EXTENDED REPORT

Effect of refractive surgery on binocular vision and ocular alignment in patients with manifest or intermittent strabismus

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Objective: To evaluate the effect of refractive surgery on binocular vision and ocular alignment in patients with manifest or intermittent strabismus, with or without vertical component.

Setting: University Hospital Antwerp, Edegem, Belgium.

Patients and methods: 13 patients (22 eyes) with strabismus underwent refractive surgery. Five of these patients presented with an esotropia and four of them with a small vertical deviation. Five patients had a manifest exotropia, of whom two presented with a small vertical deviation. Two patients had an intermittent exotropia with binocular vision, of whom one patient had a vertical deviation. One patient had a hypertropia with a dissociated vertical deviation.

Results: Ocular alignment and binocular function remained unchanged postoperatively in all except two patients with high anisometropia who experienced an improvement in binocular function. In these patients, the preoperative manifest deviation became intermittent or latent after surgery, allowing fusion and stereopsis. Vertical deviation was found preoperatively in 8 of the 13 patients. This vertical deviation remained unchanged postoperatively, but improved in one patient with anisometropia.

Conclusion: Preoperative intermittent or manifest strabismus is not a contraindication for refractive surgery provided some specific recommendations are taken into account, such as an adequate preoperative orthoptic examination and aiming at emmetropia for both eyes.

Refractive surgery has become a common procedure for the correction of myopia, hyperopia, astigmatism and anisometropia. Depending on the amount and type of ametropia, different refractive procedures can be used. Diplopia and strabismus have been reported as complications after refractive surgery,^{1–7} cautioning the ophthalmologists to include an orthoptic examination in the preoperative evaluation and to define patients at risk.^{7–9} Recently, hyperopic accommodative strabismus^{10–15} and myopic exotropia in anisometropia¹⁴ have been proposed as a separate indication for refractive surgery.

Our study aimed to evaluate the effect or the benefit of refractive surgery on ocular alignment and binocular function in patients with preoperative intermittent or manifest strabismus.

MATERIALS AND METHODS

In 13 patients with strabismus, refractive surgery was performed on 22 eyes between January 2000 and May 2005. Of them, six patients were male and seven were female. The patient's age ranged between 24 and 68 years (mean 44.3 years). Patients seeking refractive surgery and having a medical history of strabismus with mild amblyopia, ametropia or anisometropia were consecutively included in this study. Amblyopic eyes with visual acuity <20/60 were excluded from the study.

For the purpose of refractive surgery, the ophthalmological examination included visual acuity, manifest and cycloplegic refraction, anterior and posterior segment evaluation, intraocular pressure, corneal topography, ultrasonic pachymetry, pupillometry and fundus cyclotorsion. The uncorrected visual acuity and best-corrected visual acuity (BCVA) were measured with the Logmar chart at a distance (4 m) and near (33 cm). Subjective manifest refraction was measured, obtaining the maximum plus correction or minimum minus

correction, and objective refraction was measured with the Nidek autorefractometer. Cycloplegic refraction was determined 40 min after instillation of cyclopentolate 1%. Fundus cyclotorsion was measured with the scanning laser ophthalmoscope.

Five patients were myopic, four patients were hyperopic and four were anisometropic. Seven patients had a phakic anterior chamber lens implantation (Iris Claw/Artisan) for the correction of high myopia (patients 4, 5 and 13) or high hyperopia (patients 6, 7, 8 and 11). Three patients had diode thermokeratoplasty for the correction of low hyperopia (patients 9, 10 and 11) and the remaining three patients had laser in situ keratomileusis (LASIK; patient 3), laser epithelial keratomileusis (patient 2) and photorefractive keratectomy (PRK; patient 1) for the correction of a low to moderate myopia.

Amblyopic eyes with vision <20/60 were the only eyes excluded in this series. One patient had a BCVA of 20/60 in his strabismic eye (patient 1) and four patients had a BCVA of 20/40 in their most ametropic or strabismic eye (patients 2, 8, 12 and 13). All other patients had a BCVA of ≥20/30 in both eyes.

