

# Visual Performance After Reduced Blinking in Eyes With Soft Contact Lenses or After LASIK

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## ABSTRACT

**PURPOSE:** To evaluate visual performance during concentrated visual work in patients wearing soft contact lenses or after LASIK.

**METHODS:** Thirty-one eyes of 17 patients who had worn soft contact lenses before LASIK were examined by the following tests immediately and 10 seconds after eye opening: 1) functional visual acuity, which is defined as visual acuity measured after prolonged eye opening without blinking; 2) surface regularity index (SRI) and surface asymmetry index (SAI) in corneal topography; and 3) higher order aberration measured with NIDEK OPD-Scan. Results were compared in the same patients before (with soft contact lenses and no eye surgery) and 1 month after LASIK (without soft contact lenses).

**RESULTS:** Functional visual acuity was significantly decreased 10 seconds after eye opening compared with immediately after eye opening, both with soft contact lenses and after LASIK, and decreased to a greater extent with soft contact lenses. The SRI and SAI were significantly increased 10 seconds after eye opening compared with immediately after eye opening, both with soft contact lenses and after LASIK, and increased to a greater extent with soft contact lenses. Higher order aberration was increased 10 seconds after eye opening with soft contact lenses, but not after LASIK.

**CONCLUSIONS:** Our results suggest that prolonged eye opening induces a decreased quality of vision in eyes of soft contact lens wearers and after LASIK. Under conditions in which blinking is restricted due to concentrated visual work, such as visual display terminal work, reading, and driving, visual performance may be more compromised with soft contact lens wear than after LASIK. [*J Refract Surg.* 2009;25:69-73.]

It is clinically known that dry eye patients sometimes complain of decreased visual acuity during reading, driving, and visual display terminal work. This may be attributable to the instability of precorneal tear film, which induces optical aberrations and a decreased quality of vision. To measure visual acuity while gazing, Goto et al<sup>1</sup> developed a “functional visual acuity (FVA)” test, which is defined as Snellen visual acuity in high contrast measured after prolonged eye opening without blinking for 10 to 20 seconds. Functional visual acuity simulates the expected visual acuity of daily life while performing the above mentioned activities. In dry eye patients, FVA significantly decreases whereas conventional best spectacle-corrected visual acuity with free blinking remains within normal limits. In addition to FVA, indices, such as the surface regularity index (SRI)<sup>2</sup> and refraction<sup>3</sup> determined by corneal topography, are altered with sustained eye opening, suggesting that the tear film becomes unstable and induces corneal irregular astigmatism while gazing. Higher order aberrations are known to increase in dry eye patients with an unstable tear film.<sup>4-6</sup>

A recent study by Nichols et al<sup>7</sup> indicated that contact lens wearers were 12 times more likely to complain of dryness than emmetropes. Others reported that the tear film on soft contact lenses becomes thinner and unstable compared to that without soft contact lenses.<sup>8</sup> These data suggest that contact lenses induce tear film instability, which leads to dry eye symptoms and objective signs such as decreased tear breakup time. Therefore, many contact lens wearers become contact lens intolerant due to dry eye and require refractive surgery such as LASIK, photorefractive keratectomy, laser epithelial

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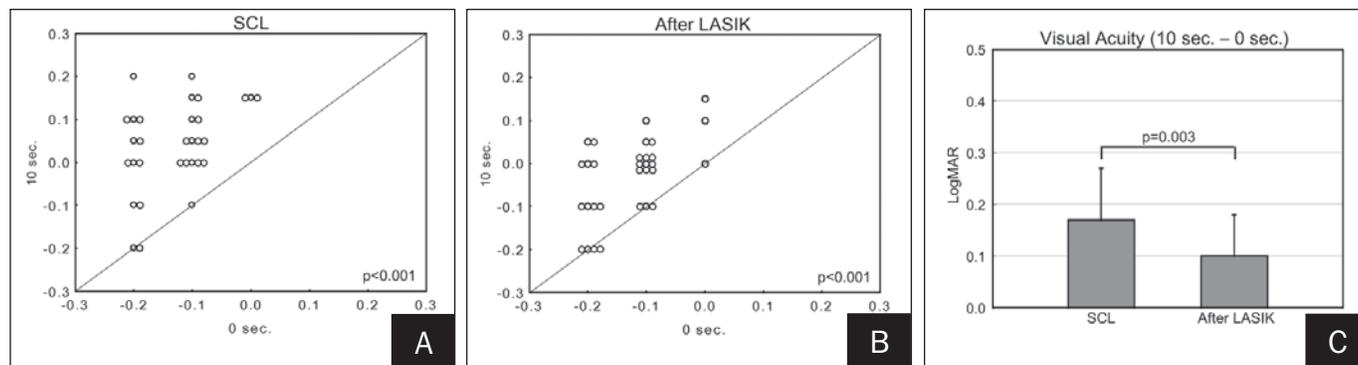
*The authors have no proprietary interest in the materials presented herein.*

