 subjects, aged 18 to 60 years, who had LASIK or continued using contact lenses.

**Methods:** Twenty sites across the United States enrolled subjects who completed a study-specific baseline survey during a contact lens examination or while being evaluated as a candidate for LASIK. Links to follow-up surveys were emailed annually for 3 years. Between-group differences were assessed by analysis of variance, and associations were assessed by logistic multivariate regression.

**Main Outcome Measures:** Visual satisfaction.

**Results:** Of 1800 subjects, 694 (39%) comprised the control group who continued contact lens wear, 819 (45%) wore contacts at baseline and had LASIK, and 287 (16%) wore glasses at baseline and had LASIK. Most contact lens users had worn them successfully  $\geq 5$  years. The proportion expressing strong satisfaction with their current vision correction method decreased from 63% at baseline to 54% at year 3 in the contact lens control group, whereas 88% of former contact lens wearers and 77% of former glasses wearers were strongly satisfied with LASIK at year 3. Patients 40 years of age or younger when they had LASIK were somewhat more likely to be strongly satisfied than older patients. LASIK significantly reduced difficulties with night driving and nighttime visual disturbances among former contact lens users and former glasses users. The proportion with dry eye symptoms at 1, 2, or 3 years after LASIK was not significantly increased relative to baseline contact lens wear but was significantly increased relative to baseline glasses use, consistent with many glasses users having tried and abandoned contact lenses because of latent dry eye problems. Compared with continued contact lens wear, LASIK significantly reduced the self-reported rates of eye infections, ulcers, and abrasions each year.

**Conclusions:** Compared with contact lens wear, current LASIK technology improved ease of night driving, did not significantly increase dry eye symptoms, and resulted in higher levels of satisfaction at 1, 2, and 3 years follow-up. *Ophthalmology* 2016;123:1659-1666 © 2016 by the American Academy of Ophthalmology.



Supplemental material is available at [www.aaojournal.org](http://www.aaojournal.org).

Clinically important myopia, hyperopia, or astigmatism is estimated to affect half of the adult population in the United States.<sup>1</sup> Any vision correction option, including spectacles, contact lenses, or refractive surgery, has unique risks and benefits. For the general public, contact lenses are popular, especially among children and young adults, because many think they provide more functional or aesthetic vision correction than spectacles. Surgical correction of refractive error can be preferable for patients who do not want the expense and maintenance responsibility of optical correction and for those in the military or who work/live in dirty environments or conditions of possible trauma.<sup>2</sup> An estimated 40.9 million persons in the United States aged  $\geq 18$  years wear contact lenses (16.7% of US adults),<sup>3</sup> and 0.62 to 0.72 million LASIK procedures were

performed annually in the United States between 2010 and 2014.<sup>4</sup>

The efficacy and safety of LASIK have been demonstrated in clinical trials,<sup>5,6</sup> perhaps most definitively in the LASIK Quality of Life Collaboration Project PROWL-1 and PROWL-2 studies organized by the US Food and Drug Administration.<sup>7</sup> However, because it is a surgical procedure, there is a natural tendency to compare the outcomes with the best preoperative optically corrected vision and—for some patients—with their idea of vision in a hypothetical perfect eye. Therefore, it is important to establish an appropriate benchmark with which to compare outcomes. Previous studies have assessed patient-perceived outcomes with LASIK,<sup>7-13</sup> but to our knowledge none has had a control group that continued using

contact lenses. The purpose of this study was to assess perceived benefits and risks with LASIK and contact lenses by comparing visual satisfaction before and for a period of 3 years after LASIK with that in a control group consisting of people who continued to use contact lenses as their primary method of vision correction.

## Methods

This was a prospective, multicenter, longitudinal survey study. Twenty centers in the United States enrolled participants between November 2010 and March 2013. The study was conducted in accordance with the Declaration of Helsinki, and an independent or institutional review board approved the conduct of the study. All participants provided written informed consent.

### Inclusion/Exclusion Criteria

The inclusion criteria were English-speaking subjects between the ages of 18 and 60 years with myopia, hyperopia, or astigmatism who used contact lenses or planned to undergo LASIK for vision correction. Exclusion criteria were a diagnosis of keratoconus, abnormal topography, multifocal treatment, or any significant visual problem other than myopia, hyperopia, or astigmatism. No restrictions were placed on the type of contact lenses used or on the types of excimer lasers or flap creation methods used with LASIK to broadly sample self-reported outcomes with any devices that were currently in use.

A total of 1882 eligible subjects were enrolled. Those who had a refractive surgical procedure other than LASIK ( $n = 20$ ) and those who wore glasses at baseline and did not elect to have LASIK ( $n = 62$ ) did not meet the criteria for continued enrollment in this longitudinal study, so they were withdrawn from the study and their baseline survey responses were excluded from the data analysis. Thus, responses were tabulated from 1800 participants.

### Study Procedures

Potential subjects were invited to enroll in the study if they were continuing in contact lenses or being evaluated for LASIK. Those being evaluated for LASIK completed the baseline survey before undergoing surgery. The baseline Internet-based survey was administered while subjects were at the study site. The site study coordinator recorded each subject's refractive error and the date of surgery if the subject had LASIK. A link to a follow-up survey was automatically emailed to each subject annually along with several follow-up reminders, and several years into the study we added text message reminders as well.

### Survey Instrument

The baseline study-specific survey included questions about demographics and contact lens use. Questions about visual satisfaction and symptoms were asked at baseline and repeated on the annual follow-up surveys. The questions were adapted from publicly available questionnaires on the basis of their perceived relevance to the study population. In particular, the selected questions focused on concerns that have been raised in the past about LASIK, including night-driving vision, visual symptoms such as starbursts and halos at night, difficulty reading small print, dry eyes, and depression.<sup>9,11–13</sup> The responses to each question were compared between groups rather than being combined into a scoring system.

