

Binocular decompensation and diplopia after refractive laser surgery

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Abstract

An increasing number of people undergo refractive surgery, and even if the refractive result after surgery is perfect, the outcome is not always successful. Decompensation of binocular vision anomalies is rarely mentioned in reports considering the outcome of refractive surgery. This report presents 4 cases with binocular vision problems after refractive laser surgery. The patients were referred to the eye department of a Norwegian hospital after having received refractive laser surgery. All patients were male adults. For all patients the reason for referral was intermittent or constant binocular diplopia. Examinations were performed according to standard procedures of the hospital eye department. Two patients were diagnosed with decompensated esodeviations; they both had a history of treatment for accommodative esotropia. One patient had unstable binocular vision of unknown cause, and one had a decompensated congenital trochlear nerve paresis. Some binocular vision problems can be foreseen with proper evaluation before surgery. A thorough history and binocular evaluation are recommended before initiating refractive laser surgery.

Keywords: Binocular vision, refractive laser surgery, decompensation, diplopia

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Introduction

Refractive laser surgery has continuously been developing and expanding since it was first introduced in the early 1990s (Ang, Couper, Dirani, Vajpayee, & Baird, 2009). Today, it is a widely performed procedure amongst a large proportion of ophthalmology clinics throughout the world. Several methods are used in refractive laser surgery, and Laser In Situ Keratomileusis (LASIK) with femtosecond laser is usually the preferred procedure (Tanna, Schallhorn, & Hettinger, 2009). Other common procedures are laser epithelial keratomileusis (LASEK), epi-LASIK and photorefractive keratectomy (PRK). LASIK and LASEK are reported to be the two most commonly used procedures in Norway (Rees, 2009).

More than half of the vision problems in the world can be explained by refractive errors (Ang et al., 2009). In America approximately 1.5 million people undergo LASIK surgery each year (Kushner & Kowal, 2003). This represents 0.44% of the population. There are at least 4500 refractive laser procedures performed in Norway each year (Rees, 2009). This represents about 0.1% of the population. When comparing with the American numbers it seems likely that this may be an underestimation. In 2006 more than 8 million procedures were performed worldwide (Ang et al., 2009). Without doubt, a significant number of people are having refractive surgery today. Binocular vision impairment can be a potential threat to a successful postoperative outcome for some of these patients. The following cases describe binocular vision problems with significant symptoms for the patients that appeared after refractive surgery. The case series illustrates the need for a complete binocular vision history and evaluation before refractive surgery. It seems that a complete orthoptic examination is not the standard in the pre-examination for refractive surgery (Godts, Tassignon, & Gobin, 2004). The aim of this case report is to point out the importance of a binocular vision evaluation before refractive surgery.

Methods

Four patients presented subsequently at the eye department of a Norwegian hospital between January and May 2009. The patients were referred from private eye clinics after refractive surgery. They were all male and between 27 and 43 years old. Two were referred for a second opinion from a refractive surgeon; the other two were referred for consideration of strabismus surgery. The test procedure they underwent at the hospital differed according to the reason for referral. All patients had binocular vision problems with symptoms that interfered with their daily life, and intermittent or constant binocular diplopia. Examinations were performed according to standard procedures within the hospital eye department. The binocular evaluations were done with subjective refraction unless otherwise is stated. The emphasis in this case report is on the problems caused by the laser surgery, thus the treatment options of the binocular problems are not discussed. All patients were seen by an optometrist (one of the authors; K. J.); two patients were additionally seen by a refractive surgeon and the other two by an orthoptist.