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**Figure 1. A)** Functional visual acuity (FVA) at 0 seconds and 10 seconds after eye opening in eyes with soft contact lenses. **B)** FVA at 0 seconds and 10 seconds after eye opening in eyes after LASIK. **C)** The difference between values at 0 seconds (FVA0) and 10 seconds (FVA10). SCL = soft contact lens

keratomileusis, and epi-LASIK. Interestingly, LASIK surgery itself temporarily induces dry eye with tear film instability and decreases tear secretion for several weeks after surgery.<sup>9</sup> However, dry eye signs and symptoms improve within this period and patients feel better than preoperatively and are free of contact lens-related symptoms.

These facts suggest it is possible that both contact lens wearers and patients who undergo LASIK surgery experience a decreased quality of vision due to tear film instability. In this study, we measured the FVA, SRI, and higher order aberrations in eyes of soft contact lens wearers and after LASIK in the same patients, and then compared the values immediately and 10 seconds after eye opening. We also compared the change of values after 10 seconds among the eyes with soft contact lenses and those after LASIK.

**PATIENTS AND METHODS**

Thirty-one eyes of 17 patients who had worn soft contact lenses before LASIK surgery were enrolled in this study. Mean patient age was  $30.8 \pm 7.6$  years and preoperative refraction was  $-5.84 \pm 0.51$  diopters (D). All patients were examined before surgery (with soft contact lenses and no eye surgery) and 1 month post-operatively (without soft contact lenses).

The following three tests were performed immediately and 10 seconds after eye opening. The FVA was measured using a Continuous Functional Visual Acuity Measurement Device (NIDEK, Aichi, Japan). The test commences with the smallest recognizable Landolt’s ring under full refractive correction. With the patient’s eyes remaining open, the monitor continuously displays different Landolt’s rings depending on the patient’s response using a joystick. If the patient makes a correct response, the next target will be of the same size as the preceding one. If the patient makes an incorrect response or fails to respond after 2 seconds, a one-step larger target is shown. The FVA at 0

seconds and 10 seconds after eye opening was defined as FVA0 and FVA10, respectively. The SRI and surface asymmetry index (SAI) were measured every second after eye opening using a TMS-2 topography unit (Tomey, Nagoya, Japan). The values at 0 seconds and 10 seconds were defined as SRI0 and SAI0, and SRI10 and SAI10, respectively. Total higher order aberration, spherical-like aberration, and coma-like aberration were measured using OPD-Scan (NIDEK) at 0 seconds and 10 seconds after eye opening and defined as HOA0 and HOA10, respectively.

The changes of values at 0 to 10 seconds were compared before and after LASIK. Statistical analysis was performed using Wilcoxon test, and a *P* value <math>< 0.05</math> was considered significant.

**RESULTS**

**FUNCTIONAL VISUAL ACUITY**

The FVA10 was significantly decreased compared to the FVA0 in eyes with soft contact lenses and eyes after LASIK (Figs 1A and 1B). The difference between FVA0 and FVA10 in eyes with soft contact lenses was significantly greater than that in eyes after LASIK (Fig 1C).

