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SHORT COMMUNICATION

The importance of cyclotorsional changes in refractive surgery

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PURPOSE. *To provide evidence of the importance of a precise record of torsional alterations in all patients about to undergo refractive surgery and particularly in patients with latent strabismus that may become decompensated due to the dissociation phenomenon produced during different surgical procedures that result in fixation loss.*
METHODS. *Using 3D-VOG video-oculography, the authors analyzed the horizontal, vertical, and torsional movements of each eye after inducing fixation loss in one and both eyes in a patient with well-compensated dissociated vertical deviation (DVD). As the dissociated techniques, the authors used occlusion according to Posner maneuver and the placing of Bagolini filters with increasing densities by means of the Bielschowsky phenomenon, both pathognomonic of DVD.*
RESULTS. *The authors observed not only horizontal and vertical alterations, but also cyclotorsional alterations which may even exceed 15° depending on the resulting dissociation component.*
CONCLUSIONS. *In view of the obtained results, the authors consider it important to conduct a meticulous study of ocular motility in all patients about to undergo refractive surgery, especially in the case of high astigmatism to rule out possible latent strabismus that may condition cyclotorsional alterations important in refractive surgery. (Eur J Ophthalmol 2008; 18: 285-9)*

KEY WORDS. *Cyclotorsional changes, Dissociated vertical divergence, 3D-VOG, Refractive surgery*

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INTRODUCTION

One relevant problem that we face in refractive surgery is due to the visual axis alignment system when conducting ablation so as to avoid possible misalignments with the inherent unpredictable outcomes. For this reason, major advances have been made in eye-tracking systems. While these systems may initially be considered efficacious in the majority of cases, there are patients with compensated motor abnormalities, such as dissociated vertical deviation (DVD), that may go undetected, and where the use of one system as opposed to the other may be crucial to the outcomes.

DVD is a special form of strabismus where the principal characteristic is that the elevation movement violates Herring's Law. The magnitude of the hypertropia may be bilateral and is usually asymmetric. There are several etiopathogenic theories that tried to explain DVD, such as those proposed by Posner, Guyton (1), Brodsky (2), Bielchowsky, White, Helveston, Houtman et al (3), and Mein and Jonson. According to the latter, there are stimuli anomalies on the vertical divergence due to the abnormal influence of light,

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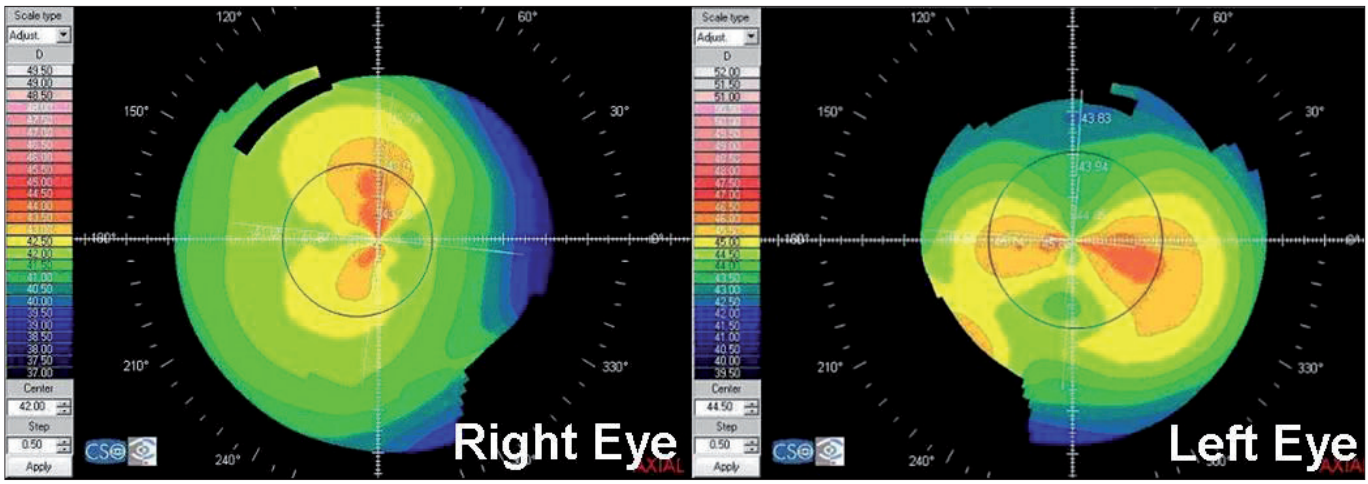

Fig. 1 - *Image of right and left eye video-keratometry.*

Fig. 2 - (A) *Dissociated vertical deviation in right eye.* **(B)** *Dissociated vertical deviation in left eye.* **(C)** *Image of both eyes in primary position.* **(D)** *Record with Bagolini filter bar of increasing density.*

with light disparity being necessary, which would be corroborated by the Posner phenomenon (4).

