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A case of paradoxical diplopia in large-angle consecutive exotropia

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Abstract

PURPOSE To describe the investigation and subsequent management of paradoxical diplopia in unsightly exotropia. A 32-year-old lady requested surgical correction of a large manifest consecutive exotropia which, on initial correction with any base-in prism, was accompanied by paradoxical diplopia.

METHODS Botulinum toxin to the right lateral rectus reduced the deviation to 30^{Δ} over a one-week period. The residual deviation was corrected with base-in Fresnel prisms which the patient wore constantly for another two weeks. Although there was demonstrable diplopia initially, it disappeared after 3–4 days of prism wear. Surgery was carried out comprising right lateral rectus recession (6mm) and right medial rectus advancement from 12mm to 6mm posterior to the limbus.

RESULTS There was no diplopia following the surgery and the residual exodeviation measured 6^{Δ} for near and 16^{Δ} for distance (fixing OD). The patient remains symptom-free and cosmetically excellent.

CONCLUSION A gradual progressive reduction in the deviation using a combination of Botulinum toxin and prisms allowed a more informative conclusion to be made regarding the potential post-operative sensory status in this patient, by allowing her to slowly adjust to an altered ocular alignment.

In patients with non-functional strabismus who may be at risk from post-operative diplopia, a trial with prisms over a few weeks with or without the addition of Botulinum toxin is advocated.

Key words Paradoxical diplopia; consecutive exotropia; large-angle exotropia; prism therapy; lateral rectus recession; medial rectus advancement; Botulinum toxin

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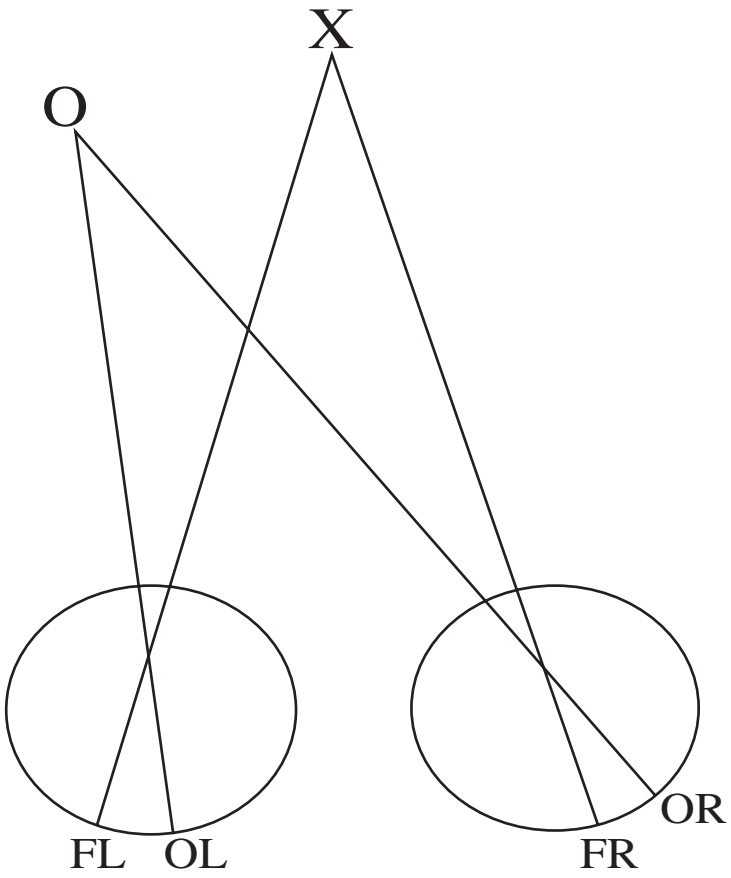

Fig. 1. Projection diagram showing the fovea of the left and right eyes (FL & FR, respectively) projecting the image of object X as lying straight ahead, while object o stimulates the same eccentric retinal points in each eye (ol and or, respectively) and is thus perceived as lying on the left hand side of object X.

Introduction Paradoxical diplopia is the phenomenon whereby projection of diplopic images is not commensurate with the angle or direction of deviation.

Normal projection of visual stimuli assumes that the fovea, nasal and temporal retinae of one eye share a common visual direction with the fovea and temporal and nasal retinae, respectively, in the fellow eye (see Figure 1). In the presence of a convergent squint, the image of the object of regard stimulates retinal elements medially to the fovea, which results in temporal-ward projection of the diplopic image; this is known as homonymous diplopia. In the presence of a divergent squint, the image of the fixation object stimulates retinal elements lateral to the fovea, which results in nasal-ward projection of the diplopic image; this is known as heteronymous diplopia.