Case presentations

Case 1, Decompensated esophoria

Patient

A 27-year-old male was referred for evaluation for strabismus surgery. The strabismus developed after refractive laser surgery to both eyes. His main problems were dizziness and discomfort, and his symptoms were reduced by closing one eye. He had a history of accommodative esotropia as a child, reported to be 10-20 prism dioptres (PD) base out at distance and 40 PD base out at near. He was treated with patching until his visual acuity was the same in both eyes, and he had a low hyperopic prescription. At age 8, a retro positioning of the medial rectus muscle of 4 mm of the right eye and a resection of the lateral rectus muscle of 3 mm of the left eye were performed. He could not recall any binocular problems after this. The patient developed a moderate myopia with age and he underwent LASIK surgery in October 2007, as he had trouble with contact lens wear. This was thought to be a consequence of his job as a mechanic. Visual acuity (Snellen decimal) and prescription before surgery were OD: 1.0 with -1.50 -0.75 x 105 and OS: 1.0 with -1.75 -1.25 x 85. After the operation he had a small overcorrection, about +1.00 DS in both eyes. The first postoperative day a manifest left esotropia was noted. In February 2008 he was reoperated and the refraction became close to emmetropia.

Examination and findings

See Table 1 for examinations and findings from January 2009.

Management

The patient was tentatively diagnosed with decompensated esophoria after LASIK surgery for moderate myopia. After further investigations with the orthoptist and strabismus surgeon he is on the waiting list for strabismus surgery.

Case 2, Decompensated esophoria

Patient

A 38-year-old male was referred for a second opinion of a laser surgeon. The reason for referral was an area of scarring in the cornea of the right eye and a small residual hyperopia in both eyes after laser surgery. The patient's main complaint was reading problems and diplopia. Visual acuity (Snellen decimal) and refraction before surgery were OD: 1.0 with +5.25 DS and OS: 1.0 with +5.00DS. He wore contact lenses most days and his contact lens wear was unproblematic. The patient received LASEK to both eyes in a private clinic, right eye in December 2006 and left eye in January 2007. Retreatment of the right eye was done after 5 months. The visual acuity and refraction at that time were OD: 0.7 with +2.50 -0.50 x 175. Visual acuity and refraction after the second surgery (May 2007) were OD: 0.7 with +1.00 -1.00 x 140 and OS: 1.0 with +2.25 -1.00 x 180. The patient had a known history of accommodative esotropia and had strabismus surgery 15-20 years ago. Binocular status before LASEK is unknown, but according to the patient he was symptom free.

Examination and findings

Corneal topography measured with Precisio high definition surgical tomography in May 2009 showed higher order aberrations and temporal decentration of the ablation zone in the right eye. See Figure 1 for the topographical map.

The patient had intermittent esotropia with troublesome diplopia. The surgeon decided to do a third treatment to the right eye to regularise the cornea, diminish the scar and treat the small hyperopia. There is a known risk of increase in hyperopia with regularisation and resolving scars, as it flattens the cornea (Dogru, Katakami, & Yamanaka, 2001).

See Table 2 for examinations and findings from October 2009.

Management

The patient was diagnosed with decompensated accommodative esotropia after refractive surgery. Full correction of his anisometropia with contact lenses was initiated. If this did not sufficiently control the esotropia, prismatic correction and strabismus surgery would be considered.

Case 3, Unstable binocular vision

Patient

A 43-year-old man was referred at his own request to the eye hospital for a second opinion with a laser surgeon. He had refractive laser surgery (LASIK) 10 years ago. His symptoms were severe eyestrain, problems with changing focus and intermittent diplopia at distance and near, which had increased over the last years. He felt disabled because of his vision problems. The patient was initially myopic and his refraction and visual acuity (Snellen decimal) before surgery were OD: 1.0 with -4.50 DS and OS: 1.0 with -6.00 DS. After surgery his uncorrected visual acuity (UCVA) was OD 1.0 and OS 1.0. He had a history of strabismus from childhood, but no strabismus surgery. He reported that he had no binocular or focusing problems before the refractive surgery. Regular consultations with an orthoptist since 2005 did not result in satisfactory improvement. Both atropine treatment (over months) and botulinum toxin treatment had been tried without success.

Table 1

Case 1, examinations and findings, January 2009

Complaint	Dizziness and discomfort, tiredness. Helps to close one eye.
Subjective refraction	Plano OU (Cycloplegic refraction: +0.50 DS OU)
BCVA (Snellen decimal)	OD: 1.0, OS: 0.9+
Cover test	Small esotropia distance and near with DVD. Feels strong discomfort when tested at near.
Prism cover test	Distance: left esotropia, 8 PD base out, and 14 PD hyper OS and OD (DVD) Near: left esotropia, 14 PD base out and 14 PD hyper OS and OD (DVD) The esotropia is increasing during the consultation and increases further with Cyclopentolate.
Maddox rod	Distance and near: left esotropia, 20 PD base out
Accommodation (RAF-ruler)	Binocular 8 D
Motility	Normal
Bagolini	Left suppression

Note. DVD = dissociated vertical deviation; PD = prism dioptres; D = dioptres.

