Br Ir Orthopt J 2006; **3:** 27–31

Refractive surgery and strabismus

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Abstract

***Aim*: To evaluate the orthoptic outcome of patients with a pre-existing ocular motility defect who presented for Lasik refractive surgery.**
***Method*: The case notes were reviewed of 59 patients who had presented to two centres for Lasik refractive surgery and were judged to be at risk of post-operative symptoms because of a pre-existing ocular motility defect. All patients had undergone a comprehensive orthoptic assessment. Factors examined in the analysis were the type of refractive error, the type of deviation, change in binocular status, change in the angle of deviation, and incidence of symptoms/diplopia after refractive surgery.**
***Results*: Forty-four patients were considered suitable for refractive surgery. Of these, 39 proceeded to surgery; data were incomplete for 12 cases, leaving 27 cases for analysis. No patient experienced diplopia or a change in binocular status after refractive surgery. Five patients with an accommodative-type esotropia had a reduction in the angle of deviation of between 9^{Δ} and 20^{Δ}. There was a small reduction in angle of 5^{Δ} to 6^{Δ} in 3 patients with exo deviations and a reduction of 12^{Δ} base-out and 15^{Δ} base-in for 2 patients with myopic anisometropia.**
***Conclusion*: Full orthoptic assessment of binocular status prior to refractive surgery is essential for patients with a pre-existing ocular motility defect, in order to identify those who are at risk of post-operative symptoms/diplopia and provide advice on the possible consequences of proceeding with the surgery.**

Key words: Esotropia, Exotropia, Laser refractive surgery

Introduction

Refractive surgery is currently seen as an attractive and preferable alternative to spectacles or contact lenses for the correction of refractive errors. As strabismus and amblyopia are said to occur in approximately 5% of the population[1] there will be a proportion of adults seeking laser refractive surgery who have a pre-existing ocular motility disorder. Similarly, because of the publicity given to laser procedures, patients and their parents frequently enquire about their present or future suitability for refractive surgery. It has been suggested in the literature on refractive surgery[2–7] that it may provide a preferable management option in certain types of strabismus and amblyopia. However, anecdotal evidence has suggested that diplopia may result from inappropriate refractive surgery.

Those likely to be at risk are anyone who has, or has had, a condition that interrupts the development of, or functioning of, the binocular system.[8] Patients with a pre-existing esotropia or exotropia, or residual deviation following squint surgery in childhood, are possibly the largest group of patients at risk. Many have abnormal, weak or absent binocular vision and any change in the deviation may result in images falling outside a pre-existing suppression scotoma. Some may have had intensive occlusion and anti-suppression treatment in childhood, which may result in an increased risk of diplopia.

It is reported that cases of congenital and acquired paralytic strabismus and patients with associated vertical and torsional deviations may decompensate following laser refractive surgery.[9] Decompensation may also occur in cases of heterophoria greater than 10^{Δ} with poor fusion, and in patients with intermittent exotropia who may have a large underlying exodeviation at near and wear overcorrecting concave lenses to aid control of the deviation.

Prisms are frequently incorporated into glasses. This may be for an insignificant horizontal or vertical deviation and in such cases it would be advisable to remove the prism prior to refractive surgery to ensure the patient does not experience any symptoms. Refractive surgery may be contra-indicated in cases where prisms are necessary for the maintenance of binocularity, or where the patient has become used to the prismatic effect of a high refractive error.

Full correction of hypermetropia has been advocated[8] but full correction is not always achieved in one Lasik procedure; multiple refractive surgeries may disrupt binocular vision. A surgical change in an anisometropic refractive error may cause fixation switch diplopia when the formerly amblyopic and suppressed eye is forced to fix preferentially at one distance. It is advised that a patient who wears monovision contact lenses constantly should discontinue wear to allow normal binocular vision to re-establish prior to refractive surgery.[10]

It is evident that there are a number of patient groups

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who are at risk of symptoms/diplopia after laser refractive surgery. It is important to identify those patients in order to advise them of the possible consequences of refractive surgery.[8,11–14] The aim of this retrospective study was to evaluate the orthoptic outcome of patients with a pre-existing ocular motility defect who presented for Lasik refractive surgery.