## Data Analysis

Survey responses were tabulated to provide descriptive statistics about each vision correction group (i.e., those continuing contact lens wear, those wearing contacts at baseline before having LASIK, and those wearing spectacles at baseline before having LASIK). Responses were compared between groups using analysis of variance, and the significance of respondent characteristics within study groups (i.e., age and spherical equivalent refraction) was assessed with logistic multivariate regression. Statistical analysis was performed with Statistical Analysis Software (SAS Version 9.4, SAS Institute, Cary, NC). The significance threshold for individual comparisons was  $P < 0.01$ .

## Results

### Demographics

Twenty sites across the United States (listed in the Appendix, available at [www.aojournal.org](http://www.aojournal.org)) enrolled 1800 subjects who met protocol criteria; 694 (39%) comprised the control group who continued contact lens wear, 819 (45%) were contact lenses users who had LASIK, and 287 (16%) were glasses wearers who had LASIK. Of the 1106 subjects who had LASIK, 1063 (96%) had bilateral treatment and 43 (4%) had unilateral treatment. Overall, 1558 participants (87%) completed 1 or more annual follow-up surveys. The 1-, 2-, and 3-year surveys were completed by 1265 (70%), 1075 (60%), and 1375 (76%) participants, respectively.

Table 1 shows the baseline demographics and refractive distribution of the study participants. Those who wore spectacles were older on average and had a lower mean spherical equivalent refraction than the contact lens wearers. Approximately two thirds of the contact lens wearers were female, whereas more than half of those wearing spectacles at baseline were male. The duration of contact lens use and type of lenses worn were well balanced across the control group who continued contact lens wear and the group of contact lens users who subsequently had LASIK.

At baseline, 42% reported a history of allergies, 16% used migraine medication, 8% used a steroid inhaler, and 6% used oral steroids. Among those with allergies, 40% had hay fever and 23% reported that they often used allergy medication. The proportions did not differ significantly among the 3 vision correction groups for any of these characteristics.

### Defection from Contact Lens Use

On each of the 1-, 2-, and 3-year surveys, between 17% and 25% of the control group who continued contact lens wear reported that they had decreased their lens wearing time during the previous year. Of the 694 participants who planned to continue contact lens wear at the baseline examination, 96 (14%) reported that they quit using contacts at some point during the 3-year follow-up period; 73 changed to glasses, and 23 had refractive surgery. Any survey responses received from these patients after they said they quit using contacts as the primary means of vision correction were not included in the subsequent reported averages for the control group. Of the 96 defectors, 38 provided reasons; 18 (47%) quit because of dryness or irritation, 11 (29%) quit because of visual difficulty with astigmatism correction, 4 (11%) quit because of infections or eye injuries, and 5 (13%) quit for other individual reasons.

### Overall Satisfaction with LASIK versus Contact Lenses

Strong agreement with the statement "I would recommend my current method of vision correction to a close friend or family

Table 1. Baseline Demographics in Those Continuing with Contact Lenses, Those Using Contact Lenses before LASIK, and Those Using Spectacles before LASIK

| Vision Correction Method         | Contacts (Continuing)<br>N = 694 | Contacts (before LASIK)<br>N = 819 | Spectacles (before LASIK)<br>N = 287 | P Value |
|----------------------------------|----------------------------------|------------------------------------|--------------------------------------|---------|
| Age, yrs                         |                                  |                                    |                                      |         |
| Mean ± SD                        | 34±12                            | 34±9                               | 37±11                                | <0.0001 |
| SE in myopic eyes (D)            |                                  |                                    |                                      |         |
| Median (range)                   | -3.6 (-15.7 to -0.1)             | -4.1 (-12.5 to -0.25)              | -3.1 (-10.5 to -0.1)                 | <0.0001 |
| SE in hyperopic eyes (D)         |                                  |                                    |                                      |         |
| Median (range)                   | 1.9 (0.1-5)                      | 1.8 (0.1-4.6)                      | 1.3 (0.1-4.1)                        | 0.099   |
| Sex, male:female (%)             | 34:66                            | 40:60                              | 55:45                                | <0.0001 |
| Duration of contact lens use (%) |                                  |                                    |                                      | <0.0001 |
| >5 yrs                           | 87                               | 93                                 |                                      |         |
| 2-5 yrs                          | 9                                | 6                                  |                                      |         |
| <2 yrs                           | 4                                | 1                                  |                                      |         |
| Contact lens type (%)            |                                  |                                    |                                      | 0.12    |
| Soft daily wear                  | 52                               | 46                                 |                                      |         |
| Soft extended wear               | 45                               | 49                                 |                                      |         |
| Rigid gas permeable              | 2                                | 3                                  |                                      |         |
| Other                            | 2                                | 2                                  |                                      |         |

D = diopters; SD = standard deviation; SE = spherical equivalent. Bold values represent statistically significant *P* values.

member” was considered indicative of satisfaction. In the 1-, 2-, and 3-year surveys, the strongly satisfied proportion was substantially higher among those who had LASIK compared with those who continued to wear contact lenses (Fig 1, Table 2). Of note, the strongly satisfied proportion was somewhat higher among the patients with LASIK who previously wore contact lenses compared with those who previously wore glasses (Fig 1, Table 2).

The proportion of contact lens users who strongly agreed they would recommend them decreased over time from 63% at the initial survey to 54% at year 3 (Fig 1). This decline occurred despite the discontinuation of contact lens use during that time period by those who were presumably the least satisfied, which excluded them from the satisfaction calculations in subsequent years. In contrast, the strongly satisfied proportion remained high throughout the 3-year follow-up period after LASIK both among

those who previously used contacts (84%–88%) and among those who previously wore glasses (77%–80%) (Fig 1). Satisfaction with contact lenses or LASIK did not differ significantly between those who used daily wear lenses and those who used extended wear soft lenses at baseline. Consistently across all vision correction groups, approximately 1% of the respondents each year said they were unlikely to recommend their current form of vision correction to others (Table 2).

