

BINOCULAR VISION FOLLOWING REFRACTIVE SURGERY IN HYPEROPIC PATIENTS

VISIÓN BINOCULAR TRAS CIRUGÍA REFRACTIVA EN PACIENTES HIPERMÉTROPES

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ABSTRACT

Purpose: To evaluate the changes in binocular vision and ocular motility in hyperopic patients undergoing refractive surgery.

Methods: Prospective study of 31 consecutive patients who underwent bilateral refractive surgery for hyperopia between May 1999 and February 2002. The examination included best-corrected visual acuity, cycloplegic refraction, ocular motility, fusion at distance, stereopsis and fusional amplitudes, before and at one month, 3 months, 6 months, one year after surgery and annually thereafter.

Results: After refractive surgery, there were changes in visual acuity, residual hyperopic refractive errors, and anisometropic changes that influenced the oculomotor status. The most frequent sensory modifications were suppression at distance, with much less change in stereopsis. From the point of view of ocular motility, we found a significant tendency to esotropia in strabismic patients ($p=0.003$). In non-strabismic patients, we also found sensorimotor modifications, but of less intensity and with fewer consequences than in strabismic patients. Sensorial and/or motor decompensation appeared in

RESUMEN

Objetivo: Analizar si existen modificaciones de la visión binocular y motilidad ocular en pacientes hipermétropes operados de cirugía refractiva.

Métodos: Estudio prospectivo de 31 pacientes consecutivos operados de cirugía refractiva bilateral de hipermetropía entre mayo de 1999 y febrero de 2002. El protocolo de exploración incluyó la agudeza visual corregida, el error refractivo bajo cicloplejía, la motilidad ocular, la fusión en visión lejana, la estereopsis y el grado de amplitud de fusión, realizándose de nuevo al mes, 3 meses, 6 meses, un año y en sucesivas revisiones anuales.

Resultados: Tras la cirugía refractiva se han encontrado alteraciones de la agudeza visual, defectos hipermetrópicos residuales, así como cambios de anisometropía, que han influido en la situación oculomotora. El tipo de alteración sensorial más frecuentemente modificado ha sido la supresión de lejos, alterándose la estereopsis en mucho menor grado. Desde el punto de vista de motilidad ocular, en los pacientes estrábicos se ha encontrado una tendencia significativa en el sentido endotrópico ($p=0,003$). En los sujetos no estrábicos, aunque se han hallado modificaciones sensoriomotoras, han

Received: 8/6/05. Accepted: 20/2/06.

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Comunicación presentada parcialmente en el LXXVIII Congreso de la S.E.O. (Murcia 2002).

Los autores no tienen interés comercial ni han recibido apoyo económico en la investigación en la que se basa este artículo.

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25% of strabismic patients, and asthenopia symptoms developed in 28.7% in the same group.

Conclusions: Slight binocular modifications with no symptomatic consequences were found in patients with normal binocular vision. However ocular motility was modified towards esotropia in strabismic patients, binocular decompensation appeared in 25%, and 28.7% of them suffered from asthenopia (*Arch Soc Esp Oftalmol* 2006; 81: 107-114).

Key words: Binocular vision, refractive surgery, hyperopia, stereopsis, strabismus.

side de menor intensidad y repercusión que en los sujetos estrábitos. Un 25% de los pacientes estrábitos presentó una descompensación sensorial y/o motora, y un 28,57% del mismo grupo mostró síntomas astenópicos.

Conclusiones: En los pacientes con visión binocular normal existieron leves modificaciones binoculares que no tuvieron repercusión sintomática. Sin embargo, en los pacientes estrábitos se modificó la motilidad ocular en sentido endotrópico, se descompensó un 25% y refirió síntomas astenópicos un 28,7% de ellos.

Palabras clave: Visión binocular, cirugía refractiva, hipermetropía, estereopsis, estrabismo.

INTRODUCTION

One of the complications of refractive surgery has been the appearance of asthenopia, diplopia and strabismus decompensation. To date, this is an infrequent complication (1,2) although the true prevalence of these alterations are not known. The pathogeny thereof may include various factors such as reduction of visual acuity or sensitivity to contrast in one or both eyes, a residual refraction defect, surgery-induced anisometropia or aniseiconia (-35) or change of dominant eye. These factors may produce temporary or permanent modifications of binocular vision.

