

Change in the accommodative convergence per unit of accommodation ratio after bilateral laser in situ keratomileusis for myopia in orthotropic patients

Prospective evaluation

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PURPOSE: To analyze the effect of bilateral laser in situ keratomileusis (LASIK) on the accommodative convergence per unit of accommodation (AC/A) ratio in otherwise normal orthotropic myopic patients.

SETTING: Cornea and refractive services of a tertiary-care ophthalmic center.

METHODS: This prospective clinical trial consisted of 61 myopic patients who had bilateral LASIK. Those with manifest tropia, previous squint surgery, amblyopia, or absent or impaired binocularity or those in whom monovision was planned were excluded. The preoperative examination included visual acuity, cycloplegic refraction, assessment of binocularity, a prism cover test, and evaluation of the stimulus AC/A ratio by the gradient method. All patients had LASIK using the Zyoptix platform (Bausch & Lomb). Postoperative evaluation included uncorrected and best corrected visual acuities, residual refraction, and the AC/A ratio.

RESULTS: All patients had a follow-up of 9 months. There was significant decrease in the mean AC/A ratio at the 1-week and 1-month follow-ups. The AC/A progressively recovered to near preoperative values between 3 months and 9 months after surgery (analysis of variance test). There was a significant reduction in the number of symptomatic patients from the first month onward (chi square = 89.23; $P < .001$).

CONCLUSIONS: The AC/A ratio varied after LASIK, stabilizing between 3 months and 9 months after surgery. This suggests that the maximum variation in the accommodation–convergence relationship after LASIK occurs in the first 3 months.

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The accommodative convergence per unit of accommodation (AC/A) ratio is an established method for assessing the relationship between 2 important components of the near reflex mechanism; that is, convergence and accommodation. Studies show that the AC/A ratio can alter after surgical correction of strabismus and with increasing age.^{1–3}

Laser in situ keratomileusis (LASIK) induces a state of emmetropia in a patient with previous myopia, suddenly increasing the amount of accommodation required for near vision. Moreover, in the absence of the prismatic effect of concave glasses, the convergence required for near fusion is also altered in

myopia. However, there is a paucity of literature on prospective evaluation of changes in the accommodation–convergence relationship after LASIK. This study analyzed the effect of bilateral LASIK on the AC/A ratio in otherwise normal orthotropic myopic patients.

PATIENTS AND METHODS

The prospective trial comprised 61 patients who had bilateral LASIK for correction of myopia at the cornea and refractive services of a large tertiary-care ophthalmic center. All patients provided written informed consent. Those with manifest tropia, a history of squint surgery, amblyopia, or

absent or impaired binocular vision and those in which monovision was planned were not included in the study.

The preoperative evaluation included Early Treatment Diabetic Retinopathy Study visual acuity, cycloplegic refraction under homatropine 2%, assessment of binocularity using synoptophore-based tests, and the prism cover test for a 6/6 fixation target. Assessment of the stimulus AC/A ratio was performed using the gradient method described by Von Noorden and Campos.⁴ All patients had LASIK on the Zyoptix platform using the Technolas Ilz system and XP microkeratome (Bausch & Lomb). Both eyes were treated during the same session.

The postoperative assessment included uncorrected and best corrected visual acuities, residual refraction, and the AC/A ratio. Symptoms related to asthenopia and difficulties in near work after LASIK were assessed. Asthenopia was assessed using a questionnaire based on assessment of symptoms and their relative grading. Occasional difficulty only after prolonged reading or near work was considered a mild symptom. Symptoms that did not arise during day to day near work but were bothersome on sustained accommodative or convergent activity (eg, working on a monitor, reading fine print) were considered moderate asthenopia. Persistent asthenopia requiring cessation of all near work related activity was considered a severe symptom. In addition, the patient was asked to write down nonspecific symptoms and those not listed on the questionnaire. Dry eyes, postoperative astigmatism, or other symptoms simulating asthenopia were ruled out.

The data were analyzed using SPSS software (version 13.0, SPSS, Inc.). The analysis of variance (ANOVA) test was used to compare the change in the AC/A ratio after surgery. The Tukey honestly significant difference (HSD) test was used for intergroup comparison. The chi-square test was used for comparison of qualitative data.

RESULTS

All patients were followed for 9 months. The mean age of the 26 men and 35 women was 23.16 years \pm 2.51 (SD) (range 19 to 29 years). The mean spherical equivalent (SE) was -3.69 ± 2.52 diopters (D) in the right eye and -3.93 ± 2.32 D in the left eye. The mean interpupillary distance was 63.42 ± 2.71 mm. The mean residual SE at 9 months was -0.43 ± 0.23 D in the right eye and -0.25 ± 0.34 D in the left eye.