Methods

The case notes were reviewed of 59 patients who had presented to two centres for Lasik refractive surgery and were judged to be at risk of post-operative symptoms because of a pre-existing ocular motility defect. All patients had undergone a comprehensive orthoptic assessment which comprised:

- Cover test for near and distance in all positions of gaze.
- Assessment of ductions and versions.
- Measurement of the deviation in all gaze positions.
- Assessment of sensory and motor fusion.
- Assessment of the depth of suppression and mapping of the suppression scotoma, using the synoptophore or Sbisa bar where necessary.
- Stereo-acuity assessment using the Lang and TNO stereo-tests.
- A diplopia test to assess the risk of a post-laser change in the angle of deviation. This comprised a standard diplopia test with and without red and green glasses, correcting the deviation partially or wholly with prisms using fixation targets and a light for both near and distance. Patients deemed to be at risk of diplopia were advised that it would be necessary to proceed to wearing Fresnel prisms on their glasses before a decision about refractive surgery could be made.

All patients were assessed with and without glasses. An esophoria or exophoria $>10^{\Delta}$ was considered to be significant. The diplopia risk was judged to be high if a change in angle of deviation of 5^{Δ} resulted in diplopia, or if the patient already appreciated some diplopia in the absence of normal binocular vision.

Some patients presented for laser refractive surgery with an error that was outside the range of myopia (−1.00 DS to −8.00 DS) and hypermetropia (+1.00 DS to +4.00 DS) which can be safely treated. Generally these cases were not referred for orthoptic assessment.

The final decision to proceed with refractive surgery was made by the ophthalmologist, and was based upon the diplopia risk, the presence or absence of binocular vision, and the general condition of the eye itself, in particular the cornea. Where possible patients were reviewed by the orthoptist at their routine 6-week post-operative follow-up with the refractive surgeon. Investigation of patients was in accordance with the Declaration of Helsinki.

Factors examined in the analysis were the type of refractive error, the type of deviation, change in binocular status, change in the angle of deviation, and incidence of symptoms/diplopia after refractive surgery.

Results

Of the 59 patients, 27 were female and 32 were male. The age ranged from 17 to 65 years. Fifteen patients were advised against proceeding with refractive surgery. Forty-four were considered suitable for refractive surgery. Of these, 39 proceeded to refractive surgery and 5 decided not to proceed. Of the 39 in the refractive surgery group, complete data were not available for 12 cases. The data for 27 cases remained for analysis.

Patients not undergoing refractive surgery (n = 15)

Fifteen patients were considered unsuitable for refractive surgery. Nine of these had an esotropia and 2 had an exotropia and all had a risk of post-operative symptoms/diplopia. One patient wished to be given permanent monovision and the ophthalmologist refused this wish. Two patients were unwilling to have the laser procedure prior to strabismus surgery. There was 1 case of residual congenital III nerve palsy with multiple squint operations, 1 patient who was unable to dispense with a small prismatic correction incorporated in glasses, and 2 patients with anisometropic and strabismic amblyopia who did not realise that the condition could not be cured by refractive surgery.

Patients undergoing refractive surgery (n = 27)

The clinical details of the 27 cases available for analysis are shown in Table 1. Twelve had an eso deviation, 11 had an exo deviation and 4 had a variety of ocular motility defects.

1. Patients with an eso deviation (n = 12)

Of the 12 patients with an eso deviation, 4 had myopia, which ranged from −0.25 DS to −7.00 DS. Eight patients had hypermetropia, which ranged from +1.25 DS to +6.00 DS.

Myopic eso patients (n = 4)

Of the myopic patients, 1 had an esophoria with good binocular vision (case 1), 1 had esotropia with binocular vision (case 2) and 2 had esotropia without binocular vision (cases 3, 4).

After laser surgery, there was no change in the angle of deviation for 3 patients (cases 1, 3, 4). The remaining patient (case 2), who had −2.75 DS of anisometropia, had a decrease in the angle of deviation of 12^{Δ} after surgery.

One patient required further Lasik surgery (case 3).

