

## Stereoacuity Following LASIK

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**Purpose:** To evaluate the effect of laser in situ keratomileusis (LASIK) on stereoacuity (SA).

**Methods:** This prospective study includes 200 patients scheduled for LASIK. SA was evaluated preoperatively and one week, one month and three months postoperatively using the Random Dot test. Patients with preoperative SA worse than 480 sec/arc were excluded from the study.

**Results:** The study included 138 female (69%) and 62 male (31%) subjects. Spherical equivalent was -0.5 to -12.0 D. Mean preoperative SA was  $124.80 \pm 124.64$  (range 480-15) sec/arc which deteriorated to  $138.30 \pm 126.48$  sec/arc one week after surgery ( $P=0.158$ ) but improved to  $111.30 \pm 112.15$  sec/arc ( $P=0.002$ ) one month and  $103.65 \pm 112.20$  sec/arc ( $P=0.001$ ) three months postoperatively. Overall, stereoacuity decreased in 9.5%, increased in 32.5% and remained unchanged in 58% of patients ( $P=0.007$ ). Patients with anisometropia had worse SA; eventually, SA increased in 5 non-amblyopic anisometropic patients.

**Conclusion:** Despite the overall improvement in mean SA after LASIK, a minority of patients experienced decreased SA. Anisometropic patients without amblyopia seem to have a chance for improved SA after LASIK.

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### INTRODUCTION

Vision includes different subjective aspects such as visual acuity, visual fields, contrast sensitivity, color vision and stereopsis. Stereopsis is the ability to perceive an object in three dimensions which is due to disparate stimulation of retinal elements in the eyes. This ability, in contrast to other visual functions, requires the coordination of both eyes creating a new level of visual function. Three-dimensional vision is the highest level of binocular coordination, offering a valuable measure for diagnosis of abnormalities in binocular vision and deter-

mination of certain non-surgical treatments. Three-dimensional vision occurs when there is an amount of disparity between retinal images in each eye, but not to an extent which diplopia occurs. For each person, a minimum amount of disparity exists to allow three-dimensional vision which is called stereoacuity (SA). Binocular vision is evaluated for assessment of visual function in children and before employment in certain critical professions such as pilotage or surgery.<sup>1</sup>

Keratorefractive surgery, especially laser in situ keratomileusis (LASIK), has become very popular nowadays. This type of surgery elimi-

nates the minification or magnification effect of glasses, which could theoretically increase image disparity. Moreover, LASIK may affect other aspects of visual function related to stereopsis such as contrast sensitivity. Various studies have evaluated the effect of LASIK on contrast sensitivity; however, the results have been controversial and inconsistent.<sup>2-6</sup> Furthermore, refractive surgery may eliminate aniseikonia to a great degree and it has been proved that changes in aniseikonia exceeding a certain limit are detrimental to SA. It has also been found that use of sunglasses decreases SA more than visual acuity.<sup>7</sup> Similarly, minor corneal opacification following keratorefractive surgery may adversely affect SA. The present study was designed in a before-after fashion to evaluate the effect of LASIK on SA.

## METHODS

This prospective study was performed on 200 myopic patients with myopia less than -12 D who were scheduled for LASIK. Patients with any contraindications for refractive surgery, monocular cases and those in whom SA was not measurable by Randot (Random dot) test (i.e. SA worse than 480 sec/arc) were excluded. Eligible patients underwent a complete ophthalmologic examination including cycloplegic refraction, best-corrected visual acuity (BCVA) and slitlamp biomicroscopy. SA was measured using Randot test. To eliminate learning effect of the test, patients were initially trained in a group session and were then given enough time to get familiar with the test before finally undergoing assessment. Randot and other ophthalmic tests were repeated one week and one and three months postoperatively. All LASIK procedures were performed by one surgeon (H.R.) and all pre- and postoperative examinations were performed by one ophthalmologist (M.R.A).

Since the results of Randot are non-linear and the Kolmogorov-Smirnov test rejected the hypothesis of data normality, we used the non-parametric Wilcoxon test for statistical analysis with significance set at 0.05.