Patients younger than 40 years of age were more likely to be strongly satisfied with LASIK than older patients, whereas the proportion strongly satisfied with contact lens wear was lower and not age dependent (Fig 2). The satisfaction ratings did not differ significantly between men and women for LASIK or contact lenses.

The following additional preoperative factors were assessed for potential association with strong satisfaction with LASIK at 3 years: absolute spherical correction, absolute cylindrical correction, baseline myopia versus hyperopia, difficulty reading small print, dry eyes severity, night-driving difficulties, and artificial tears use. Bilateral versus unilateral surgery also was considered. The significant predictors of satisfaction in multivariate analysis were younger age ( $P = 0.0022$ ), previously using contacts rather than glasses ( $P = 0.0037$ ), and less dry eyes at baseline ( $P = 0.0039$ ).

When former contact lens users who had LASIK were asked whether LASIK worked better for them than contact lens wear, 87% strongly agreed (Fig 3). Less than 1% preferred contact lenses.

### Night-Driving Difficulty and Night Visual Disturbances

LASIK significantly reduced difficulties with night driving. The proportions who reported no difficulty with night driving were comparable across groups at baseline ( $P = 0.041$ ) and similar at baseline (36%) and 3 years (37%) in the control group that continued contact lens wear (Fig 4 and Table 2). In contrast, the proportion reporting no difficulties with night driving improved from 42% preoperatively to 60% at 3 years after LASIK to replace contacts and from 44% to 57% at 3 years after LASIK to replace glasses (Fig 4 and Table 2). The proportions with no difficulty driving at night were significantly better in both LASIK groups compared with the contact lens control group at 3 years ( $P < 0.0001$ ).

### Strongly recommends current vision correction (%)

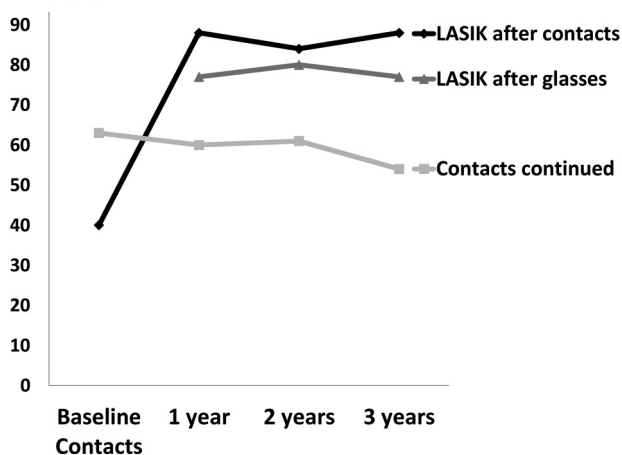


Figure 1. Proportions who strongly agreed they would recommend their current method of vision correction to a close friend or family member at baseline (using contact lenses) and at 1, 2, and 3 years after LASIK or with continued contact lens use.