Hypermetropic eso patients (n = 8)

Of the hypermetropic patients, 1 had an esophoria with weak binocular vision (case 5), 4 patients had esotropia with some degree of binocular vision (cases 6, 7, 8, 9) and 3 patients had an esotropia without binocular vision (cases 10, 11, 12).

After laser surgery 5 patients (cases 6, 7, 8, 10, 11) had a decrease in the angle of deviation of between 9^{Δ} and 20^{Δ} (mean 14.6^{Δ}; median 16^{Δ}). These patients had

Table 1. The clinical details of the 27 patients who had refractive surgery

Patient no.	Age (years)	Refractive error	Type of deviation	Angle before laser	Angle after laser	BV before laser	BV after laser	Diplopia	Further laser	Squint surgery
Myopic eso patients										
1	41	R −2.50/−0.50 × 85 L −1.50/−0.50 × 85	E	12BO	12BO	Yes	Yes	No	?	No
2	46	R −3.50 L plano/−0.75 ×180	ET	30BO	18BO	Yes	Yes	No	No	No
3	31	R −7.00/−1.25 × 30 L −6.75/−2.0 × 157	ET	15BO	15BO	No	No	No	Yes	No
4	64	R −2/−0.5 × 75 L −0.25/−0.25 × 50	ET	40BO	40BO	No	No	No	No	Yes
Hypermetropic eso patients										
5	27	R +0.50/−0.25 × 90 L +5.75/−4.00 × 175	E	4BO	4BO	Weak	Weak	No	No	No
6	48	R +4.50/−0.25 × 125 L +5.00/−0.50 × 57	ET	10BO	8BI	Yes	Yes	No	No	No
7	43	R +4.00/−0.50 × 7 L +3.00/−0.75 × 170	ET	18BO	4BO	Weak	Yes	No	No	No
8	38	R +4.00/−1.25 × 32 L +4.00/−1.5 × 151 +1.75 add bifocals	ET	45BO	25BO	Yes	Yes	Yes until 2nd laser	Yes	Yes
9	37	R +3.25/−0.75 × 135 L +6.00/−3.00 × 20	ET	4BO	4BO	Weak	Weak	No	No	No
10	52	R +4.75/−1.25 × 172 L +4.75/−2 × 180	ET	25BO	16BO	No	No	No	No	No
11	48	R +1.25/−0.25 × 75 L +1.25/−1.25× 100	ET	30BO	20BO	No	No	No	No	Yes
12	31	R +5.25/−5.75 × 170 L +4.50/−5.50 × 180	ET	10BO	10BO	No	No	No	No	No
Myopic exo patients										
13	35	R −2.75/−0.75 ×10 L −2.00	X	6BI	6BI	Yes	Yes	No	No	No
14	28	R −1.25 L −1.50	X	8BI	8BI	Yes	Yes	No	No	No
15	35	R −4.00/−0.50 × 120 L −4.50/−0.50 × 100	X	12BI	6BI	Yes	Yes	No	No	No
16	41	R −2.25 L −0.50/−0.50 × 90	X	12BI	10BI	Weak	Weak	No	Yes	No
17	45	R −4.00/−2.25 × 160 L −0.25/−5.5 × 175	X	15BI	10BI	Weak	Weak	No	No	No
18	23	R −4/−0.75 × 90 L −2.5/−2.5 × 157	X(T)	35BI	10BI	Yes	Yes	No	No	Yes
19	45	R −2.50 L −1.50/−0.50 × 15	X(T)	14 BI	14BI	Yes	Yes	No	No	No
20	30	R +0.50/−0.5 × 20 L −2.75/−0.75 × 180	XT	20BI	5BI	No	No	No	No	No
Hypermetropic exo patients										
21	31	R +1.75/−5.25 × 180 L +2/−6.00 × 178	XT	60BI	55BI	No	NO	No	No	Undecided
22	25	R +4.50/−5.00 × 180 L +1.00/−3.50 × 180	XT+R/L	14BI R/L12	14BI R/L 12	No	No	No	No	Yes
23	43	R +3.50 L −1.50	XT +R/L	30BI R/L10	30BI R/L 10	No	No	No	No	Yes
Various motility defects										
24	45	R −2.75/−0.50 × 15 L −1.75	E	8BO	8BO	Yes	Yes	No	No	No
25	44	R −4.75/−1.00 × 55 L −4.25/−0.75 × 150	X+R/L	4BI R/L2	4BI	Yes	Yes	No	No	No
26	40	R +2.00 L −2.00/−0.50 × 170	L/R	L/R18^	L/R12	No	No	No	No	No
27	50	R +1.00/−1.00 × 120 L +1.25/−0.50 × 155	R/L	R/L4	R/L4	Weak	Weak	No	No	No