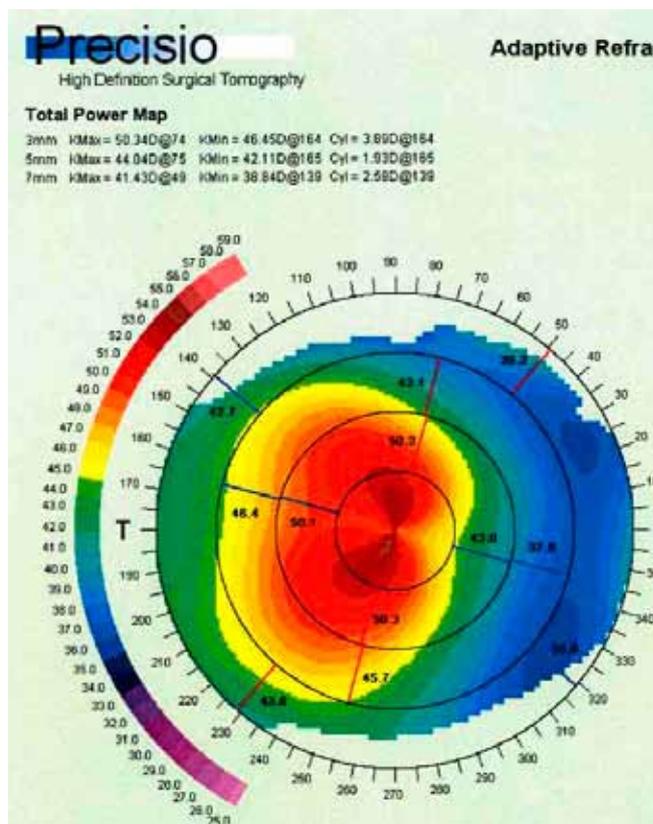


Figure 1. Precisio Topography result from Case 2 shows higher order aberration and temporal decentration of the ablation zone.

Table 2
Case 2, examinations and findings, October 2009

Complaint	Persistent diplopia and reading problems
Subjective refraction	OD: +6.00 -1.00 x 95, OS: +2.25 -1.00 x 170
BCVA (Snellen decimal)	OD: 1.2, OS: 1.0- and a persistent shadow
Prism cover test	Distance: right esotropia, 6 PD base out Near: right esotropia, 8-10 PD base out
Positive relative convergence at near (40 cm)	8-10 PD base out, weak
Negative relative convergence at near (40 cm)	6 PD base in, weak
Accommodation (RAF-ruler)	OD: 7 D, OS: 8 D, Binocular: 10 D
Worth 4 dot (Distance and near)	Alternating suppression, able to fuse with concentration
Orbscan	Regular right corneal topography
Slitlamp	OD: cornea is clear, OS: cornea shows a Fleischer's ring

Note. PD = prism dioptres. D = dioptres.