Table 2. Survey Questions and Responses

|  | Contact Lens Control Group |          |           |           | LASIK after Contacts Group |                    |          |           |           | LASIK after Glasses Group |                    |          |           |           |
|--|----------------------------|----------|-----------|-----------|----------------------------|--------------------|----------|-----------|-----------|---------------------------|--------------------|----------|-----------|-----------|
|  | Baseline (%)               | 1 yr (%) | 2 yrs (%) | 3 yrs (%) | Baseline (%)               | Preoperatively (%) | 1 yr (%) | 2 yrs (%) | 3 yrs (%) | Baseline (%)              | Preoperatively (%) | 1 yr (%) | 2 yrs (%) | 3 yrs (%) |
| Please indicate your level of agreement with: "I would recommend my current method of vision correction to a close friend or relative."                    |                            |          |           |           |                            |                    |          |           |           |                           |                    |          |           |           |
| Strongly agree   | 63                         | 60       | 61        | 54        | 40                         | 88                 | 84       | 88        |           | 77                        | 80                 | 77       |           |           |
| Agree  | 33                         | 37       | 38        | 43        | 50                         | 10                 | 14       | 10        |           | 20                        | 17                 | 22       |           |           |
| Not sure   | 2                          | 2        | 0.3       | 2         | 5                          | 1                  | 1        | 1         |           | 2                         | 2                  | 0.5      |           |           |
| Disagree   | 1                          | 1        | 1         | 1         | 3                          | 1                  | 1        | 1         |           | 2                         | 1                  | 0.5      |           |           |
| Strongly disagree  | 0.4                        | 0        | 1         | 0.3       | 1                          | 0.2                | 0.2      | 0.3       |           | 0                         | 0                  | 0.5      |           |           |
| Do you have any difficulty driving at night?   |                            |          |           |           |                            |                    |          |           |           |                           |                    |          |           |           |
| None   | 36                         | 48       | 40        | 37        | 42                         | 63                 | 61       | 60        |           | 44                        | 56                 | 65       | 57        |           |
| Little   | 48                         | 40       | 45        | 49        | 45                         | 29                 | 30       | 30        |           | 39                        | 37                 | 30       | 33        |           |
| Moderate   | 12                         | 10       | 14        | 12        | 11                         | 6                  | 8        | 8         |           | 15                        | 6                  | 5        | 9         |           |
| Severe   | 1                          | 1        | 1         | 2         | 1                          | 1                  | 1        | 1         |           | 1                         | 1                  | 1        | 1         |           |
| Unable due to vision   | 1                          | 0.4      | 0         | 0.3       | 0.2                        | 0.5                | 0.2      | 0.2       |           | 0.3                       | 0.5                | 0        | 0         |           |
| Do you have any difficulty with your vision at night because of starbursts or halos around bright lights?  |                            |          |           |           |                            |                    |          |           |           |                           |                    |          |           |           |
| None   | 45                         | 56       | 51        | 46        | 49                         | 62                 | 60       | 60        |           | 52                        | 56                 | 64       | 62        |           |
| Little   | 41                         | 33       | 37        | 42        | 39                         | 33                 | 31       | 31        |           | 35                        | 35                 | 30       | 28        |           |
| Moderate   | 11                         | 7        | 10        | 10        | 10                         | 4                  | 9        | 7         |           | 11                        | 8                  | 5        | 9         |           |
| Severe   | 3                          | 2        | 2         | 2         | 1                          | 1                  | 1        | 2         |           | 2                         | 2                  | 1        | 1         |           |
| During the past week have you experienced a feeling of dry eyes?   |                            |          |           |           |                            |                    |          |           |           |                           |                    |          |           |           |
| None   | 29                         | 34       | 31        | 29        | 44                         | 42                 | 45       | 50        |           | 51                        | 28                 | 38       | 42        |           |
| Occasionally   | 54                         | 53       | 53        | 57        | 45                         | 46                 | 44       | 41        |           | 40                        | 55                 | 46       | 42        |           |
| Half of the time   | 11                         | 8        | 11        | 8         | 7                          | 8                  | 7        | 5         |           | 5                         | 9                  | 10       | 8         |           |
| Most of the time   | 5                          | 4        | 4         | 5         | 4                          | 3                  | 3        | 3         |           | 3                         | 6                  | 4        | 6         |           |
| All of the time  | 1                          | 1        | 1         | 1         | 0                          | 1                  | 1        | 1         |           | 0                         | 3                  | 2        | 2         |           |
| On average how many times a day do you use artificial tears in either eye?   |                            |          |           |           |                            |                    |          |           |           |                           |                    |          |           |           |
| Never  | 76                         | 68       | 69        | 69        | 76                         | 54                 | 62       | 67        |           | 77                        | 39                 | 48       | 60        |           |
| No more than once a day  | 16                         | 23       | 22        | 24        | 15                         | 32                 | 27       | 24        |           | 11                        | 38                 | 35       | 24        |           |
| 2-4 times per day  | 6                          | 8        | 8         | 7         | 9                          | 13                 | 9        | 9         |           | 10                        | 21                 | 16       | 14        |           |
| 5-8 times per day  | 1                          | 1        | 1         | 1         | 1                          | 1                  | 1        | 1         |           | 1                         | 3                  | 1        | 2         |           |
| Once per hour  | 1                          | 0        | 0         | 0         | 0.1                        | 0                  | 0        | 0         |           | 1                         | 0                  | 0        | 0         |           |
| Do you have any difficulty reading small print, such as a telephone book, newspaper, or medicine bottle?   |                            |          |           |           |                            |                    |          |           |           |                           |                    |          |           |           |
| Not at all   | 55                         | 63       | 59        | 57        | 67                         | 79                 | 74       | 72        |           | 50                        | 58                 | 51       | 47        |           |
| A little   | 29                         | 26       | 26        | 27        | 21                         | 14                 | 17       | 17        |           | 28                        | 22                 | 26       | 27        |           |
| Moderate   | 12                         | 8        | 11        | 12        | 9                          | 5                  | 7        | 8         |           | 14                        | 12                 | 17       | 18        |           |
| Severe   | 3                          | 3        | 4         | 5         | 3                          | 2                  | 2        | 2         |           | 7                         | 7                  | 6        | 8         |           |
| During the past 2 weeks how often, if at all, have you felt down, depressed, or hopeless? (not at all, several days, over half the days, nearly every day) |                            |          |           |           |                            |                    |          |           |           |                           |                    |          |           |           |
| Not at all   | 87                         | 89       | 88        | 87        | 94                         | 93                 | 93       | 93        |           | 93                        | 90                 | 93       | 93        |           |
| During the past 2 weeks how often, if at all, have you been bothered by little interest or pleasure in doing things? (same choices as previous question)   |                            |          |           |           |                            |                    |          |           |           |                           |                    |          |           |           |
| Not at all   | 87                         | 89       | 90        | 87        | 92                         | 94                 | 93       | 95        |           | 91                        | 93                 | 94       | 93        |           |
| In the past year, have you experienced any eye infection? (yes, no)  |                            |          |           |           |                            |                    |          |           |           |                           |                    |          |           |           |
| Yes  |                            | 8        | 11        | 8         |                            | 3                  | 4        | 3         |           |                           | 2                  | 6        | 3         |           |
| In the past year, have you experienced any type of ulcer in your eye? (yes, no)  |                            |          |           |           |                            |                    |          |           |           |                           |                    |          |           |           |
| Yes  |                            | 1        | 2         | 2         |                            | 0.2                | 0        | 1         |           |                           | 0                  | 0        | 0.5       |           |
| In the past year, have you experienced any abrasion of your eye? (yes, no)   |                            |          |           |           |                            |                    |          |           |           |                           |                    |          |           |           |
| Yes  |                            | 4        | 6         | 5         |                            | 2                  | 2        | 3         |           |                           | 1                  | 1        | 2         |           |

Percentages do not add up to exactly 100% because of rounding.