The Posner maneuver (pathognomonic of DVD) is described as the situation in a patient with DVD that when one eye is covered with a translucent occluder while fixing on a light in the primary position, this eye can be seen to drift upwards. Then, when the fixed eye is occluded without uncovering the other eye, the hypertrophic eye is seen to descend. When we uncover the originally fixed eye, this recovers fixation and the eye that remains covered ascends again.

The Bielschowsky phenomenon, pathognomonic of DVD, consists in the descent of the nonfixed eye when filters of increasing densities are placed in front of the fixed eye which causes light disparity and triggering DVD in the fixed eye. In order to maintain fixation, this eye stimulates the depressor muscles, which is manifest by the descent of the hypertrophic nonfixed eye that reaches the primary position or even below this point remaining hypotrophic.

The aim of this study is to provide evidence that after the loss of fixation due to light disparity and the loss of the sense of shape, we do not just have vertical movements but also horizontal and especially cyclotorsional. These significantly affect the change in the astigmatic axis which

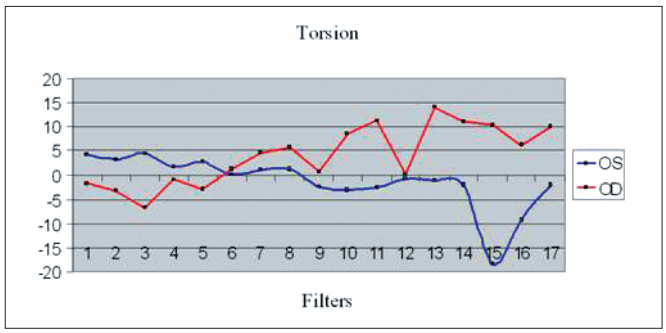

Fig. 3 - *Torsional changes during Bielschowsky phenomenon (positive torsion signs indicate extorsion and negative signs indicate intorsion).*

may lead to major postsurgical repercussions if not considered prior to surgery.

METHODS

The measuring system we used was 3D video-oculography (3D-VOG) (Sensomotoric Instrument®) which is a non-invasive optical system with two infrared video cameras that measures horizontal, vertical, and torsional movements of both eyes independently with a spatial resolution of 0.05°/0.05°/0.10° (horizontal/vertical/torsional), a measuring range of ±25°/±20°/±18° (horizontal/vertical/torsional), and with a measurement area for the recording of torsional ocular movement of ±20° around the primary position of the eye.

A 20-year-old woman who underwent surgery for congenital esotropia was studied; she wanted to be operated (refractive surgery) because of hypermetropic astigmatism. She had 20/20 visual acuity in both corrected eyes, right correction +2.75+1.5*85, left +3.0+1.75*175 (Fig. 1), 16/17 mmHg intraocular pressure respectively, normal biomicroscopy of anterior chamber, and normal fundus. The ocular motility exploration demonstrated residual microesotropia of +4 DP, with spontaneous alternance, without alphabetical components and without limitations in lateral versions or marked incomitance. She presented well-compensated asymmetric DVD (Fig. 2C), which after prolonged occlusion revealed 40 DP in the right eye (Fig. 2A) and 12 DP in the left eye (Fig. 2B) in the primary position of the eye. The stereopsis tests were negative, presenting spontaneous alternance with alternate suppression in the vectographic study and with Worth's lights for near and distance vision.