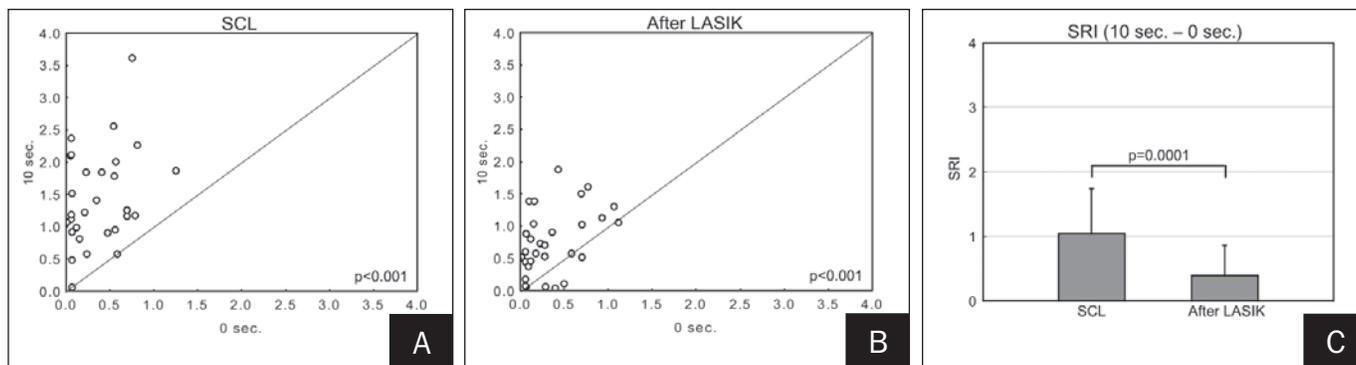
**SURFACE REGULARITY INDEX AND SURFACE ASYMMETRY INDEX**

The SRI10 was significantly increased compared to SRI0 in eyes with soft contact lenses and eyes after LASIK (Figs 2A and 2B). The difference between SRI0 and SRI10 in eyes with soft contact lenses was significantly greater than that in eyes after LASIK (Fig 2C).

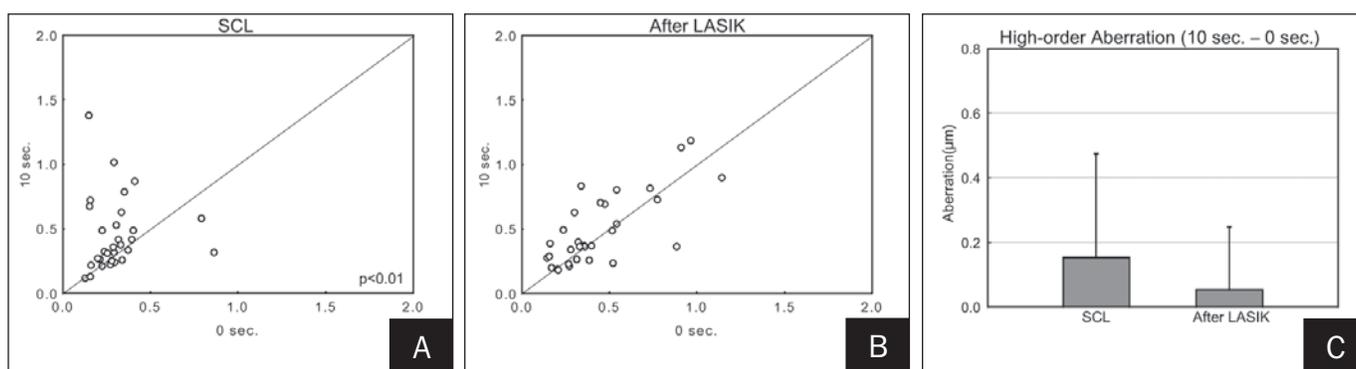
The SAI10 was significantly increased compared to SAI0 in eyes with soft contact lenses and eyes after LASIK. The difference between SRI0 and SRI10 in eyes with soft contact lenses was significantly greater than that in eyes after LASIK.

**HIGHER ORDER ABERRATIONS**

For the total higher order aberrations, spherical-like



**Figure 2.** **A**) Surface regularity index (SRI) at 0 seconds and 10 seconds after eye opening in eyes with soft contact lenses. **B**) SRI at 0 seconds and 10 seconds after eye opening in eyes after LASIK. **C**) The difference between values at 0 seconds (SRI0) and 10 seconds (SRI10). SCL = soft contact lens



**Figure 3.** **A**) Total higher order aberration (HOA) at 0 seconds and 10 seconds after eye opening in eyes with soft contact lenses. **B**) Total HOA at 0 seconds and 10 seconds after eye opening in eyes after LASIK. **C**) The difference between values at 0 seconds (Total HOA0) and 10 seconds (Total HOA10). SCL = soft contact lens

higher order aberrations, and coma-like higher order aberrations, the values at 10 seconds were significantly increased compared to the values at 0 seconds in the eyes with soft contact lenses, but not in the eyes after LASIK (Figs 3A, 3B, 4A, 4B, 5A, and 5B). There was no difference between the values at 0 seconds and 10 seconds in eyes with soft contact lenses and eyes after LASIK in total higher order aberration and coma-like higher order aberration (Figs 3C and 5C), whereas the difference was significantly greater in eyes with soft contact lenses compared to eyes after LASIK in spherical-like higher order aberration (Fig 4C).