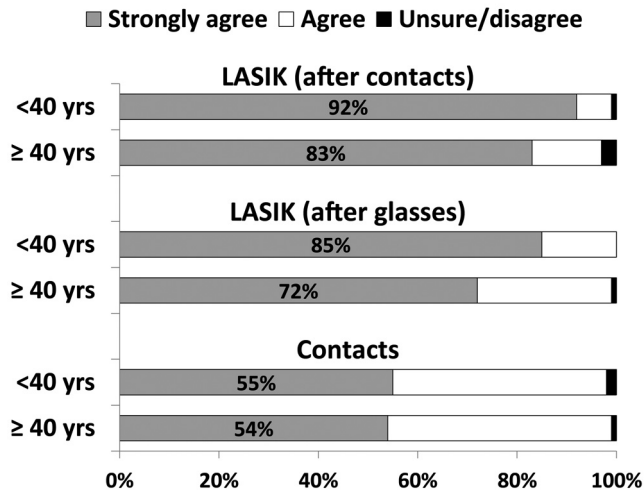
LASIK also reduced nighttime visual disturbances such as starbursts or haloes around bright lights compared with continued contact lens wear. The 3 vision correction groups did not differ significantly at baseline ( $P = 0.081$ ), and the proportion without nighttime visual disturbances was similar at baseline (45%) and 3 years (46%) in the contact lens control group. In contrast, the proportion who reported no visual disturbances at night improved from 49% preoperatively to 60% at 3 years after LASIK to replace contacts and from 52% preoperatively to 62% at 3 years after LASIK to replace glasses. Compared with the contact lens control

group, both LASIK groups had significantly higher proportions without nighttime visual disturbances at 3 years ( $P \leq 0.0003$ ).

### Dry Eyes

In the contact lens control group, 29% reported no feelings of dry eyes during the previous week both at baseline and at 3 years (Fig 5, Table 2). Likewise, in the group that had LASIK after wearing contacts, the proportion reporting no dry eyes changed nominally from 44% at baseline to 42% at 1 year, 45% at 2

**Would recommend vision correction method**



**Figure 2.** Agreement with the statement, “I would recommend my current vision correction method to a close friend or family member,” shown by age and method of vision correction at year 3.

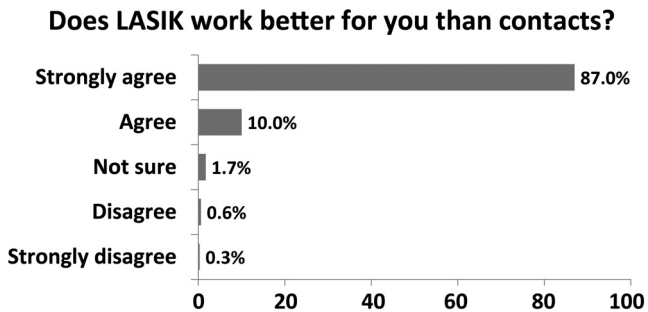
years, and 50% at 3 years (Fig 5 and Table 2). In contrast, among those who wore glasses, the proportion with no dry eyes decreased from 51% at baseline to 28% 1 year after LASIK with subsequent improvement to 42% by year 3, and the proportion who reported feeling dry eyes most or all of the time increased from 3% at baseline to 8% at 3 years.

Of note, 74% of those who wore glasses at baseline reported that they had tried contact lenses, and the most common reason given for no longer using them was dry eyes (59%). Among those who had switched from contact lenses to glasses because of dry eyes, 54% reported no dry eye symptoms on the baseline survey while using glasses.

In a multivariate model that controlled for dry symptoms at baseline, the characteristics significantly associated with having at least some dry eye symptoms 3 years after LASIK were older age ( $P = 0.0058$ ) and preoperative use of allergy medications ( $P = 0.0049$ ), whereas baseline allergies, use of steroids, and use of migraine medications were not significant.

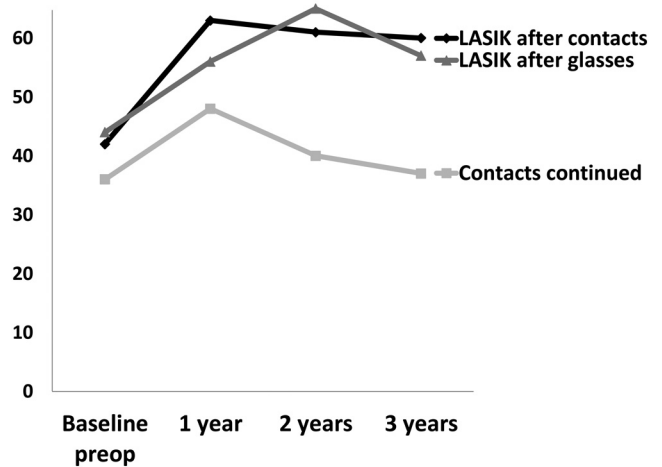
**Artificial Tear Use**

The proportion of patients reporting no artificial tear use was comparable between groups at baseline (76% in all 3 groups) but declined in the contact lens control group to 68% to 69% in the



**Figure 3.** Responses at year 3 to the following question asked of those who had LASIK after wearing contact lenses at baseline: “At this time do you believe that LASIK works better for you than contact lenses?”

**No difficulty driving at night (%)**



**Figure 4.** Proportions who reported no difficulty driving at night because of vision at baseline (using contact lenses or glasses) and at 1, 2, and 3 years after LASIK or with continued contact lens use, by vision correction group.

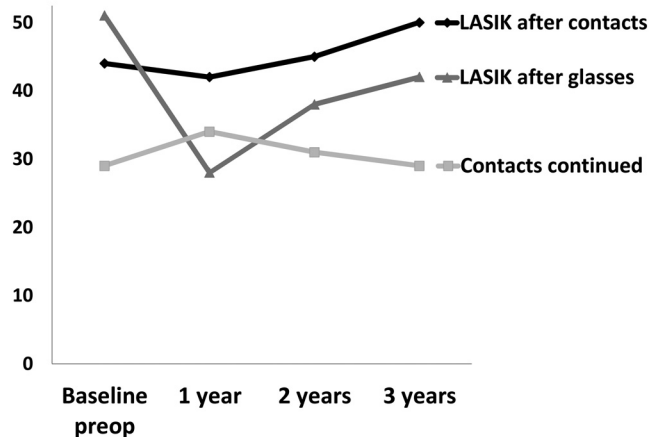
1- to 3-year follow-up surveys. Artificial tears are commonly prescribed after LASIK. Among those who had LASIK after wearing contact lenses, the proportion using no artificial tears decreased from 76% preoperatively to 54% at 1 year and increased to 67% at 3 years, which was comparable to the proportion using no artificial tears in the contact lens control group ( $P = 0.12$ ). Among those who had LASIK after wearing glasses, the proportion using no tears decreased more dramatically from 77% at baseline to 39% at 1 year and increased to 60% at 3 years.