In a previous study by our group we analyzed the alteration of binocular vision caused by refractive surgery in a retrospective study of myopic and anisometropic myopic patients operated with refractive photokeratometry (PRK). Binocular instability was found in the first months after surgery, with persistence of a slight reduction of binocularity mainly due to the reduction of visual acuity and residual refraction (6).

To date, experience in hyperopia surgery has been less than in myopia surgery, characterized (among other factors) by lower predictability of its results (7,8). In addition, the binocular vision of hyperopic patients is more labile and is sometimes associated to strabismus. Their binocularity and degree of oculomotor compensation is frequently linked to the correction of their refraction, and refractive surgery could cause a decompensation (9,10).

The objective of this study is to make a retrospective analysis of the modifications in binocular vision of hypermetropic and astigmatic hypermetropic patients after refractive LASIK surgery, both in patients with normal binocular or strabismic eyesight.

SUBJECTS, MATERIAL AND METHODS

A prospective study was made of patients operated between May 1999 and February 2002 by means of Excimer laser-assisted in situ keratomileusis (LASIK) for correcting hyperopia and hyperopic astigmatism. All patients were operated by the same surgeon (AAP) with the Excimer laser MEL-70 G-Scan® (Asclepion-Meditec).

The study comprised 21 patients (10 men and 11 women) aged between 18 and 59, with mean age 29.68 SD 8.77 years. We first considered the patients with normal binocular vision (BV) (14), analyzing in second place those with strabismic alterations (17).

The evaluation protocol was identical before and after surgery. Evaluations were carried out at 1 month, 3 months, 6 months, one year after surgery and in successive annual visits. The mean follow-up time after the last surgery was 11.10 SD 7.64 months (3 to 31). The evaluation protocol included:

1. Visual acuity (VA) log MAR with best correction (Test ETDRS®). The «best eye» was the one

with best corrected visual acuity, the dominant eye in cases of suppression, the eye with lower spherical equivalent and, if no difference was found, the right eye.

2. Refraction under cyclopeggy, annotating its spherical equivalent (SE).

3. A binocular study including retinal correspondence (synoptophore Oculus[®], foveal cards), far sight suppression (vectographic test), stereopsis (Lameris test TNO[®]), scope of fusion (synoptophore Oculus, foveal cards), objective angle in synoptophore corresponding to the phoria degree in normal patients and to deviation in strabismic ones. In the latter group we also studied the type of strabismus.

From the motor point of view, 14 patients exhibited orthotropy and 17 strabismus; of these, three were congenital endotropies, nine were essential, three were accommodative and two consecutive exotropies. As regards the senses, orthotropic

patients exhibited normal retinal correspondence (NRC), 14 of the 17 strabismic patients exhibited abnormal retinal correspondence (ARC) and a further three had accommodative endotrophy and NRC. Therefore, for practical reasons, we divided the series in three subgroups, analyzing first the group with orthotropy and NRC, followed by strabismic patients with ARC and finally we described the evolution of the patient group with accommodative endotrophy and NRC.

Some differences were found before surgery between the two main groups. The strabismic group was more hyperopic than the non-strabismic group (best eye $p=0,056$, worst eye $p=0,019$). The degree of anisometropia and anisoacuity was also greater in the strabismic group, without being significant in this series (table I).

Table I illustrates the degree of motor deviation prior to surgery. In the evaluation of motor stability,

Table I. Description of the refractive and binocular characteristics of the series before and after refractive surgery, divided by sensory groups