TABLE I - HORIZONTAL, VERTICAL, AND TORSIONAL DEVIATIONS OF BOTH EYES WHEN ONE AND BOTH EYES ARE ALTERNATELY OCCLUDED

	Right	Left	Right–left
Test occluding right eye (RE)			
Horizontal eye position RE uncovered	–2.0°	–1.4°	–0.5°
Horizontal eye position RE covered	–4.0°	–1.2°	–2.8°
Horizontal eye position RE covered	–10.0°	–0.7°	–9.2°
Vertical eye position RE uncovered	–7.6°	–9.6°	+1.9°
Vertical eye position RE covered	+7.1°	–6.6°	+13.7°
Vertical eye position RE covered	–1.3°	–1.8°	0.5°
Torsion RE uncovered	–0.6°	–4.4°	+3.9°
Torsion RE covered	+8.2°	+0.4°	+7.7°
Torsion RE covered	–1.6°	–4.9°	+3.3°
Test occluding left eye (LE)			
Horizontal eye position RE uncovered	+0.4°	–0.1°	+0.5°
Horizontal eye position LE covered	–6.4°	–4.1°	–2.3°
Horizontal eye position RE covered	–6.4°	–4.1°	–2.3°
Vertical eye position RE uncovered	–5.9°	–5.8°	–0.2°
Vertical eye position LE covered	–6.6°	–2.2°	–4.5°
Vertical eye position RE covered	–9.4°	–10.1°	+0.7°
Torsion RE uncovered	+2.0°	–3.2°	+5.2°
Torsion LE covered	+1.2°	–3.4°	+4.5°
Torsion RE covered	+5.7°	+2.5°	+3.3°

TABLE II - VERTICAL AND TORSIONAL COMPONENT WITH OCCLUSION OF LEFT EYE (LE) AND USE OF BAGOLINI FILTERS OF INCREASING DENSITY IN RIGHT EYE (RE)

	Right	Left	Right–left
LE covered			
Vertical eye position	Hypotropia –0.3º	Hypertropia +7.4º	DVD –7.7º
Torsional eye position	Incyclotorsion –0.6º	Excyclotorsion –1.4º	–0.8º
Filter #1 RE/LE covered			
Vertical eye position	Hypertropia +0.4º	Hypertropia +6.7º	DVD –6.3º
Torsional eye position	Incyclotorsion –1.7º	Excyclotorsion –4.3º	+2.6º
Filter #2 RE/LE covered			
Vertical eye position	Hypertropia +1º	Hypertropia +7.2º	DVD –7.2º
Torsional eye position	Incyclotorsion –1.4º	Excyclotorsion –3.2º	+1.8
Filter #3 RE/LE covered			
Vertical eye position	Hypertropia +2.6º	Hypertropia +6.7º	DVD –4.2º
Torsional eye position	Incyclotorsion –6.8º	Excyclotorsion –4.4º	–2.4º
Filter #4 RE/LE covered			
Vertical eye position	Hypertropia +2.1º	Hypertropia +7.5º	DVD –5.5º
Torsional eye position	Incyclotorsion –0.9º	Excyclotorsion –1.7º	+0.8º
Filter #5 RE/LE covered			
Vertical eye position	Hypertropia +2.4º	Hypertropia +8.5º	DVD –6.1
Torsional eye position	Incyclotorsion –2.9º	Excyclotorsion –2.7	–0.1º
Filter #6 RE/LE covered			
Vertical eye position	Hypertropia +3.8º	Hypertropia +9.3º	DVD –5.5º
Torsional eye position	Excyclotorsion +1.3º	Excyclotorsion –0.1º	+1.4º
Filter #7 RE/LE covered			
Vertical eye position	Hypertropia +5.2º	Hypertropia +8.6º	DVD –3.4º
Torsional eye position	Excyclotorsion +4.5º	Excyclotorsion –1.1º	+5.6º
Filter #8 RE/LE covered			
Vertical eye position	Hypertropia +8º	Hypertropia +9º	DVD –1.1º
Torsional eye position	Excyclotorsion +5.8º	Excyclotorsion –1.3º	+7.1º
Filter #9 RE/LE covered			
Vertical eye position	Hypertropia +2.6º	Hypertropia + 8.4	DVD –5.7º
Torsional eye position	Excyclotorsion +0.8º	Incyclotorsion +2.4º	–1.6º
Filter #10 RE/LE covered			
Vertical eye position	Hypertropia +7.5	Hypertropia +9.6º	DVD –2.1º
Torsional eye position	Excyclotorsion +8.6º	Incyclotorsion +3.1º	+5.5º
Filter #11 RE/LE covered			
Vertical eye position	Hypertropia +8.2º	Hypertropia +9.5º	DVD –1.3º
Torsional eye position	Excyclotorsion +11.2º	Incyclotorsion +2.5º	+8.8º
Filter #12 RE/LE covered			
Vertical eye position	Hypertropia +8.3º	Hypertropia +9.5º	DVD –1.2º
Torsional eye position	Excyclotorsion +0.1º	Incyclotorsion +0.8º	–0.7º
Filter #13 RE/LE covered			
Vertical eye position	Hypertropia +9.3	Hypertropia +11.8º	DVD –2.5º
Torsional eye position	Excyclotorsion +14.0º	Incyclotorsion +1.1	+12.9º
Filter #14 RE/LE covered			
Vertical eye position	Hypertropia +9.4º	Hypertropia +10.1º	DVD –0.7º
Torsional eye position	Excyclotorsion +11.1º	Incyclotorsion +2.1º	+9.0º
Filter #15 RE/LE covered			
Vertical eye position	Hypotropia –3.7º	Hypotropia –6.7º	DVD +3.0º
Torsional eye position	Excyclotorsion +10.3º	Incyclotorsion +18.3º	–8.0º
Filter #16 RE/LE covered			
Vertical eye position	Hypotropia –6.2º	Hypotropia –7.1º	DVD +0.9º
Torsional eye position	Excyclotorsion +6.3º	Incyclotorsion +9.2º	–2.9º
Filter #17 RE/LE covered			
Vertical eye position	Hypertropia +9.7º	Hypertropia +8.6º	DVD +1.1
Torsional eye position	Excyclotorsion +10.1	Incyclotorsion +2.0º	+8.1