Table 1 summarises the patient's age, sex, surgical procedure, preoperative refractive error, BCVA, ocular dominance and fundus cyclotorsion.

Unilateral macular excyclotorsion was found in three patients (patients 1, 12 and 13). Bilateral fundus excyclotorsion was found in another three patients (patients 4, 5 and 7).

A complete orthoptic examination was carried out before and 2 months after surgery. The ocular alignment was measured with the alternate prism cover test at 6 m and

Abbreviations: BCVA, best-corrected visual acuity; LASIK, laser in situ keratomileusis; PRK, photorefractive keratectomy

Table 1 Preoperative and postoperative examination

Patient no	Age/sex	Surgery	Preoperative refractive error		Preoperative BCVA		Macular torsion	Dom.	Postoperative refractive error		Postoperative BCVA	
			RE	LE	RE	LE			RE	LE	RE	LE
1	24/M	PRK BE	-0.25-3.50×20	-1.50-2.50×160	20/60	20/25	Excyclotors. RE	LE	-0.25×115	-0.50×145	20/30	20/20
2	55/M	LASEK BE	-2.50-0.75×10	-3.50-0.75×0	20/40	20/20	None	LE	+1.00-1.75×	-0.75×0	20/40	20/20
3	33/M	LASIK BE	-4.75-1.25×165	-4.25-1.25×0	20/20	20/20	None	RE	0.00	-0.25	20/20	20/20
4	43/M	Iris Claw BE	-9.50-1.00×175	-9.00-1.00×0	20/30	20/30	Excyclotors. BE	LE	-1.00-1.00×5	-0.50-1.25×175	20/30	20/30
5	39/F	Iris Claw BE	-14.00	-13.50	20/25	20/25	Excyclotors. BE	RE	-1.25-0.50×100	-1.50-0.75×60	20/20	20/20
6	28/F	Iris Claw BE	+6.25-1.50×0	+7.00-1.50×0	20/32	20/20	None	LE	+0.75-1.25×0	+1.00-1.25×0	20/32	20/20
7	37/F	Iris Claw BE	+6.00-1.25×110	+6.00-0.75×50	20/30	20/25	Excyclotors. BE	LE	+1.00-1.75×115	-1.00×50	20/25	20/20
8	53/F	Iris Claw BE	+6.50-0.50×0	+7.50-2.00×0	20/25	20/40	None	RE	0.00	+1.25-1.50×20	20/25	20/40
9	68/F	DTK BE	+2.00-1.00×90	+2.50-0.75×110	20/20	20/20	None	RE	+1.25-1.75×100	+1.25-1.75×100	20/20	20/20
10	57/M	DTK LE	-2.50-0.50×125	+1.25-0.50×0	20/20	20/20	None	LE	-2.50-0.50×125	-0.50	20/20	20/20
11	49/M	DTK RE	+1.50	-1.75	20/20	20/30	None	RE	0-0.50×80	-1.75	20/20	20/30
12	46/F	Iris Claw LE	-1.75-0.50×40	+7.50-1.50×0	20/20	20/40	Excyclotors. LE	RE	-1.50-0.50×40	+0.50-1.50×60	20/20	20/30
13	44/F	Iris Claw RE	-9.00-1.25×160	-0.75×0	20/40	20/20	Excyclotors. RE	LE	+0.50-1.00×130	-0.75×0	20/40	20/20

BCVA, best-corrected visual acuity; BE, both eyes; Dom, dominant; DTK, diode thermokeratoplasty; F, female; LASEK, laser epithelial keratomileusis; LASIK, laser in situ keratomileusis; LE, left eye; M, male; PRK, photorefractive keratectomy; RE, right eye.

Table 2 summarises the orthoptic measurements.

33 cm and in the synoptophore. Measurements were carried out with and without correction, after fixating a light and an accommodative target that was at a distance and near. The maximum deviation was recorded. Ocular motility was evaluated with the alternate cover test in the nine directions of gaze. Binocular vision was measured with the Gobin's 15-prism dioptre¹⁶ measuring peripheral fusion or suppression scotoma. Fusion or suppression range was measured at a distance and near with the prism bar and in the synoptophore. Suppression depth was measured with the Bagolini red filter bar. Stereo acuity was measured with the Titmus and Lang test and retinal correspondence was evaluated in the synoptophore. All binocular vision tests were evaluated with optimal spectacle correction or contact lens correction before refractive surgery and without correction postoperatively.