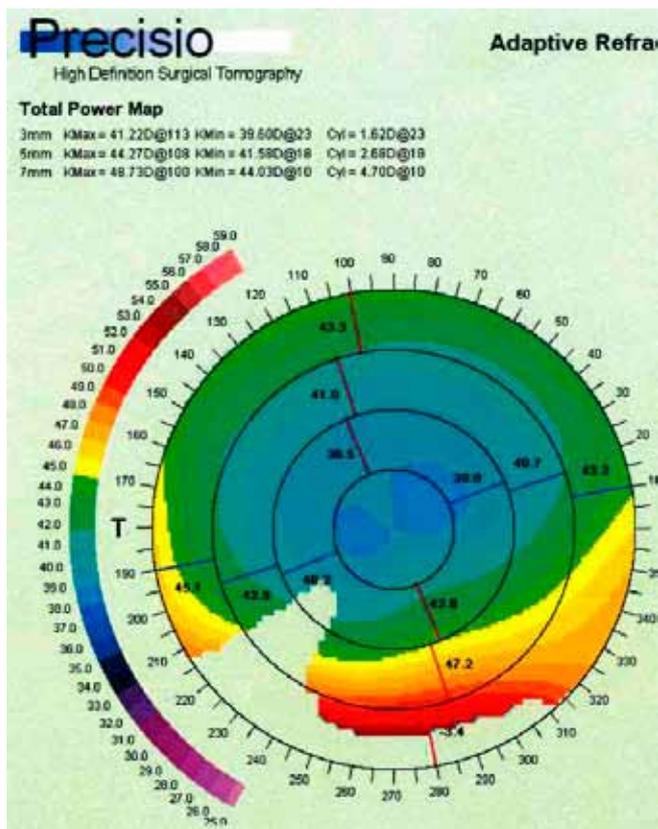


Figure 2. Precisio Topography result from Case 3 shows a small astigmatic irregularity, no aberrations and a possible vertical decentering of the ablation zone which was considered to be without impact.

Examination and findings

See Table 3 for examinations and findings from January 2009.

Management

The patient was diagnosed with unstable binocular vision and accommodative function. He then got a pair of "as good as it gets" glasses mainly for near work (habitual prescription). The binocular status and visual acuity seemed more stable than described in the referral letter, thus no laser treatment was recommended and he would continue with orthoptist follow-up privately.

Case 4, Decompensated congenital trochlear nerve paresis

Patient

A 38-year-old male was referred for consideration for strabismus surgery for his vertical strabismus that developed after laser surgery to his left eye. His initial refraction before surgery was approximately -3.00 DS in both eyes, and he had LASIK done to his left eye in 2002. At the first attempt the flap on the cornea was decentred and the surgery was rescheduled for a week later. It then resulted in an overcorrection of +1.50 DS. He was reoperated with the end result of +0.75 DS. After the second operation he noticed an increasing vertical diplopia and postponed the operation of his right eye. The referring surgeon described only small abnormalities in Orbscan and Zywave topography. The patient normally wore a -3.00 DS contact lens in the right eye.

Examination and findings

See Table 4 for examinations and findings from January 2009.

Management

The patient was diagnosed with a weak superior oblique muscle, due to a decompensated congenital trochlear nerve paresis. He was initially unsure of an operation on the right eye as it is his dominant eye, but he agreed to strabismus surgery. A moderate retro positioning of the inferior oblique muscle of the right eye was scheduled.

Discussion

Diplopia is a rare side effect after refractive surgery, but is nevertheless frustrating for both patient and surgeon. Only a few reports on disturbance of the binocular vision after refractive surgery exist (Godts et al., 2004; Godts, Trau, & Tassignon, 2006; Kowal, Battu, & Kushner, 2005; Kushner & Kowal, 2003; Schuller, Silverberg, Beade, & Moadel, 1999; Snir, Kremer, Weinberger, Sherf, & Axer-Siegel, 2003; Sugar et al., 2002; Yap & Kowal, 2001). Even though this is a small number of reports, they are well documented. Still, in a report by the American Academy of Ophthalmology on safety and efficacy of LASIK, normal or comfortable binocular vision was not listed as a criterion for success and binocular impairment was not mentioned as an adverse complication (Sugar et al., 2002). Neither did this report describe any orthoptic examination in the pre-examination of refractive surgery patients. Another two systematic reviews based on clinical trials comparing LASIK and PRK, did not consider binocular vision a parameter for success (Hersh, Steinert, & Brint, 2000; Shortt & Allan, 2006). In 2000, a standard guideline recommended some parameters for refractive surgery evaluation, but binocular vision measurements were not included (Ang et al., 2009).