BV, binocular vision; BO, base-out; BI, base-in; E, esophoria; ET, esotropia; X, exophoria; X(T), intermittent exotropia; XT, exotropia; R/L, right hypertropia; L/R, left hypertropia.

an accommodative element to their esotropia, and 2 had an associated microtropia. There was no change in the angle of deviation for 3 patients (cases 5, 9, 12), 2 of whom had significant anisometropia (cases 5, 9).

One patient required further Lasik surgery (case 8).

None of the patients with an eso deviation complained of diplopia or had a change in their binocular state after laser surgery. One patient reported a subjective improvement in the control of the eso deviation associated with a reduction in the angle of deviation.

2. Patients with an exo deviation (n = 11)

Of the 11 patients with an exo deviation, 8 had myopia, which ranged from −1.25 DS to −4.00 DS. Three patients had hypermetropia, which ranged from +1.75 DS to +4.50 DS.

Myopic exo patients (n = 8)

Of the myopic patients, 5 had an exophoria (cases 13, 14, 15, 16, 17), 2 had intermittent exotropia (cases 18, 19) and 1 had constant exotropia with anisometropia (case 20).

After laser surgery 2 patients with exophoria (cases 15, 17) had a change in the angle of deviation of 6Δ and 5Δ, respectively. One case of intermittent exotropia (case 18) showed an initial reduction of 25Δ but this was not maintained. The patient with exotropia and anisometropia (case 20) had a 15Δ reduction in the angle of deviation. There was no change in the deviation for 4 patients (cases 13,14,16, 19).

One patient had further Lasik surgery (case 16).

Hypermetropic exo patients (n = 3)

Of the hypermetropic patients 1 had exotropia (case 21) and 2 had exotropia with an associated vertical deviation and anisometropia (cases 22, 23).

After laser surgery, there was a 5Δ reduction in angle for 1 patient (case 21) but no change in the angle of deviation for the other 2 patients (cases 22, 23).

None of the patients with an exo deviation complained of diplopia or had a change in the binocular state after laser surgery.

3. Patients with various motility defects (n = 4)

There were 4 patients in this group. One patient had a resolved VI nerve palsy (case 24); 1 had vertical prisms incorporated in glasses, which were successfully removed prior to treatment by gradual reduction of the prism strength over a 3 month period (case 25). Two patients had residual vertical deviations, following horizontal and vertical strabismus surgery in childhood, with no binocular vision (cases 26, 27).

After laser surgery 1 patient (case 26) had a 6Δ reduction in the vertical angle of deviation. No patient had diplopia or a change in binocular state.

Strabismus surgery

Six patients required squint surgery after laser surgery (cases 4, 8, 11, 18, 22, 23).

Discussion

A retrospective review of 27 patients with a pre-existing ocular motility defect who had Lasik refractive surgery revealed that no patient experienced diplopia or a change in binocular status after surgery. This suggests that the diplopia risk criteria used to advise whether surgery should proceed in these individuals was appropriate.

Five patients with an accommodative-type esotropia had a reduction in the angle of deviation of between 9Δ and 20Δ after laser surgery. This reduction is in agreement with studies that have reported reductions of 5.8°[4] and 11Δ.[2] Stidham *et al.* reported that 58% of the esotropic patients in their group had a reduction in the angle of strabismus; all except one had been diagnosed as having an accommodative element prior to laser refractive surgery.[2] However, Godts *et al.* reported no change in eso deviation.[15] This was the case for 7 of the patients in this review, who had esophoria or residual esotropia.

No patient in this series had fully accommodative esotropia and in our experience it is an uncommon condition in adults. However, there was 1 patient who had convergence excess esotropia with high AC/A ratio who required repeat Lasik and strabismus surgery in order to restore full binocular single vision (case 8).