Then the torsional study was conducted demonstrating the horizontal, vertical, and torsional ocular movements of both eyes. The record was made with both eyes uncovered, with one eye covered to simulate loss of fixation in one eye, and with both eyes covered to simulate loss of fixation in both eyes (Tab. I). Likewise, we studied the Bielschowsky phenomenon occluding the left eye with an opaque occluder (as DVD was compensated in binocularity) and then placing the Bagolini filters in front of the right eye (Fig. 2D) in a progressively increasing manner, recording the torsional and vertical ocular movements at each point (Tab. II, Fig. 3).

RESULTS

As seen in Table I, the torsional changes that are produced after covering the other eye with a translucent occluder are less than 5º. On covering the right eye, the left eye goes from an extorsion of 4.4º to an intorsion of 0.4º, returning to the extorsion of 4.9º on covering both eyes. Likewise, on covering the left eye with a translucent occluder, the right eye goes from an extorsion of 2º to 1.2º, increasing to 5.7º on covering both eyes. Although these changes may appear of little importance, we went on to analyze the torsional results with the reduction of light stimuli and shape in different grades, as recorded in Table II. This shows that on occlusion of the left eye and depending on the deprivation produced on the right eye (by placing Bagolini filters), we can see torsional changes in the right eye greater than 20º (filter 3–intorsion 6.8º/filter 13–extorsion 14º), with major fluctuations depending on the filter used (Fig. 3).

DISCUSSION

These situations are comparable to those of a patient with high refractive defect, where without the corrective lenses and in the different surgical environments where fixation is more difficult (the additional conditioning factor that many patients receive a presurgical anti-anxiety treatment of diazepam 5 mg to relieve their anxiety) may condition decompensation of previously compensated motor components and which may not be detected if a correct exploration is not conducted from the point of view of the previous strabismus status (5).

If we also add the possibility that we may find cases of high astigmatism where the precision of its axis is fundamental, we then have a key factor when examining these patients.

Therefore, we conclude the need of a correct motor exploration in all patients who are about to undergo refractive surgery, especially those with high astigmatism and with compensated ocular deviation, supporting the idea of other authors on the usefulness of having ocular torsion control systems, as well as establishing a safety measure before surgery, such as marking the axis of 12 hours in order to obtain a surgical reference in the case of the occurrence of these motor alterations conditioning the results of the intervention, or the use of laser systems where the eye tracking system is not only based on the centering of the pupil but also on the anatomic characteristics of the iris, which would enable us to monitor the torsional eye movements during the intervention.

Proprietary interest: None.

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