	NON-STRABIC (SD, Range)		STRABIC (SD, Range)		ET + NRC (SD, Range)	
	Pre-LASIK	Post-LASIK	Pre-LASIK	Post-LASIK	Pre-LASIK	Post-LASIK
VA best eye (Logmar)	0.04 (0.08, 0.3 a 0)	0.03 (0.04, 0.16 a 0)	0.01 (0.01, 0.04 a 0)	0.08 (0.07, 0.22 a 0)	0.01 (0.01, 0.02 a 0)	0.01 (0.02, 0.04 a 0)
VA worst eye (Logmar)	0.06 (0.09, 0.3 a 0)	0.07 (0.06, 0.18 a 0)	0.13 (0.18, 0.54 a 0)	0.21 (0.19, 0.70 a 0.02)	0.13 (0.23, 0.40 a 0)	0.05 (0.05, 0.10 a 0)
Refraction best eye (dp)	+2.96 (2.17, -0.63 a 6.38)	+0.81 (1.16, -0.38 a +3.25)	+4.28 (1.31, +2.16 a +7.00)	+0.51 (0.57, -0.50 a +1.38)	+4.46 (1.69, +2.75 a +6.13)	+0.96 (1.16, 0 a +2.25)
Refraction worst eye (dp)	+3.34 (2.23, -0.63 a +7.00)	+0.89 (0.96, -0.50 a +2.75)	+5.16 (1.44, +3.16 a +7.75)	+1.00 (0.93, 0 a +2.50)	+4.75 (1.56, +3.00 a +6.00)	+0.92 (0.88, 0 a +1.75)
Anisoacuity (lines)	1/5 (3/5, 0 a 2)	2/5 (3/5, -3/5 a 1+3/5)	1+1/5 (1+4/5, 0 a 5+1/5)	1+2/5 (1+4/5, 0 a 6+2/5)	1+1/5 (2+1/5, 0 a 3+4/5)	2/5 (3/5, 0 a 1)
Anisometropia (dp)	0.48 (0.37, 0 a 1.00)	0.38 (0.26, 0 a 0.75)	0.88 (0.79, 0 a 3.25)	0.53 (0.56, 0 a 1.75)	0.38 (0.33, 0.13 a 0.75)	0.29 (0.26, 0 a 0.5)
Objective deviation (°)	+2.64 (4.0, -2 a +10)	+2.21 (3.0, -1 a +9)	+4.07 (4.23, -5 a +9)	+5.07 (6.15, -9 a +14)	+0.33 (1.53, -1 a +2)	+4.00 (2.65, +1 a +6)
Alteration in suppression		28.57%		28.57%		0%
Stereopsis (" arc)	132.86 (49.17, 60 a 480)	111.43 (110.03, 60 a 480)	—	—	100.00 (34.64, 60 a 120)	120.00 (103.92, 60 a 240)
Amplitude of fusion (°)	8.80 (6.67, 0 a 22)	14.21 (14.29, 2 a 46)	—	—	15.67 (19.35, 4 a 38)	16.67 (19.40, 4 a 39)
Symptomatology		0%		28.57%		0%

BV: Binocular vision; ET: endotrophy; SD: Standard Deviation; VA: Visual acuity; NRC: Normal retinal correspondence.

significant decompensation was determined when the modification was equal to or over 4°. From the sensory viewpoint, it was found that apparently normal patients exhibited mild suppression in 42.86% of cases, while all strabismic patients had intense suppression, either in a single eye (71.4%) or alternating (28.6%).

For the statistical treatment of data, the SPSS 11.0 (Windows) program was utilized (SPSS Inc, Chicago, Illinois, EEUU). The t for Student test was utilized for independent and related samples, Fisher's exact test and Pearson's correlation with bifactorial analysis. Differences were considered significant when the p value was below 0.05.

RESULTS

Table I shows the situation of patients after refractive surgery in relation to visual acuity, refraction and binocular exploration. In the analysis of results, we evaluated the sensory-motor modifications for any variation between patients with normal binocular and strabismic vision.

A mean reduction of VISUAL ACUITY vis-à-vis the initial situation was found. This reduction occurred in relationship to the initial hyperopia degree ($r = -0.276$, $p = 0.03$). Since the strabismic patients exhibited more previous hyperopia, we found in them a significant reduction of VA, both in the best eye ($p = 0.001$) and in the worst eye ($p = 0.015$), in contrast to normal patients where this reduction was not found.

After surgery we frequently identified a hypoco-rection of hyperopia. The final refraction was within a range of ± 0.50 dp in 14 of 31 patients; in a further 12, the range was $+0.50$ to $+1.50$ dp, and in five from $+1.50$ to $+3.00$ dp. Said tendency to post-surgery hyperopia occurred in similar manner in the two groups of patients.