## RESULTS

The study was performed on 396 eyes of 200 patients including 138 (69%) female and 62 (31%) male subjects with mean age of  $26 \pm 6.3$  (range 18-45) years. Mean preoperative spherical equivalent refractive error was  $-4.5 \pm 2.3$  D (range -0.5 to -12 D). Mean SA was  $124.80 \pm 124.64$  sec/arc preoperatively, which slightly but insignificantly deteriorated to  $138.30 \pm 126.484$  sec/arc one week postoperatively ( $P=0.158$ ) but later significantly improved to  $111.30 \pm 112.15$  sec/arc ( $P=0.002$ ) and  $103.65 \pm 112.20$  sec/arc ( $P<0.001$ ), one and three months after the procedure respectively. SA improved in 65 patients (32.5%), deteriorated in 19 patients (9.5%) and remained unchanged in 116 patients (58%) three months postoperatively ( $P=0.007$ ). Table 1 details the distribution of patients according to pre- and postoperative SA. Gender had no effect on SA, however the smallest amount of change in SA was observed in patients older than 36 years. Eleven patients had anisometropia greater than 2 D with mean SA of  $248.9 \pm 273.1$  sec/arc preoperatively, of whom four subjects had some degree of amblyopia. Out of 7 non-amblyopic anisometropic patients, five cases demonstrated improvement in SA while two patients showed no change in SA.

**Table 1** Distribution of patients according to stereoacuity.

Stereoacuity (sec/arc)	No (%)			
	Pre-op	1 wk	1 mon	3 mon
≤15	1 (0.5)	0	1 (0.5)	1 (0.5)
16-30	40 (20)	24 (12)	45 (22.5)	58 (29)
31-60	70 (35)	63 (31.5)	68 (34)	66 (33)
61-120	51 (25.5)	73 (26.5)	58 (29)	51 (85.5)
121-240	22 (11)	20 (10)	15 (7.5)	11 (5.5)
241-480	16 (8)	20 (10)	13 (6.5)	13 (6.5)

Chi-square test,  $P=0.007$

## DISCUSSION

Stereopsis is an important aspect of binocular vision. Despite being an easy procedure and the lack of need for complicated instruments, measurement of SA is not routinely performed

in the preoperative evaluation of keratorefractive procedures and outcomes of refractive surgery are usually evaluated only in the monocular state. There are only a few case reports assessing SA after keratorefractive procedures. Studies have shown that refractive surgery may result in diplopia or even strabismus. Marmer et al<sup>8</sup> reported a patient with history of strabismus surgery who developed esotropia after radial keratotomy. Mandava et al<sup>9</sup> described diplopia in a patient with compensated esotropia after photorefractive keratectomy. Holland et al<sup>10</sup> reported permanent diplopia following LASIK in a case of high myopia. Yap and Kowal<sup>11</sup> presented a case of postoperative vertical diplopia in a patient with preoperative esophoria. On the other hand, Liu et al<sup>12</sup> concluded that eliminating anisometropia improves binocular vision and SA in patients with anisometropia >2.5 D but has no effect in cases with anisometropia <2.5 D.

Godts et al<sup>13</sup> evaluated five patients who had developed diplopia and decreased SA following keratorefractive surgery. Change or elimination of the prismatic effect of glasses, under-correction in the dominant eye leading to elimination of the dominance effect, decentration of the ablated area and the resultant change in the angle of phoria, creation of anisometropia and changes in the location of the nodal point were reported as factors causing diplopia or reducing SA. The latter factor can explain decreased SA after monovision state induced by keratorefractive surgery.<sup>14-16</sup> On the other hand, factors which may positively influence SA include correction of anisometropia, elimination of the minification and prismatic effect of glasses and improved UCVA or BCVA.<sup>17,18</sup>

In our study, SA improved in 32.5% and deteriorated in 9.5% of cases, however mean SA improved overall. To our knowledge no other study has addressed changes in SA in patients undergoing keratorefractive surgery with correction targeted at emmetropia in both eyes. Improvement in SA can be explained by elimination of the prismatic effect of spectacles, enhanced quality of the vision in both eyes,

correction of anisometropia or even learning effect related to the test procedure. SA deterioration may be due to factors mentioned by Godts et al<sup>13</sup> or other factors such as decreased UCVA, lower order aberrations and corneal opacifications. In the present study, anisometropic patients had lower SA preoperatively which is consistent with previous studies.<sup>19</sup> Among 7 anisometropic patients without amblyopia, SA improved in 5 patients 3 months postoperatively and remained unchanged in the other two which is similar to the results reported by Liu et al.<sup>12</sup>

This study was not designed to evaluate the relationship between visual acuity and SA, we rather aimed to evaluate changes in SA as one of the most evident aspects of binocular vision following keratorefractive surgery. Therefore, we suggest evaluating the correlation between SA and other parameters such as visual acuity, contrast sensitivity and corneal aberrations.

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