Although it could be expected that those experiencing dry eyes after LASIK would use artificial tears, 41% of the patients who reported occasional dry eyes after LASIK reported no artificial tear use. Among those reporting dry eyes half the time or most of the time, 7% and 12%, respectively, were not using tears.

**Small Print**

At baseline, the proportion with no difficulty reading small print was comparable between the contact lens control group and the

**No dry eyes (%)**



**Figure 5.** Proportions who reported no feelings of dry eyes during the previous week at baseline (using contact lenses or glasses) and at 1, 2, and 3 years after LASIK or with continued contact lens use, by vision correction group.

glasses users who subsequently had LASIK ( $P = 0.18$ ) but higher among the contact lens users who subsequently had LASIK ( $P < 0.0001$ ). The proportion without difficulty reading small print did not change substantially from baseline to 3 years in any of the groups (from 55% to 57% in the contact lens control group; from 67% to 72% in the LASIK after contacts group; and from 51% to 47% in the LASIK after glasses group) (Table 2). In multivariate analysis, the age at baseline ( $P < 0.0001$ ) and difficulty reading small print at baseline ( $P < 0.0001$ ) were significant predictors of difficulty reading small print at 3 years.

## Depression

Two survey questions inquired about any feelings of depression or little interest in doing things during the previous 2 weeks. Both resulted in similar proportions reporting none (Table 2), and there was no evidence of increased rates of depression relative to baseline on the 1-, 2-, or 3-year follow-up surveys in any of the vision correction groups.

## Infection, Ulceration, and Abrasion

In 2346 surveys completed 1, 2, or 3 years after LASIK, there were 84 eye infections (4%), 11 ulcers (<1%), and 41 abrasions (2%) reported to occur in the year before the survey. In contrast, the proportions were more than 2-fold higher in the 1358 annual surveys completed by the control group who continued to wear contacts, with 117 infections (9%), 21 ulcers (2%), and 69 abrasions (5%).

## Discussion

This study found the proportion of strongly satisfied patients was significantly higher after LASIK compared with continued contact lens wear. It also answered questions about concerns that have been raised in the past about LASIK, including night-driving vision, visual disturbances such as starbursts or haloes around bright lights at night, difficulty reading small print, dry eyes, and depression.<sup>8–12</sup>

At 3 years, satisfaction was stronger with LASIK than with contacts; 54% of those using contacts strongly recommended their vision correction method compared with 88% of those who had LASIK after wearing contacts and 77% of those who had LASIK after wearing glasses preoperatively. When the group that self-selected to abandon contact lens wear and have LASIK was asked whether LASIK worked better for them than contact lenses, 97% of those who had LASIK after wearing contacts strongly agreed (87%) or agreed (10%). Across all groups, 1% said that they were unlikely to recommend their current form of vision correction to others, and 1.5% of patients with LASIK versus 3% of contacts wearers were unsure about recommending.

Satisfaction with LASIK was particularly strong among patients who were aged less than 40 years when treated. Consistent with other studies, 31% of the study patients were aged 40 years or more when they had LASIK. Although satisfaction may not be as strong in presbyopic patients who need reading glasses after having vision corrected for distance, those older than 40 years of age still expressed a high level of satisfaction with LASIK and a strong preference for LASIK relative to previous contact lens wear.

LASIK reduced night-driving difficulties and night vision disturbances for both those previously in contacts and those previously in glasses. Increased night-driving difficulties after LASIK used to be a concern with earlier excimer lasers that had smaller diameter ablations and blend zones and did not incorporate wavefront optimization.<sup>2,13</sup> The present study found that modern excimer lasers and ablation patterns can significantly improve night vision relative to contact lenses or glasses.

Dry eye sensation was prevalent among the contact lens wearers in this study and was a leading reason given for contact lens discontinuation, consistent with findings in other studies.<sup>14</sup> A transient increase in dry eye symptoms is commonly reported after LASIK.<sup>15</sup> Among those who previously used contacts, the proportion reporting no dry eye symptoms decreased slightly at 1 year but was somewhat higher at 2 and 3 years after LASIK relative to the baseline preoperative level. In contrast, among those who wore glasses at baseline, the proportion reporting no dry eye symptoms was substantially lower at 1 year after LASIK and despite improvement had not yet recovered to the baseline level by 3 years, and the proportion reporting dry eyes most to all of the time increased after LASIK. Approximately 74% of those wearing glasses at baseline said they previously tried and discontinued contact lens wear, often because of dry eye problems, suggesting that a tendency toward dry eyes may be common and not as obvious in LASIK candidates who primarily use glasses for vision correction. This suggests these patients should be asked about any history of contact lens intolerance.

Surprisingly, 34% of those who reported dry eye symptoms after LASIK said they were not using any artificial tears, although they are commonly prescribed. Some may be adverse to the inconvenience of buying, carrying, and dropping tears, and some with mild dry eyes may not view it as a significant problem. In any case, it is a concern because dryness can potentially cause regression of the LASIK treatment effect from epithelial hyperplasia.<sup>16</sup>

A small but vocal group of people have claimed that they became depressed after having LASIK.<sup>17</sup> We did not detect any significant increase in the proportion of patients reporting feelings of depression during the 3-year study period after LASIK or in the control group that continued contact lens wear.