The problems experienced by Case 1 are not a result of any

surgical mistake, and according to the refractive result the surgery was successful. When operating on patients with moderate and high myopia, it is important to remember that the accommodative and convergence demands will increase after the surgery (for an explanation, see Rabbetts 1998). The accommodation required for a given distance is larger for a patient wearing contact lenses than for a patient wearing spectacles. Most contact lens fitters will have experienced this, especially in early presbyopia. This might create problems for patients with a history of accommodative esotropia or weak binocular fusion. Case 1 was mainly bothered at distance, but one would expect that patients with his refraction and history could typically have convergence excess, larger esotropia at near than distance with a high accommodative convergence to accommodation (AC/A) ratio. Normal treatment for convergence excess is a near add, often in progressive lenses. Refractive laser surgery is not known to change the AC/A, and a near add will still be needed. A similar case has been reported where the patient had convergence excess, but the refractive surgeon was not aware that the patient wore progressive lenses (Kowal et al., 2005). If this was the case for our patient, reading glasses may be indicated even after strabismus surgery to keep the esodeviation controlled. The patient was known to have trouble with contact lens wear and this was thought to be a consequence of his job as a mechanic. In hindsight one might think that he also had binocular discomfort without being able to identify it. Contact lens wear, like refractive surgery, would have increased the accommodative demand and thereby broken down the fragile binocular control. We believe a thorough history and evaluation of this patient's binocular status could have revealed the risk of decompensation.

Case 2 had a history of strabismus surgery. After refractive surgery the right eye had a corneal scar, the topography showed higher order aberrations and the ablation zone was temporally decentred. This led to an optical image of poorer quality, and for him this was enough to break down his binocular vision. We do not know which eye was dominant, but this case could well be a matter of switch of dominance. Kushner (1995) described fixation switch as a possible mechanism behind diplopia and decompensated phoria. Changing fixation to fixate with the non-dominant eye will result in a secondary deviation that gives a larger tropia of the non-paretic eye, following Hering's law. This will often exceed the well-established fusional amplitudes. This fixation switch can also interrupt a well-compensated trochlear nerve paresis (Kowal et al., 2005; Kushner, 1995; Kushner & Kowal, 2003). Godts et al. (2006) advocate performing refractive surgery on the dominant eye first to avoid this switch of fixation or dominance. Case 2 also had poor vergence facilities (Palomo, Puell, Sanchez-Ramos, & Villena, 2006), which indicates that his accommodative esotropia was barely under control before the laser surgery. Patients with poor vergence facilities and significant amounts of hyperopia are classified as having a moderate risk of postoperative diplopia (Kushner & Kowal, 2003). Even a slight interruption of his binocularity and accommodative demand caused a decompensation in this case. With a preoperative orthoptic examination the patient could have been informed about this increased risk of postoperative diplopia. Laser treatment to regularise cornea was performed and this resulted in a clear right cornea for Case 2. His visual acuity was improved to normal levels, but even fully corrected he still had problems. Even if he was suppressing on the Worth 4 dot test, he was bothered with

Table 3
Case 3, examinations and findings, January 2009

Complaint	Eyestrain and problems with changing focus and intermittent diplopia, mainly horizontal
Habitual prescription	OD: +1.00 -0.50 x 155, 2.5 PD base down, OS: +0.75 -0.25 x 169, 1.0 PD base up
Subjective refraction	OD: +0.25 -0.50 x 155, OS: 0.00 -0.25 x 170
BCVA (Snellen decimal)	OD: 1.0, OS: 1.0
UCVA	OD: 1.0, OS: 1.0-
Cover test distance, uncorrected	Esophoria, right esotropia and right hypertropia when decompensated
Cover test near with accommodative object, uncorrected	Exophoria, right hypertropia when decompensated
Cover test at near with non-accommodative object, uncorrected	Small right esotropia and right hypertropia
Prism cover test, uncorrected	Distance: 18 PD base out (right esotropia)
Worth 4 dot, uncorrected	Distance: positive (no suppression)
Precisio topography	Small astigmatic irregularity and no aberrations. See Figure 2.

Note. PD = prism dioptres.