Paradoxical diplopia is the presence of heteronymous diplopia accompanying a convergent deviation or homonymous diplopia in the presence of a divergent deviation. This case report describes paradoxical diplopia in an adult who requested surgical correction of her consecutive divergent squint.

Case report A 32-year-old lady requested surgical correction of her consecutive exotropia in the right eye. She had previously undergone surgery for an infantile esotropia of the right eye at the age of two years

and had noticed her eye gradually diverge with time, more so since the birth of her first child some 18 months previously. She had previously sought the opinion of two other ophthalmologists who advised against surgery for the exotropia on the grounds of a high risk of diplopia with any level of correction.

On examination, there was a large manifest exotropia with slight hypertropia of the right eye. There was no diplopia; sensory testing revealed suppression of the right eye in free space. Ocular ductions were full. There was no evidence of latent nystagmus, DVD or vertical muscle dysfunction. Visual acuity was recorded at 6/6 (OU) on the Snellen chart; there was no significant refractive error. The angle of deviation was measured as follows using the simultaneous and alternating prism cover test:

Fixing OU

Near 45^{Δ} exo, $5^{\Delta}\ ^{R}/_{L}$

Dist. 45^{Δ} exo, $4^{\Delta}\ ^{R}/_{L}$

Testing with prisms to indicate the likely post-operative sensory status revealed homonymous (uncrossed) diplopia with any amount of base-in prism. The only way to induce heteronymous diplopia (as is expected with a divergent squint) was to increase the exotropic angle with an 8^{Δ} base-out prism, thus creating a deviation of almost 58^{Δ}. Interestingly, only the horizontal diplopia was noted to be paradoxical, the vertical separation of images was commensurate with the small vertical deviation with the lower image belonging to the hypertropic, right eye.

On the synoptophore, the objective angle of –26° was unequivocal with the subjective angle of +5°. At the subjective corrected angle there was demonstrable simultaneous perception but no superimposition or fusion. A projection diagram to explain the sensory findings is shown in Figure 2.

Correction with loose base-in prisms in free space resulted in constant homonymous diplopia. Botulinum toxin (BT) 7.5 µg was injected into the right lateral rectus muscle. Review a week later showed a manifest exotropia measuring 30^{Δ}. The patient had noted homonymous diplopia for three days following the BT injection. The residual deviation was corrected with a 30^{Δ} base-in Fresnel prism applied to the right lens of plano spectacles. This resulted in a 'ghost image' projected homonymously but the patient was asked to persevere with this for another two weeks.

Review two weeks later showed a residual right exotropia of 10^{Δ}, with no reports of diplopia or 'ghost images'. The patient subsequently underwent right lateral rectus recession of 6 mm on adjustable suture and a left medial rectus re-advancement from 12 mm to 6 mm behind the limbus. The adjustable suture was tied down the next day without further adjustment.

Further review two weeks later showed a residual right exotropia; there was suppression in free space using Bagolini lenses at 1/3 m and 6 m, and Worths lights at 1/3 m, 1 m and 6 m. The angle of deviation was measured as follows (using the alternating prism cover test):