Twenty of the 31 patients exhibited anisometropia prior to surgery (≥ 0.50 dp). In most cases (90%) it reduced, and in the rest it remained stable (mean 0.94 SD 0.60 a 0.41 SD 0.44 , $p = 0.001$).

The non-anisometric group (<0.50 dp) comprised 11 patients. Surgery induced anisometropia greater than 0.50 dp in 36,46% of cases, while in the rest it remained stable. The mean value increased from 0.14 (SD 0.13) to 0.49 (SD 0.46), a non-significant increase.

The changes in anisometropia had no sensory or symptomatic repercussion in any of the groups.

On the other hand, seven of the 31 patients exhibited previous anisoacuity greater than or equal to one line. This VA difference improved in 71.43% and worsened in 28.70% of cases, with the mean value going from 2.97 lines (SD 1.62) to 2.51 lines (SD 2.00). However, said improvement was non significant.

In addition, surgery induced anisoacuity in 20.83% of the 24 patients who did not exhibit anisoacuity previously, with the mean going from 0,09 (SD 0.19) to 0.33 (SD 0.42) lines of difference ($p = 0.006$).

Changes in anisoacuity occurred in a similar way in normal as well as strabismic patients and had no relationship with the rest of parameters. Only one patient exhibited better VA in the (initially) worst eye: he began to suppress the previously dominant eye without showing other variations or symptoms. In the rest of patients (87,5%) the anisoacuity increase was due to a VA decrease in the worst eye vis-à-vis the best one, without any subjective repercussion.

In a relevant number of patients (25.81%), the eye dominance or far fusion was modified, with similar prevalence in normal and strabismic patients. The changes were varied: we found patients who began to suppress one eye after surgery (3) and others in whom the form of suppression varied (4). Among the latter there was a change of sensory dominance, i.e., the eye which prior to surgery suppressed now became dominant, altering binocularity. Finally, another patient ceased to suppress (fig. 1).

Contrary to what may be expected, in our series we were unable to correlate to date the change of dominance with variations in anisometropia or anisoacuity, or with symptomatic repercussions.

The fusion in synoptophore remained stable in normal patients. Even though there were clinical modifications in the degree of amplitude of fusion, no significant differences were found (fig. 2). We did not find any strabismic patient exhibiting fusion or fusion amplitude after surgery.

No modifications were found in what concerns the presence or absence of stereopsis; however, we did find modifications vis-à-vis intensity. Stereopsis improved in two of the 14 normal patients and worsened in three, but these differences were not statistically significant (fig. 3).

In what concerns the stability of eye motility, we did not find any case of strabismus or diplopia in



Fig. 1: Alterations of suppression or dominance in different sensory groups.

the group of normal patients. Phoric modifications were found in 10 of 14 patients, albeit of small magnitude, variable direction and therefore not significant (fig. 4).

However, eye deviation in strabismic patients increased, both in endotropic patients ($p=0.003$) as in exotropic ones, and due to the small number of subjects it was not possible to carry out statistical analysis (fig. 5).

Accordingly, it can be considered that 57.14% of strabismic patients suffered slight decompensations ($\leq 3^\circ$) (all of them endotropic, from $+5.25^\circ$ SD 2.71 to $+7.00^\circ$ SD 2.83). A more intense decompensation ($\geq 4^\circ$) occurred in 28.57% (endotropies from $+5.50^\circ$ SD 4.95 to $+10.00^\circ$ SD 5.66; exotropies from -3.00° SD 2.83 to -7.00° SD 2.83) (table I).

A group of patients (12.90% of the total number) complained of binocular symptoms after refractive surgery. Said symptoms included headaches, dizziness, irritation when fixing the gaze and diplopia due to greater deviation after visual effort. These symptoms occurred only in the group of patients

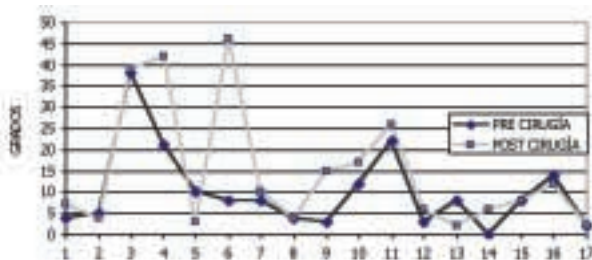


Fig. 2: Degree of fusion of amplitude before and after surgery. Patients 1-3 correspond to accommodative ET (endotrophy), while patients 4-17 are those with normal binocular vision. The mean variation was not significant.