Three patients with preoperative esotropia had hyperopia (patients 6, 7 and 8); one was myopic (patient 3) and one anisometropic (patient 11). All three patients with hyperopia had a partial accommodative esotropia, a V-pattern and a small vertical deviation. The patients with myopia had no vertical component. The patient with anisometropia had an esotropia, a V-pattern and a small vertical deviation.

Seven patients had an exodeviation preoperatively, of whom three had a small vertical deviation as well (patients 4, 5 and 13). Three patients with exotropia were myopic in both eyes (patients 2, 4 and 5), one was hyperopic in both eyes (patient 9) and three were anisometropic (patients 10, 12 and 13). In all patients, the exodeviation was more important at near than at distance. Patients 4, 5 and 9 had a V-pattern. Patients 4 and 5 presented additionally with an overaction of the inferior oblique muscle of the strabismic eye. The exodeviation of patient 9 was latent at a distance and intermittent at near. In patient 5, the exodeviation was intermittent at a distance and at near. These two patients (patients 5 and 9) had fusion and stereopsis. Patient 12 had a manifest exodeviation at near, which was intermittent at distance. In this patient, fusion was poor at a distance and was absent at near fixation.

Patient 1 had a manifest vertical deviation with dissociated vertical deviation, no binocular vision, a V-pattern and overaction of the left inferior oblique muscle.

Suppression was found in all 11 patients with a manifest deviation; 8 of them had a suppression depth of >17 as measured with the Bagolini red filter bar.

All patients had normal retinal correspondence (NRC) when measured with the synoptophore.

As all patients were at high risk for postoperative diplopia as defined by Kowal,^{8,9} they were informed about that risk. Surgery was only performed after having obtained patients' informed consent.

The intraocular refractive surgery was performed by M-JT and the corneal refractive surgery by RT. Corneal refractive procedures were performed under topical anaesthesia with oxybuprocaine 0.4%. The intraocular refractive surgery was performed under topical anaesthesia with a complementary intracameral injection of lidocaine 1%.

The postoperative treatment of the patients implanted with an Iris Claw phakic IOL (intraocular lens) consisted of the topical instillation of Aculare and Tobradex four times daily, tapered over 4 weeks. Patients who underwent LASIK, PRK or laser epithelial keratomileusis were fitted with a contact lens (focus night and day) immediately postoperatively and received Trafoxa edo three times daily during the first 3–5 postoperative days. Successively, this treatment was replaced by Delcol four times daily and tapered over the following 3 months.

To avoid a switch of dominance, the dominant eye was operated first in all nine patients in whom both eyes were treated. The dominant eye was operated first, and was targeted at emmetropia. The treatment of the non-dominant eye, targeted at emmetropia, was considered only if emmetropia was achieved in the dominant eye.

The time between the two surgeries ranged from 1 week (patients 1, 5, 6 and 8) to 4 weeks (patients 2, 3, 7 and 9). Patient 4 had a 1-year interval between both eyes because of unforeseen medical reasons.

The refractive follow-up ranged from 6 to 71 months (mean 33.9 months). Within this follow-up period, no patients had changes in binocular vision that justified an additional orthoptic examination.

RESULTS

The refractive error improved in all patients after one treatment. Some patients needed additional surgery to correct a residual astigmatism to obtain emmetropia. None of the patients lost any line of visual acuity. Patients 1, 5, 7 and 12 experienced an improved postoperative visual acuity. Table 1 shows the postoperative refractive error and BCVA.