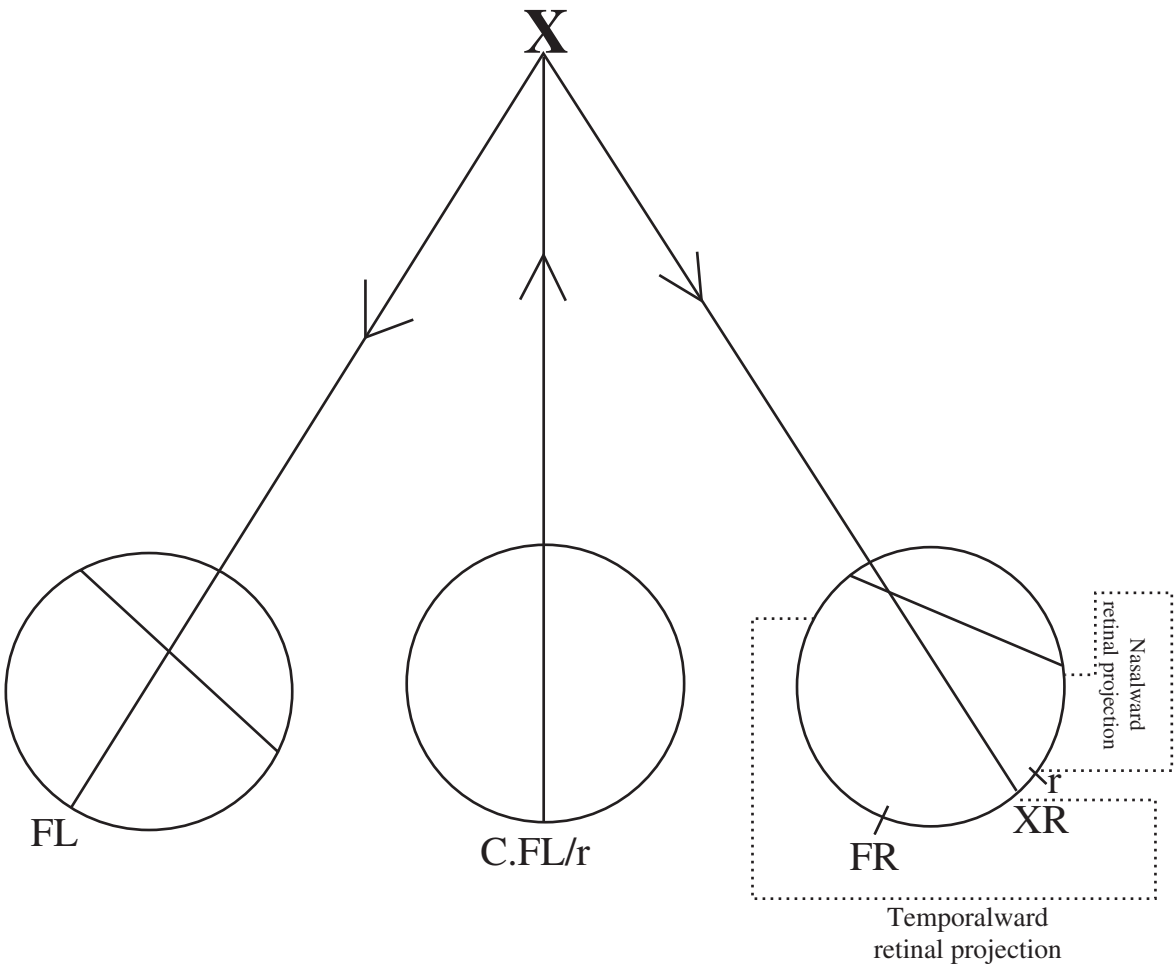

Fig. 2. Key: FL: Fovea of left eye projecting straight ahead. FR: Fovea of right eye, suppressed in free space to prevent visual confusion though assuming a temporal-ward projection. XR: Object X stimulating right temporal retina – correlates with the objective angle of deviation (45^{Δ}). r: Subjective angle noted on the synoptophore (+5°).

	Fixing Right	**Fixing Left**
Near	6^{Δ} exo, $5^{\Delta}\,{}^{R}/_{L}$	8^{Δ} exo, $5^{\Delta}\,{}^{R}/_{L}$
Dist.	16^{Δ} exo, $4^{\Delta}\,{}^{R}/_{L}$	10^{Δ} exo, $5^{\Delta}\,{}^{R}/_{L}$

The patient did report being aware of an intermittent 'ghost image' but this was only evident when fixing with her right eye.

Discussion Post-operative diplopia is often noted immediately following strabismus surgery. It is mainly noted in patients who have no binocular fusion since those who have the ability to fuse generally 'lock on' fairly quickly. Post-operative diplopia is more likely to be a problem if it is typical for the associated deviation (i.e., homonymous diplopia with a residual esotropia) while atypical forms (i.e., paradoxical and incongruous) are often a transitory problem.[1]

Paradoxical diplopia is not often encountered and its presence must infer a previous sensory adaptation. Normal retinal correspondence ensures that perception of an image is truly representative of where an object actually is. An alteration of normal retinal correspondence is generally only encountered in the presence of a microtropia, a manifest deviation of no greater than 10^{Δ} in which a form of binocular vision occurs.[2] Abnormal retinal correspondence allows an 'extra-foveal'

retinal area to assume the principal visual direction of straight-ahead. In this way, the eyes can work together and behave as a pair despite a small degree of misalignment. Although abnormal retinal correspondence is often referred to at the level of the retina and in terms of retinal eccentricity, abnormal retinal correspondence stems from a neuro-anatomic substrate found within the striate cortex.[3] In larger angles of manifest strabismus, alteration of the normal retinal correspondence is not often detected and suppression develops in childhood to avoid confusion and diplopia.