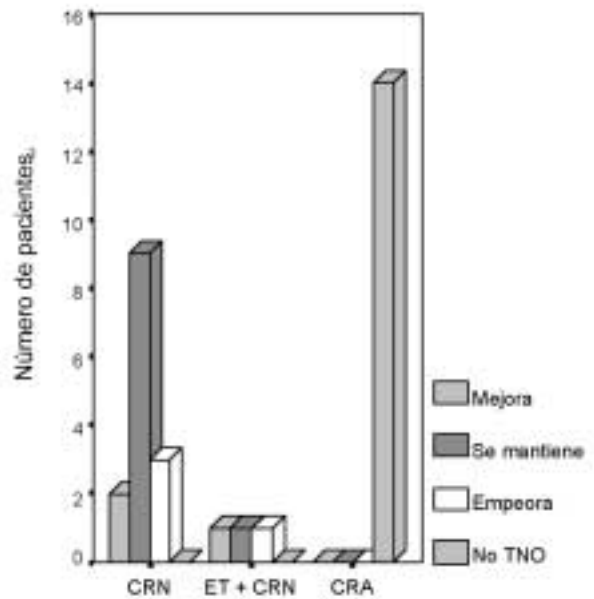


Fig. 3: Changes in stereopsis, measured with TNO test in the three sensory groups.

with previous strabismus vis-à-vis zero prevalence in normal patients. However, these symptoms were not statistically significant (Fisher= 0.098).

Finally, it is noteworthy that the group of patients with accommodative ET and NRC (3) were compensated from the motor viewpoint after the operation, with a slight, non-significant endophoria persisting. We did not find either sensory modifications in these patients.

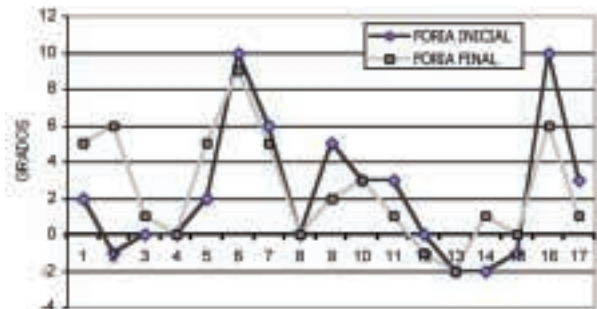


Fig. 4: Variation in the degree of phoria exhibited by NRC patients. The number 1-3 correspond to patients with accommodative ET and 4-17 to those with normal binocular vision. The mean variation of the phoric degree after surgery was not significant.

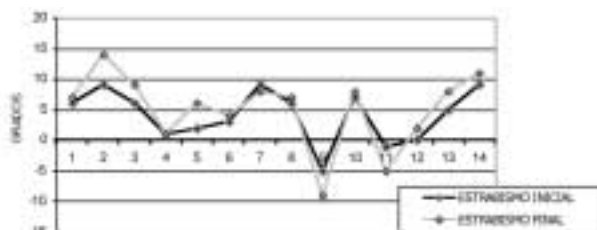


Fig. 5: Modification in the deviation angle of strabismic patients. Note the tendency to increase in deviation both in endotropic and exotropic patients (prior to surgery).

DISCUSSION

When analyzing the results of our series, we noticed there had been sensory alterations both in strabismic and non-strabismic patients, and eye motility alterations mainly in strabismic patients.

Although in the majority of patients the results of refractive surgery as regards visual acuity, refraction, VA difference and degree of anisometropia are quite satisfactory, we have seen that in a meaningful percentage of patients these patterns are altered and therefore can influence the sensory-motor condition.

The group of non-strabismic patients

Although they lack strabismic alterations, hyperopic subjects do not possess perfect binocular vision. Before refractive surgery, 42.86% of patients exhibited slight suppression of one eye and 50% of these exhibited stereopsis but it was lower than 60" of arc.

After the operation we found small modifications in all explored binocular parameters, the most significant being a change in far sight suppression or sensory dominance. In general, said modifications were slight and none of the patients exhibited binocular symptoms as a result of the surgery.