Little change in ocular alignment was observed after surgery. The preoperative partial accommodative esotropia in patients 6, 7 and 8 remained unchanged postoperatively. In patient 6, the deviation even worsened slightly. In the patients with both myopia and esotropia, however, the

Table 2 Preoperative and postoperative orthoptic examination

Patient no	Ocular alignment: distance	Ocular alignment: near	Binocular vision: fusion	Binocular vision: stereopsis	Pattern	Ocular motility inferior oblique	Postoperative ocular alignment: d	Postoperative ocular alignment: n	Postoperative fusion	Postoperative stereopsis
1	sc:RE:20LHT LE:5LHT cc:RE:20LHT LE:5LHT	sc:RE:20LHT LE:5LHT cc:RE:20LHT LE:5LHT	d: no n: no	No	V	Overaction LE	RE:20LHT LE:8LHT	RE:20LHT LE:8LHT	d: no n: no	No
2	sc:20XT cc:16XT	sc:30XT cc:25XT	d: no n: no	No	Normal	Normal	18XT	25XT	d: no n: no	No
3	sc:25ET cc:25ET	sc:30ET cc:25ET	d: no n: no	No	Normal	Normal	14ET	25ET	d: no n: no	No
4	sc:4XT4LHT cc:4XT4LHT	sc:12XT4LHT cc:12XT4LHT	d: no n: no	No	V	Overaction LE	4XT3LHT	14XT3LHT	d: no n: no	No
5	sc:2X(T)2RH(T) cc:2X(T)2RH(T)	sc:8X(T)2RH(T) cc:8X(T)2RH(T)	d: -6°/+10° n: -9°/+20°	120"	V	Overaction RE	2X2RH	8X2RH	d: -8°/+10° n: -9°/+20°	40"
6	sc:18ET4RHT cc:8ET4RHT	sc:25ET4RHT cc:12ET4RHT	d: no n: no	No	V	Overaction RE	14ET3RHT	20ET3RHT	d: no n: no	No
7	sc:6ET4RHT cc:6ET4RHT	sc:25ET4RHT cc:12ET4RHT	d: no n: no	No	V	Overaction RE	6ET3RHT	8ET3RHT	d: no n: no	No
8	sc:25ET4LHT cc:16ET4LHT	sc:30ET4LHT cc:20ET4LHT	d: no n: no	No	V	Overaction RE	16ET4LHT	16ET4LHT	d: no n: no	No
9	sc:4X cc:4X	sc:14X(T) cc:14X(T)	d: -2°/+3° n: -6°/+15°	60"	V	Normal	2X	20X(T)	d: -4°/+4° n: -6°/+15°	60"
10	sc:35XT cc:35XT	sc:40XT cc:40XT	d: no n: no	No	Normal	Normal	30XT	30XT	d: no n: no	No
11	sc:40ET4LHT cc:40ET4LHT	sc:45ET4LHT cc:45ET4LHT	d: no n: no	No	V	Overaction LE	45ET4LHT	45ET4LHT	d: no n: no	No
12	sc:10X(T) cc:10X(T)	sc:14XT cc:14XT	d: -4°/+3° n: no	No	Normal	Normal	8X	12X(T)	d: -6°/+7° n: -9°/+20°	60"
13	sc:8XT6RHT cc:8XT6RHT	sc:6XT5RHT cc:6XT5RHT	d: no n: no	No	Normal	Normal	2X(T)2RH(T)	2X(T)2RH(T)	d: -5°/+7° n: -9°/+15°	400"

cc, cum correction; d, distance; ET, esotropia; LE, left eye; LHT, left hypertropia; n, near; RE, right eye; RHT, right hypertropia; RH(T), intermittent right hypertropia; sc, sine correction; V, V-pattern; X, exophoria; XT, exotropia; X(T), intermittent exotropia; °, prism diopter; °, degrees; ", seconds of arc.

deviation decreased. In the patient with anisometropia, no change was noticed. None of the patients with exotropia had an increase in their deviation postoperatively. The patient with low hypermetropia (patient 9) presenting with intermittent exotropia did not improve; in the the two patients with high anisometropia (patients 12 and 13), deviation became intermittent to latent postoperatively, resulting in an improvement of binocular vision. Patient 12, who had minimal peripheral fusion at distance, developed postoperatively good peripheral and central fusion with stereopsis of 60". Patient 13, who had no preoperative binocular vision, developed peripheral fusion postoperatively, with stereopsis of 400". Vertical deviation improved in this patient as well. Patients 1, 4, 5, 6, 7, 8 and 11 with preoperative vertical deviation presented with minor changes in their vertical angle postoperatively. The ocular motility remained the same in all patients and no difference in excyclotorsion was noticed.