**DISCUSSION**

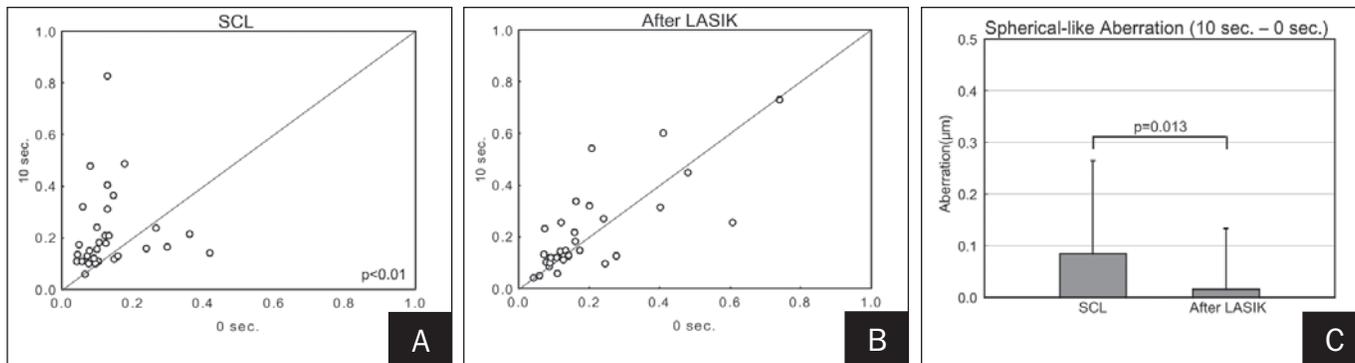
Recently, the significance of visual quality has been taken into consideration in refractive correction such as the use of contact lenses, laser refractive surgery, cataract surgery, and keratoplasty. Wavefront-guided LASIK is one such technology used to obtain a higher quality of vision.<sup>10,11</sup> Visual quality involves not only instant visual acuity but also visual function during everyday life; this is associated with factors such as inter-blinking interval, humidity, and impact of lighting levels. Visual function during concentrated visual work, such as reading, driving, and computer work,

should be influenced by blink rate and tear film stability on the ocular surface. When a person keeps his eyes open for 10 seconds, ocular surface irregularity increases due to tear film breakup, resulting in decreased visual function.<sup>12</sup>

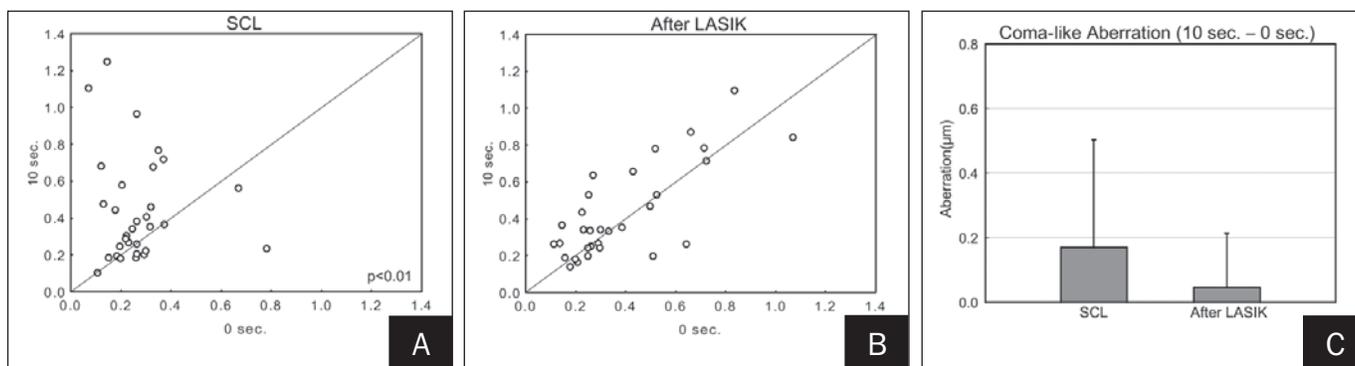
In our study, the SAI and SRI of corneal topography had increased 10 seconds after eye opening in the eyes with soft contact lenses and 1 month after LASIK, suggesting that the precorneal tear film is unstable in these situations. The FVA decreased during 10 seconds, probably due to induced irregular astigmatism caused by tear film instability on the cornea.