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Table 1. The AC/A ratios before and after LASIK.

| Exam | AC/A Ratio (deg/D) | | | |
|---------------|--------------------|--------|---------|---------|
| | Mean \pm SD | Median | Minimum | Maximum |
| Before LASIK | 3.63 \pm 1.79 | 3.93 | 0.90 | 6.13 |
| Postoperative | | | | |
| 1 week | 4.57 \pm 1.12 | 4.80 | 1.10 | 6.30 |
| 1 month | 6.54 \pm 1.05 | 6.60 | 4.40 | 11.07 |
| 3 months | 4.05 \pm 1.16 | 4.30 | 0.77 | 5.93 |
| 6 months | 4.11 \pm 1.09 | 4.30 | 0.83 | 5.66 |
| 9 months | 4.16 \pm 1.10 | 4.40 | 0.77 | 6.00 |

AC/A = accommodative convergence per unit of accommodation; LASIK = laser in situ keratomileusis

Accommodative Convergence per Unit of Accommodation Ratio

Preoperative The preoperative AC/A ratio was 3.637 deg/D (Table 1). There was no significant correlation between the ratio and refractive error, age, or sex.

Postoperative Table 2 shows the results of the between-group comparisons. There was a significant decrease in the mean AC/A ratio 1 week after LASIK ($P = .001$, post hoc Tukey HSD). At 1 month, the mean AC/A ratio was still significantly lower than before LASIK ($P = .000$, post hoc Tukey HSD). At 3 months, the mean AC/A ratio was comparable to the preoperative value ($P = .496$, post hoc Tukey HSD). No significant difference in the AC/A ratio was seen at 6 or 9 months, suggesting stabilization of the accommodation-convergence relationship.

Asthenopic Symptoms

One week after LASIK, 44 patients had at least mild asthenopic symptoms. By the end of 1 month, 27 patients had symptoms. At the 6-month follow-up, 2 patients had mild symptoms of asthenopia; the rest were asymptomatic. No patient was symptomatic at 9 months. There was a significant reduction in the number of symptomatic patients from the first month onward (chi square = 89.23; $P < .001$).

DISCUSSION

In this study, we analyzed the change in the AC/A ratio in orthotropic myopic patients who had bilateral LASIK. The assessment of this correlation between the accommodative stimulus and convergence is important because LASIK is not just a refractive procedure; it also alters the amount of accommodative response required in day-to-day activities compared to that with spectacle correction. The binocular interaction required for day-to-day activities is different

Table 2. Results of between-group comparisons.*

| Post Hoc Test | Difference of Mean | P Value (Tukey HSD) | Confidence Interval | |
|-----------------------|--------------------|---------------------|---------------------|-------|
| | | | Lower | Upper |
| Pre LASIK vs 1 week | -0.94 | .000 | -1.60 | -0.27 |
| Pre LASIK vs 1 month | -2.9 | .000 | -3.57 | -2.24 |
| Pre LASIK vs 3 months | -0.42 | .49 | -1.08 | 0.24 |
| Pre LASIK vs 6 months | -0.48 | .33 | -1.14 | 0.18 |
| Pre LASIK vs 9 months | -0.52 | .22 | -1.18 | 0.13 |

HSD = honestly significant difference; LASIK = laser in situ keratomileusis
*Between-group ANOVA comparison, $P = .000$

between myopic patients and emmetropic patients. Because the far point in myopia is between infinity and the near point, the accommodative effort required for near vision is lower than in emmetropia, in which the far point is at infinity. However, when myopia is corrected by a refractive procedure, the accommodation–convergence relationship should follow the patterns of emmetropia. This study questioned whether the above hypothesis is true and if so, what the expected time frame is for these adjustments in the accommodation–convergence arc.

We found an initial decrease in the AC/A ratio in the early postoperative period. The probable reason is an increased accommodative effort to produce the same amount of convergence in the newly induced emmetropic state.

The increased AC/A ratio 1 month after surgery provides further evidence of the unstable accommodation–convergence relationship. As the quality of accommodation effort improves with adjustment to the new emmetropic state, the amount of convergence produced per unit of accommodation probably increases. This could have resulted in the higher AC/A ratio at 1 month. With time, the AC/A ratio progressively decreased to stabilize between 3 months and 6 months after surgery. This suggests that the maximum variation in the accommodation–convergence relationship after LASIK occurs within the first 3 months.

Earlier studies^{5,6} show that the AC/A ratios in emmetropic patients are lower than those in myopic

patients. Therefore, it can be concluded that the emmetropia created by LASIK tends to simulate the accommodation–convergence relationship in naturally emmetropic eyes. A change in the AC/A ratio can predict myopia.⁷ It remains to be seen whether regression after LASIK for myopia follows a similar pattern.

In conclusion, our study evaluated the changes in the accommodation–convergence relationship after LASIK. We found the AC/A ratio gradually returned to near preoperative values. This could explain some of the postoperative symptoms in the absence of gross astigmatism, flap, and ocular surface complications. This study provides evidence of a transient change in the AC/A ratio after LASIK surgery, most of which occurs in the initial months, and that the ratio stabilizes by 3 to 6 months. Larger studies are required to assess the changes in the AC/A ratio in patients with regression after LASIK. It would also be worthwhile to evaluate whether the results are different after surface ablation procedures, in which wound-healing patterns are different and epithelial haze (and thus blurring and more accommodative stimulus) can occur, and whether sparing the corneal nerves causes a different AC/A ratio response.

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