The cause of the suppression change in this study may be related to changes in VA or anisometropia degree (in 4 out of 14 patients), although not in all cases said factors produced alterations in suppression. The appearance or increase of anisometropia may enhance the development of suppression and, on the contrary, improved fusion in the cases where anisometropia is reduced. However, the repercussions were highly individual and not proportional to

the magnitude of the change. Neither did we notice that the postsurgery evolution depended on the degree of initial suppression nor the degree of prior stereopsis in these patients.

At any rate, we believe that the cause is multiple and that there are additional factors such as sensitivity to contract or aniseiconia, which can also bear on the result.

Accordingly, the modifications in non-strabismic patients were slight, and none experienced discomfort or expressed lack of satisfaction after the intervention. We believe that their good binocular vision provided sufficient stability vis-à-vis residual hyperopia, VA modifications or changes in sensory dominance.

The group of strabismic patients

As is frequently the case in groups of strabismic patients, we found prior to surgery ARC and suppression in the subjective angle in the synoptophore, as well as in the evaluation of far fusion by means of the vectographic test. All of these patients exhibited intense suppression of one eye, either in a single eye or alternating between both. Seven of the 14 patients had a strong accommodative component associated to strabismus.

After surgery, we found a slight reduction of VA in both eyes, greater than in the group of normal patients. This is probably due to a greater initial hypermetropia and therefore surgery was more aggressive. The mono- or binocular VA reduction involved a loss of visual quality and could lead to a weaker binocular union. However, in our sample we did not find a correlation between said reduction and the alteration of other parameters such as suppression, degree of deviation or symptoms.

We found frequent modifications in motor deviation and generally in the endotropic direction. In 10 of the 12 endotropic patients this deviation increased from $+5.30^\circ$ (SD 2.91) to $+7.60^\circ$ (SD 3.37) ($p=0.003$). In the consecutive exotropes it also increased from -3.00° (SD 2.83) to -7.00° (SD 2.83). As a motor decompensation was determined as a deviation increase of 4° or more, we found a decompensation of strabismus in 28.57% of patients.

Said increase in endotropy was considered to be multi-factorial, among which the most relevant is residual hyperopia, which may have a variable

influence in each patient and which, in our series, did not correlate in a significant manner. Another factor to be taken into account is the degree of binocular union, which may maintain motor stability vis-à-vis different refractive results.

The increase in motor deviation in a strabismic patient, in addition to having an esthetic repercussion, has sensory consequences such as raising suppressions (temporary or permanent). Among strabismic patients, 28.57% complained of discomfort in some tasks, mainly in near vision and occasional diplopia (one patient). In our series we were unable to relate this with a greater increase of the deviation angle or changes in suppression as seemed likely to be the case. The only factor which had a clinical but not significant effect (Fisher 0.098) was the fact of being strabismic.

From the sensory viewpoint, we found modifications in the type of suppression in 4 of the 14 patients (28.57%); in three of them, the modification was from alternating to monocular and the other changed predominance. This patient had acute discomfort after surgery, with decompensation of exotropia in situations of stress and fatigue.

Therefore, refractive surgery in strabismic patients decompensated the motor equilibrium (already unstable per se) in a relevant percentage of cases, causing an increase in the deviation degree and the appearance of symptoms after surgery.

The group of patients with accommodative endotropia and NRC

We had a small group of patients with accommodative endotropia and NRC. We describe the results obtained with these patients, although the value thereof in the statistical analysis is not relevant due to the small amount of subject. It is to be expected that this research will be completed with a higher number of patients.

This group of patients also exhibited modifications in some parameters after surgery. The first main modification was a compensation of tropia in

the three patients even though the mean residual refraction was of +0.94 dp (SD 1.01). However, they went from having an endophoria of +0.33° (SD 1.53) to +4.00° (SD 2.65). There was a strong correlation in these cases between residual hyperopia and the degree of endophoria ($r=0.73$), without it being significant due to the low number of patients.

The rest of binocular parameters (suppression, amplitude of fusion and stereopsis) remained stable after surgery and none of the 3 patients had asthenopic symptoms as a result of the operation.

Therefore, although this is a very small subgroup, we found slight motor modifications which had no repercussion at the sensory level.

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