Infectious keratitis is a concern with contact lenses, particularly with overnight wear.<sup>18–20</sup> The self-reported rates of eye infections and abrasions were significantly lower after LASIK than with continued contact lens use.

This study is distinctive in comparing LASIK with a control group that continued to use contact lenses for vision correction. Without such a control group, one may lose sight of outcomes relative to real-life options and end up comparing outcomes with a hypothetical perfect eye, which does not exist. Contact lens wear is a popular choice for visual correction that, like LASIK, provides more functional and aesthetic results than wearing glasses, and so we believe it is an appropriate benchmark to compare with LASIK.

In addition to the inclusion of a contact lens control group, other strengths of this study were the large sample size, the range of sites distributed across the United States,

the broad sampling of self-reported outcomes with any of the contact lens or LASIK technologies in use during the enrollment period, and the longitudinal design with 3-year follow-up. Also, the surveys were self-administered, which might elicit more honest responses than the use of an interviewer, who could introduce bias.

Among the study limitations are that self-reported outcomes are inherently subjective and may be influenced by the Hawthorne effect (tendency to feel more positive about a subject because of extra attention)<sup>21</sup> and preventing cognitive dissonance (discomfort from inconsistent/negative feelings about one's choices, such as having surgery).<sup>22</sup> Also, the study was not designed to validate the subjective responses with objective measures of vision.

In conclusion, the proportion expressing strong satisfaction with their current method of vision correction was substantially higher among patients who received LASIK than in the patients in the control group who continued contact lens wear. Satisfaction was especially high among those who were younger than 40 years of age when they had LASIK. LASIK reduced night-driving difficulties and night vision disturbances relative to both contact lenses and glasses. Dry eyes increased after LASIK among former glasses wearers, many of whom reported that they had tried and abandoned contact lenses because of dry eye problems. However, dry eye symptoms were not significantly increased relative to the preoperative level at 1, 2, or 3 years after LASIK among those who used contacts at baseline. Compared with continued contact lens wear, LASIK substantially reduced the self-reported rates of eye infections and abrasions.

**Acknowledgments.** The authors appreciate the statistical expertise provided by Gary Stevens, PhD, DynaStat Consulting.

## References

- Vitale S, Ellwein L, Cotch MF, et al. Prevalence of refractive error in the United States, 1999-2004. *Arch Ophthalmol* 2008;126:1111-9.
- Stanley PF, Tanzer DJ, Schallhorn SC. Laser refractive surgery in the United States Navy. *Curr Opin Ophthalmol* 2008;19:321-4.
- Centers for Disease Control and Prevention, Cope JR, Collier SA, Rao MM, et al. Contact lens wearer demographics and risk behaviors for contact lens-related eye infections — United States, 2014. *MMWR Morb Mortal Wkly Rep* 2015;64:865-70. Available at: <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6432a2.htm>. Accessed March 23, 2016.
- Statista. Number of LASIK surgeries in the United States from 1996 to 2014. Available at: <http://www.statista.com/statistics/271478/number-of-lasik-surgeries-in-the-us/>. Accessed March 23, 2016.
- Wilson SE. Use of lasers for vision correction of nearsightedness and farsightedness. *N Engl J Med* 2004;351:470-5.
- Sutton GL, Kim P. Laser in situ keratomileusis in 2010 — a review. *Clin Exp Ophthalmol* 2010;38:192-210.
- U. S. Food and Drug Administration. LASIK Quality of Life Collaboration Project. Available at: <http://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/SurgeryandLifeSupport/LASIK/ucm190291.htm#results>. Accessed March 23, 2016.
- Solomon KD, Fernandez de Castro LE, Sandoval HP, et al; for the Joint LASIK Study Task Force. LASIK world literature review; quality of life and patient satisfaction. *Ophthalmology* 2009;116:691-701.
- Brown MC, Schallhorn SC, Hettinger KA, Malady SE. Satisfaction of 13,655 patients with laser vision correction at 1 month after surgery. *J Refract Surg* 2009;25:S642-6.
- Pasquali TA, Smadja D, Savetsky MJ, et al. Long-term follow-up after laser vision correction in physicians: quality of life and patient satisfaction. *J Cataract Refract Surg* 2014;40:395-402.
- Pesudovs K, Garamendi E, Elliott DB. A quality of life comparison of people wearing spectacles or contact lenses or having undergone refractive surgery. *J Refract Surg* 2006;22:19-27.
- Tahzib NG, Bootsma SJ, Eggink FA, et al. Functional outcomes and patient satisfaction after laser in situ keratomileusis for correction of myopia. *J Cataract Refract Surg* 2005;31:1943-51.
- Villa-Collar C, Gutierrez R, Jimenez JR, et al. Night vision disturbances after successful LASIK surgery. *Br J Ophthalmol* 2007;91:1031-7.
- Dumbleton K, Woods CA, Jones LW, Fonn D. The impact of contemporary contact lenses on contact lens discontinuation. *Eye Contact Lens* 2013;39:93-9.
- De Paiva CS, Chen Z, Koch DD, et al. The incidence and risk factors for developing dry eye after myopic LASIK. *Am J Ophthalmol* 2006;141:438-45.
- Spadea L, Fasciani R, Necozone S, Balestrazzi E. Role of the corneal epithelium in refractive changes following laser in situ keratomileusis for high myopia. *J Refract Surg* 2000;16:133-9.
- U. S. Food and Drug Administration. Summary minutes of the Medical Devices Advisory Committee Ophthalmic Devices Panel meeting, April 25, 2008. Available at: <http://www.fda.gov/ohrms/dockets/ac/08/minutes/2008-4353m1.htm>. Accessed February 16, 2016.
- Smith AF, Osborn G. Estimating the annual economic burden of illness caused by contact lens-associated corneal infiltrative events in the United States. *Eye Contact Lens* 2012;38:164-70.
- Keay L, Stapleton F, Schein O. Epidemiology of contact lens-related inflammation and microbial keratitis: a 20-year perspective. *Eye Contact Lens* 2007;33:346-53.
- Centers for Disease Control and Prevention. Healthy Contact Lens Wear and Care. Available at: <http://www.cdc.gov/contactlenses/>. Accessed February 16, 2016.
- McCarney R, Warner J, Iliffe S, et al. The Hawthorne Effect: a randomized, controlled trial. *BMC Med Res Methodol* 2007;7:30.
- Festinger L. Cognitive dissonance. *Sci Am* 1962;207:93-107.