Laser *in situ* keratomileusis has been used by Hoyos *et al.*,[5] and photorefractive keratectomy by Nucci *et al.*,[3] for the treatment of fully accommodative esotropia in adults. Excellent results with complete resolution of the esotropia after the refractive surgery are reported. The long-term follow-up on these patients, particularly with the onset of presbyopia and possible tendency towards exotropia, is awaited.

Other considerations with regard to the suitability of refractive surgery in the hypermetropic esotrope include the amount of hypermetropia that can be corrected. This is generally accepted as being +4.00 DS, although Hoyos *et al.*[5] have suggested that the limit is more likely to be +6.00 DS. The laser procedure is not always accurate and repeat treatment may be required. There is the possibility of regression after the surgery with a consequent recurrence of the esotropia. In this series one case of esotropia required repeat Lasik to eradicate the hypermetropia and to date no patient has returned for further treatment due to regression. However, the outcome of long-term follow-up is necessary before conclusions can be drawn.

There was a small reduction in angle of 5Δ to 6Δ in 3 cases with exo deviation, in agreement with Krasny *et al.*[4] who reported that refractive surgery had little effect on the deviation in exotropia. There were sizeable reductions in the angle of deviation of 12Δ base-out for a myope with esotropia, and 15Δ base-in for a myope with exotropia, both of whom had anisometropia. Two cases of hypermetropic anisometropia with esotropia had no change in the angle of deviation. Although there were only 2 myopic cases this finding does support Nehmet *et al.*[16] who maintain that in patients with myopic anisometropia any exo deviation is resolved following refractive surgery.

In patients with pre-existing anisometropic amblyopia, great care must be taken before removing the anisometropia. Adults with poor fusion, or patients made to fix with the amblyopic eye at one distance, may become seriously symptomatic and require further refractive surgery to re-establish at least some anisometropia and restore the *status quo*. None of the patients in this series complained of symptoms after surgery, although we have seen patients with severe problems.

None of the patients in the group with 'various

motility defects' complained of post-laser symptoms. Godts *et al.*[9] have reported decompensation of pre-existing vertical muscle imbalance thought to be due to decentration of the ablation.

The major difficulty with attempting to discover risk factors for patients with ocular motility disorders requesting refractive surgery is that much of the literature emanates from refractive surgeons who might be considered to have an element of bias towards the procedure. Unfortunately, patients who have had laser refractive surgery are less than enthusiastic about attending after the procedure for measurements and binocular vision assessment. Data in this series were incomplete for 12 cases. It is possible that the patients who presented for follow-up may differ systematically from those who did not and the data presented may therefore not be representative of patients as a whole. However, patients who have had refractive surgery at other centres have presented to orthoptic clinics for assessment of diplopia, fixation switch and unexpected strabismus experienced after surgery. These patients tend to be voluble in their complaints about their symptoms, so it may be that those who are not seen after surgery are asymptomatic with no noticeable deterioration in the cosmesis of their deviation.

To ensure that the patient with a history of pre-existing ocular motility problems or amblyopia does not experience insuperable diplopia after refractive surgery, a comprehensive assessment of binocular potential and the size and depth of the suppression scotoma must be undertaken.[9] The evidence appears to suggest that in esotropia it is likely there will be a shift towards orthotropia of approximately 10^{Δ}.[2–4,17,18] Although Stidham *et al.*[2] could find no predictive factors, it would seem more likely to occur in those hypermetropic patients with an accommodative element to their esotropia. In exotropia there may be a change in the deviation but the results so far are inconclusive.

Conclusion

Full orthoptic assessment of binocular status prior to laser refractive surgery is essential for all patients who have a history of strabismus and/or amblyopia in childhood, a pre-existing ocular motility defect, or a significant heterophoria. Whilst the imperative is to identify those patients who are at risk of diplopia after refractive surgery and advise them of the possible consequences, the undoubted psychological and cosmetic advantage of dispensing with glasses and contact lenses should not be ignored.

We would like to thank Gill Adams and Keith Williams for all their support and advice and for allowing us to study their patients; and Janice Vieira, Caroline Chitty and Clare Ruocco for their help and expertise.

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