Goto et al<sup>3</sup> reported that the FVA after 10 to 20 seconds of sustained eye opening decreased in dry eye patients, whereas the FVA did not change for this period in patients without dry eye. This suggests that our patients had dry eye when they wore soft contact lenses and after LASIK. A number of researchers have previously reported that the tear film on the ocular surface becomes unstable, resulting in dry eye symptoms in soft contact lens wearers<sup>13-16</sup> and in patients after LASIK.<sup>17,18</sup>

For the measurement of tear film stability on the cornea, tear film breakup time determined with fluorescein is the most popular technique. However, the



**Figure 4.** **A**) Spherical-like higher order aberration (HOA) at 0 seconds and 10 seconds after eye opening in eyes with soft contact lenses. **B**) Spherical-like HOA at 0 seconds and 10 seconds after eye opening in eyes after LASIK. **C**) The difference between values at 0 seconds (spherical-like HOA0) and 10 seconds (spherical-like HOA10). SCL = soft contact lens



**Figure 5.** **A**) Coma-like higher order aberration (HOA) at 0 seconds and 10 seconds after eye opening in eyes with soft contact lenses. **B**) Coma-like HOA at 0 seconds and 10 seconds after eye opening in eyes after LASIK. **C**) The difference between values at 0 seconds (coma-like HOA0) and 10 seconds (coma-like HOA10). SCL = soft contact lens

tear film stability analysis system developed by Goto et al<sup>3</sup> can be used to evaluate tear film stability more objectively and less invasively than fluorescein breakup time. The authors defined a change of corneal power in color map >0.50 D as an indication of tear breakup. They measured the time from eye opening to breakup and total area of breakup and compared these values before and after LASIK. They found that both values decreased after LASIK but had recovered by 6 months postoperative.<sup>17</sup> Our measurement of SAI and SRI during eye opening is a modification of the original tear film stability analysis system and also evaluates tear stability on the ocular surface while gazing.

Optical aberrations are also affected by the tear film on the ocular surface. Previous studies have demonstrated that higher order aberrations in dry eye patients are greater than in normal controls.<sup>4</sup> Punctal occlusion in dry eye patients after LASIK significantly reduces higher order aberrations.<sup>6</sup> In our patients, prolonged eye opening with soft contact lenses, but not after LASIK, induced an increase in total and coma-like higher order aberrations. A significantly compromised FVA, along with increased SAI and SRI, during 10-second eye opening was observed in the eyes with soft

contact lenses. These results indicate that the tear film is more unstable on the cornea with a soft contact lens than on the cornea after LASIK.

The potential mechanisms of tear film instability on soft contact lenses include increased evaporation and poor hydrophilia due to the lack of biocompatibility. Dryness is more pronounced in eyes with soft contact lenses possessing a higher water content.<sup>8,14</sup> Such contact lens-related dry eye is speculated to be associated with decreased visual performance. Thai et al<sup>16</sup> reported that contrast sensitivity is significantly reduced when the precontact lens tear film dries and breaks up. Patients experience and complain of decreased quality of vision as well as dry eye symptoms, particularly during concentrated visual work. These symptoms associated with contact lens intolerance often persuade patients to seek refractive surgery—this is a convenient solution for them as it improves their quality of life. Dry eye after LASIK affects visual performance for a short period; it is a self-limited complication that persists for only a few months after surgery.

Prolonged eye opening during daily activities decreases the quality of vision in soft contact lens wearers and dry eye patients after LASIK. Dry eye treatments,

such as artificial tears<sup>19-21</sup> and punctal occlusion,<sup>6</sup> may help improve the symptoms in both situations. Because the quality of vision of eyes with soft contact lenses is more compromised than that after LASIK in some patients, LASIK is a reasonable indication for symptomatic dry eye patients with soft contact lenses.

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