Table 2 summarises the postoperative orthoptic results.

No major intraoperative or postoperative complications were seen. Patients 4 and 12 presented with a transient intraocular pressure rise, which normalised a few days after treatment with glaucom drugs. In patient 13, corneal epithelialisation was delayed, requiring a more intense postoperative care.

None of the eyes treated by refractive laser techniques presented with postoperative topographic decentration of the dilated corneal zone (patients 1, 2, 3, 9, 10 and 11).

DISCUSSION

Refractive surgery did not markedly influence ocular alignment in our series. In 1997, Bilgihan *et al*¹⁰ reported on one patient with preoperative accommodative esotropia who became orthophoric postoperatively. However, data about fusion or stereopsis did not appear in this paper. Galin *et al*¹¹ reported on one patient presenting with accommodative esotropia, which was successfully corrected with bilateral

angle-supported phakic intraocular lenses. Hoyos *et al*¹³ reported on LASIK treatment in nine patients with refractive accommodative esotropia. All patients were postoperatively orthophoric or remained micro-esotropic. Postoperative orthophoria was also described by Nemet *et al*¹⁴ in six patients with total and partial accommodative esotropia. However, no data is given about the angle of deviation measured when fixating an accommodative target at near. Stidham *et al*¹² treated 24 patients (48 eyes) with LASIK for accommodative esotropia. Ten patients had a fully accommodative esotropia, of whom two became orthophoric postoperatively. Four patients had their esotropia converted to an esophoria and four patients showed no improvement at all. This contrasts with the results of Nucci *et al*¹⁵ who found 100% orthophoria after PRK for mild to moderate hypermetropia in patients presenting with a purely accommodative esotropia. Stidham *et al*¹² found a reduction of the deviation in three of four patients with non-accommodative esotropia, of whom two were orthophoric after surgery. All these patients presented with a moderate to high hypermetropia and most of them remained slightly hypermetropic postoperatively. However, data about fusion, fine stereopsis or alignment when fixating an accommodative target are unavailable in these papers. Nemet *et al*¹⁴ reported a complete resolution of exotropia after LASIK for myopic anisometropia. These results are predictable under preoperative contact lens simulation. Refractive surgery is a good option in case of a positive contact lens test or in patients with anisometropia who wore contact lenses but became intolerant to them.

Only one of the above-mentioned papers reported on refractive surgery in a patient with a combined vertical deviation. Of the 13 patients in our series, 7 (4, 5, 6, 7, 8, 11 and 13) had an Iris Claw phakic lens implantation and presented preoperatively with a vertical deviation in combination with a horizontal strabismus. Eight of the 13 patients presented with a V-pattern. One patient had a purely vertical deviation with dissociated vertical deviation, latent

nystagmus and excyclotorsion. In this patient, bilateral PRK was carried out with good centration of the ablation zone and good refractive results. None of the patients presented with a worsening of the vertical deviation after refractive surgery. We observed an improvement of the vertical deviation in one of the patients with high anisometropia whose strabismus became intermittent postoperatively (patient 13).

None of our patients presented with postoperative diplopia, dominance problems or binocular vision problems.

Our series comprises partial accommodative esotropia, non-accommodative esotropia, manifest and intermittent exotropia, and vertical deviation. All patients were treated by diverse refractive surgery techniques.

On the basis of the results obtained, we may conclude that preoperative intermittent or manifest strabismus is not a contraindication for refractive surgery provided some specific recommendations are taken into account,⁷ such as an adequate orthoptic examination, consecutive surgery of both eyes starting with the dominant eye, and aiming at emmetropia for the dominant eye and for the non-dominant eye.⁷⁻⁹ Monovision is prohibited in patients with strabismus presenting preoperatively with intermittent or manifest deviations.

Patients can be informed that no worsening in their ocular motility will occur after surgery. However, we still consider it advisable to inform the patients preoperatively about the possible risk of postoperative manifest decompensation, especially in patients presenting with an intermittent or latent deviation.

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