However, the presence of suppression should not in itself affect the subjective localisation of images, just the conscious recognition of it *per se*. Pickwell[4] proposed a physiological model for suppression suggesting the 'X' (what) system to be inhibited while the 'Y' (where) system is not. This would make sense clinically because patients with manifest squint are able to take up fixation of an object with their deviating eye when their normally fixing eye is occluded (assuming adequate visual acuity in the squinting eye). This is despite not actually having 'seen' where the object lies in true space with their squinting eye due to that eye being 'suppressed'.

In the patient described here, there must have been an alteration in the perceived localisation of images 'seen' with the squinting eye to account for the paradoxical diplopia and the incongruous subjective angle of +5° (compared with an objective angle of –26°). The projection diagram shown in Figure 2 gives a possible explanation for these findings. Point XR represents the eccentric retinal area where the object of regard stimulates the temporal retina of the right eye in the presence of the right exotropia. Point 'r' correlates to the subjective angle noted on the synoptophore of +5°. The retinal area in between point 'r' and point XR is suppressed in free space since no diplopia is noted. Retinal elements in between point XR and the fovea that are not included within a suppression scotoma have adopted an anomalous temporal-ward projection, whilst retinal elements lateral to point 'r' adopt normal nasal-ward projection. Using base-out prisms would increase the angle of deviation moving the fixation target laterally to stimulate the non-suppressed temporal retina resulting in heteronymous diplopia; whilst reducing the angle of deviation with base-in prisms would move the fixation target medially into the non-suppressed retina with temporal-ward projection resulting in paradoxical homonymous diplopia. Only the horizontal angle appears to be compensated for in this way since the separation of vertical images was commensurate with the vertical angle present.

The subjective angle on the synoptophore is representative of how a subject perceives 'straight ahead'. An angle of +5° in the presence of a large manifest exotropia suggests that the straight-ahead localisation from the deviating eye occurs from an extreme temporally displaced locus of retinal elements. Interestingly, the patient took up central fixation with the deviating eye when the fixing eye was occluded, implying that under binocular viewing conditions, a sensory adaptation to the large exotropia had occurred, but the fovea still retained its superiority by projecting straight ahead under monocular viewing conditions.

Following surgery, the projection of images was still paradoxical with respect to the residual horizontal deviation, but only evident if the patient fixed with the right eye. The suppression area did not compensate for the slightly larger angle of deviation.

When investigating the sensory status of strabismus at the corrected angle with prisms, the presence of diplopia often points towards a guarded prognosis (although this is not in itself a sole reason why surgery should be avoided[5]). Patients with strabismus are 'used' to the misalignment of their visual axes and simply correcting with prisms for the short term may not always give a true indication of the likelihood of persistent diplopia post-operatively. Pratt-Johnson & Tillson[6,7] propose a mechanism for suppression, which involves both the nasal and temporal retinal areas in all types of strabismus with the exception of microtropia. In the presence of exotropia, an image stimulating the temporal retina will result in suppression of all retinal areas involved with the binocular field. If the image crosses the vertical mid-line and stimulates the nasal side, diplopia is the result since this stimulus is not compatible with generating suppression (unless it occurs during visual immaturity). For this reason, it is preferable to allow the patient time to adjust to prismatic correction, ideally over a period of at least two weeks. If there is demonstrable diplopia with prism correction initially, it is advisable to encourage the patient to 'persevere' to see if the diplopia resolves spontaneously. It is important to ensure that a strong Fresnel prism is not imitating occlusion by re-testing on a follow-up visit with glass prisms.

Botulinum toxin (BT) or prisms in isolation are not always able to give a reliable indication as to the sensory status following strabismus surgery. Where the angle of deviation is large, a single strong prismatic correction can blur vision,[8,9] thus preventing accurate investigation, while splitting the prism strength between two eyes prevents assessment in the primary position. A single injection of BT may not be able to fully correct a large manifest deviation, and repeated injections may induce incomitance, thus adding further complications. A combination of investigative techniques was used in this case; Botulinum toxin to reduce the deviation such that it was correctable with 'stick-on' prisms without reducing the visual acuity to such an extent that would hamper further investigation. This technique can be of use in large-angled deviations where test results that predict a likely sensory outcome are ambiguous.

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