Table 4
Case 4, examinations and findings, February 2009

Complaint	Vertical diplopia (with contact lens OD)
Dominant eye	Right
Subjective refraction	OD: -3.00 DS, OS: +0.75 DS
BCVA (Snellen decimal)	OD: 1.0, OS: 1.0
Prism cover test with contact lens right eye	In primary position: 4-6 PD base down right eye and 6 PD base in In up gaze: 12 PD base down right eye and 8 PD base in In down gaze: 8 PD base down right eye and 2 PD base out
Maddox rod	Same results as prism cover test
Cyclophoria	OD: 3-4 degrees excyclotorsion, OS: 2 degrees excyclotorsion
3 step head tilt test	Tilt right: 6 PD hyper OD Tilt left: no deviation
Hess screen	Bilateral overaction of the inferior oblique muscle. See Figure 3.
Marlow occlusion (4 days)	Similar findings, larger deviation on up gaze

Note. PD = prism dioptres.

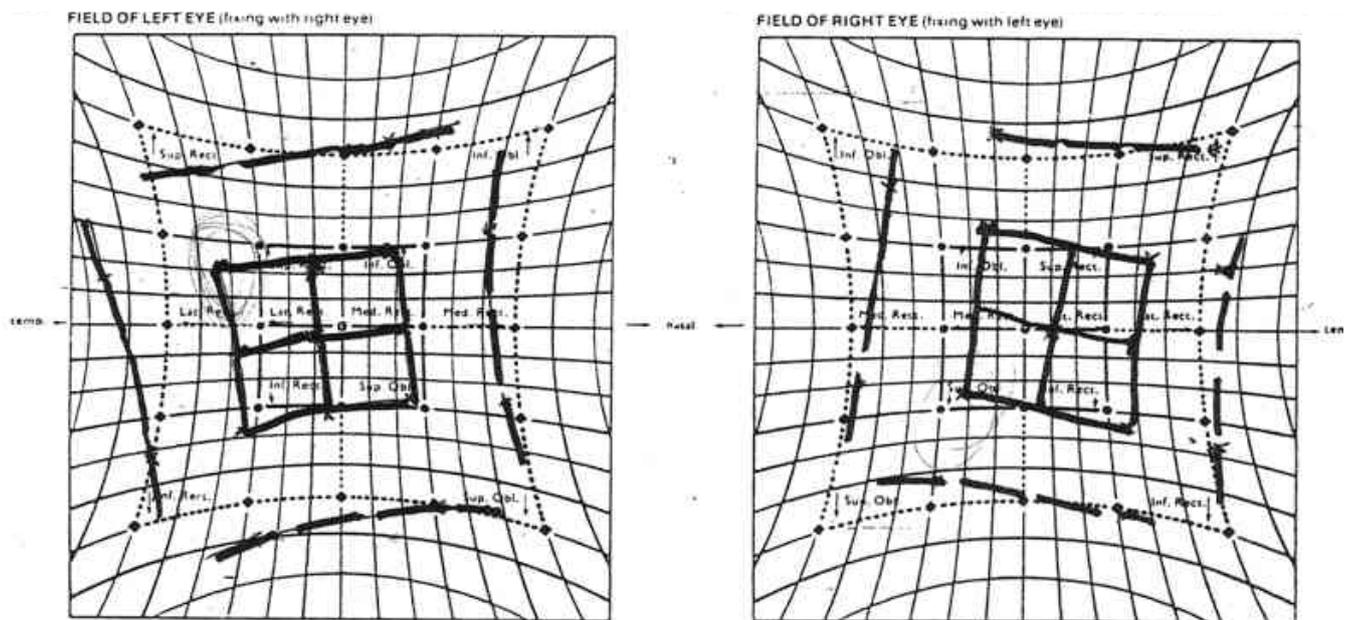


Figure 3. Hess Screen result from Case 4 shows bilateral overaction of the inferior oblique muscle in both eyes. The patient had a decompensated congenital trochlear nerve palsy.

diplopia. Increase in hyperopia after surgery is a known complication of phototherapeutic keratectomy (PTK) on scars (Dogru et al., 2001).