## Footnotes and Financial Disclosures

Originally received: March 1, 2016.

Final revision: March 29, 2016.

Accepted: April 4, 2016.

Available online: May 18, 2016.

Manuscript no. 2016-436.

<sup>1</sup> Cornea Research Foundation of America, Indianapolis, Indiana.

<sup>2</sup> Bucci Laser Vision Institute, Wilkes-Barre, Pennsylvania.

<sup>3</sup> Durrie Vision, Leawood, Kansas.

<sup>4</sup> Bond Eye Associates, Peoria, Illinois.

<sup>5</sup> Price Vision Group, Indianapolis, Indiana.

Presented at: American Academy of Ophthalmology Meeting Paper, October 2014, Chicago, Illinois (interim results).

Financial Disclosure(s):

The author(s) have made the following disclosure(s): M.O.P. and F.W.P.: Personal fees – Staar Surgical and Transcend; Grants – Bausch & Lomb; and other from Calhoun Vision, TearLab, RevitalVision, Interactive Medical Publishing, and Alphaeon, outside the submitted work.

F.A.B.: Personal fees – Abbott Medical Optics, Allergan, Bausch & Lomb, Glaukos, LENSAR, Omeros, Omega Health, and ReFocus Group; and other from Alphaeon, outside the submitted work.

D.S.D.: Personal fees, nonfinancial support, and other – Acufocus and Alphaeon; Personal fees and nonfinancial support – Alcon and Abbott Medical Optics, outside the submitted work.

W.I.B.: Reports other from Alphaeon, outside the submitted work.

The Cornea Research Foundation of America and the participating physicians provided the funding for the study. No funding was provided by government or industry.

Author Contributions:

Conception and design: MO Price, FW Price

Data collection: MO Price, DA Price, Bucci, Durrie, Bond, FW Price

Analysis and interpretation: MO Price, DA Price, Bucci, Durrie, Bond, FW Price

Obtained funding: MO Price, FW Price

Overall responsibility: MO Price, DA Price, Bucci, Durrie, Bond, FW Price

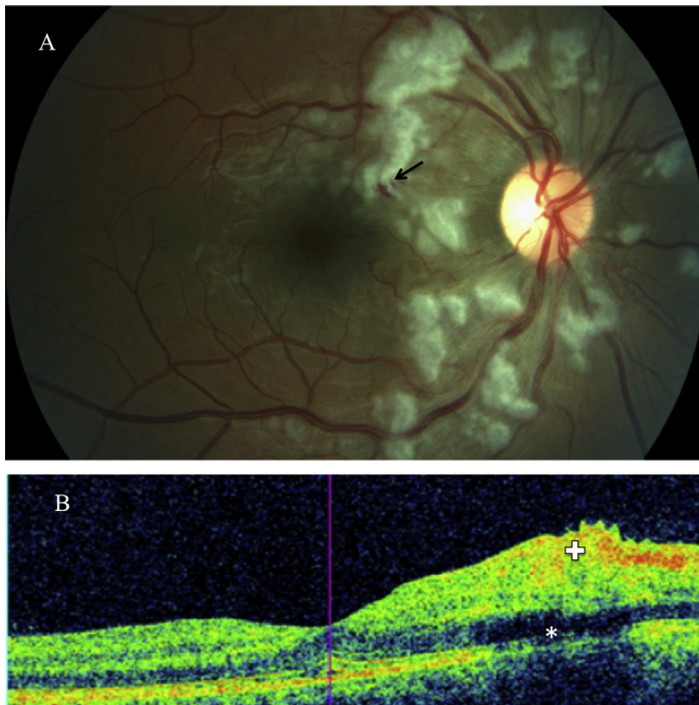
Abbreviations and Acronyms:

**D** = diopters; **LASIK** = laser in situ keratomileusis; **PROWL** = patient reported outcomes with LASIK; **SD** = standard deviation; **SE** = spherical equivalent.

Correspondence:

Marianne O. Price, PhD, Cornea Research Foundation of America, 9002 N. Meridian Street, Suite 212, Indianapolis, IN 46260. E-mail: [mprice@cornea.org](mailto:mprice@cornea.org).

## Pictures & Perspectives



### Purtscher's Retinopathy

A 24-year-old man reported “clouding” of vision in the right eye hours after jumping off a roof. He suffered contusion injuries of his left leg and scalp. Ophthalmoscopy of the right eye revealed cotton wool spots in a peripapillary configuration with macular involvement (A) and 1 flame hemorrhage (arrow). Optical coherence tomography (B) showed hyperreflectivity of the nerve fiber layer (cross) and disruption of photoreceptors (asterisk). Purtscher's retinopathy is trauma-induced embolization of retinal vasculature (likely leukocyte, platelet, fibrin, or fat emboli), with infarction of the nerve fiber layer. There is no consensus treatment.

REHAN M. HUSSAIN, MD

CHI-WAH YUNG, MD

Department of Ophthalmology, Indiana University School of Medicine, Indianapolis, Indiana