Case 3 had no clear pattern of binocular anomaly, and normally one should expect an increasing esodeviation with increased accommodative demand but here we saw the opposite as he relaxed into an esotropia. The last consultation was not a fully binocular evaluation and it would have been interesting to have a more in depth evaluation of the accommodative and vergence facilities. Latent hyperopia will become manifest with time and a previously safe, but small, motor fusion range may become insufficient to stay well-controlled. The topography showed a small astigmatic irregularity and no aberrations. There was a possible vertical decentering, of the ablation zone, but this was considered to be without impact.

Case 4 is an example of a deviation that could probably not have been foreseen. Double vision was reported even without a known history of motility problems. His diagnosis is a decompensation of a well controlled trochlear nerve palsy and the development of superior oblique paresis, which according to Schuler and his colleagues cannot be foreseen (Schuler et al., 1999). The decompensation might be secondary to a decentred ablation zone, but this was never looked into, as the strabismus was manifest when he came to the hospital eye department. In theory he could have benefited from a regularisation of cornea. According to Schuler et al. (1999) and Kowal et al. (2005) the anisometropia is too small to be a factor of the decompensation, though he might have had very fragile binocular control. Vertical phorias can lead to decentering of the optic zone during treatment (Godts et al., 2004; Yap & Kowal, 2001). Yap and Kowal described in 2001 how the laser could grind in a prism to the cornea. The newer techniques are designed to control this better, and using optimized aspherical and wavefront guided treatments, the outcome of refractive laser surgery continues to improve (Myrowitz & Chuck, 2009). Patients with vertical phorias may have a weak fusional reflex that is affected by change in refraction. Horizontal

deviations are better compensated than vertical, thus vertical decentering of the ablation zone is a greater risk for decompensation (Kushner & Kowal, 2003). Godts et al. (2004) describe a decentred treatment zone as a factor for binocular vertical deviation due to induced prismatic effect. A prismatic effect in the cornea is also likely to give significant monocular problems due to higher order aberrations, which they do not mention. They explain vertical deviation as a result of change in prismatic effect caused by the induced prismatic effect in the patient's spectacles. We question this explanation, as the prismatic effect in the primary position is close to zero and the prismatic effect will change base direction depending on the direction of gaze. However, in larger anisometropias prismatic effect, in conjunction with aniseikonia, may create discomfort with spectacle correction.

Anisometropia below 4 D is thought to give little or no symptoms (Kushner & Kowal, 2003). Still monovision as a form of anisometropia, as in Case 4, has been shown to result in absence of foveal fusion and reduced stereoacuity (Fawcett et al., 2001; Wright, Guemes, Kapadia, & Wilson, 1999). Only 3% of aniseikonia has been reported to reduce central fusion and thus contribute to symptomatic strabismus (Kowal et al., 2005). It is presumed that the number of patients requesting monovision to correct presbyopia will increase (Schuler et al., 1999). Godts et al. (2004) recommend that monovision should be tried out with contact lenses before surgery. This is probably a safe approach even though the positive predictive value of contact lens simulation has never been evaluated (Kowal et al., 2005).

Kushner and Kowal (2003) imply that the incidence of binocular decompensation after refractive surgery is so rare that randomised studies are unlikely to be published anytime soon. To minimize the risk of postoperative diplopia, risk groups and suggestions for additional tests should be defined. Several authors have described a minimum screening technique to evaluate the binocular functions before refractive surgery, and risk factors graded in low, moderate and high risk have been suggested (Godts et al., 2006; Kowal et al. 2005; Kowal, 2000; Kushner &

Kowal, 2003; Holland, Amm, & de Decker, 2000). We support these recommendations. It is important to mention that refractive surgery can sometimes be a useful tool to help patients with refractive accommodative esotropia, but only after a thorough binocular evaluation (Magli, Iovine, Gagliardi, Fimiani, & Nucci, 2009; Polat, Can, Ilhan, Mutluay, & Zilelioglu, 2009; Godts et al., 2006)

Conclusions

In three of the four cases presented it is likely that binocular problems as a result of refractive surgery could have been foreseen, or at least the patients could have been informed about the increased risk of diplopia after refractive surgery. From this we would like to stress the importance of awareness amongst eye care providers of potential binocular problems after refractive surgery. To prevent potential problems we recommend a thorough history and binocular evaluation before any surgery is performed.

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