Evaluation of subjective and objective cyclodeviation following oblique muscle weakening procedures

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Purpose: To evaluate the subjective and objective cyclodeviational changes following different weakening procedures on superior and inferior oblique muscles

Design: Comparative case series

Materials and Methods: In a prospective institution based study, 16 cases of A pattern horizontal strabismus having superior oblique overaction were randomized to superior oblique weakening procedures: either silicon expander or translational-recession. Similarly, 20 cases of V pattern horizontal strabismus with inferior oblique overaction were randomized for inferior oblique weakening procedures: either 10 mm Fink's recession or modified Elliot and Nankin's anteropositioning. Cyclodeviation was assessed subjectively with the synoptophore and objectively using the fundus photograph before surgery and 3 months postoperatively. Change in cyclodeviation was measured by subjective and objective methods. The index of surgical effect (ISE) was defined as the net torsional change postoperatively.

Results: The difference between the extorsional change induced by the two superior oblique procedures, silicone expander (-6°) and translational recession (-11.3°), was statistically significant (P=0.001). Translational recession caused more extorsional change (ISE=296%) than silicone expander surgery (ISE=107%). The two inferior oblique weakening procedures, Fink's recession (+2.5°) and modified Elliot and Nankin's anteropositioning (+4.7°) produced equitable amount of intorsional shift with no statistical difference (P=0.93). Objective measurements were significantly more than the subjective measurements.

Conclusions: Different weakening procedures on oblique muscles produce different changes in cyclodeviation, which persists even up to 3 months. Subjective cyclodeviation is less than the objective measurements indicating partial compensation by sensorial adaptations.

Key words: Fink's recession, modified Elliot and Nankin, oblique muscle surgery, silicone expander, subjective and objective cyclodeviation, torsion measurement, translational recession

Cyclodeviation and cyclofusion were not considered important in the management of horizontal and vertical strabismus for a long time irrespective of oblique muscle over actions.[1-3] However, availability of graded weakening procedures of the oblique muscles to precisely correct the cyclodeviation has made evaluation of cyclorotatory changes before and after strabismus surgery important.[4,5] The results obtained by subjective and objective methods of measurement of cyclodeviation are found to differ from each other. This has been attributed to various naturally occurring adaptive mechanisms including a motor response through cyclovergence eye movements and a sensory component limited to the extent of Panum's fusional areas.[1-3]

Very few studies have measured the changes in cyclotorsion by the subjective and objective methods following weakening procedures on the oblique muscles.[4,5] The objective of this study was to measure the cyclotorsional changes following weakening procedures on the superior and inferior oblique muscles in cases of horizontal strabismus, by using the subjective and the objective methods and to find a correlation between the two methods.

Materials and Methods

The study design was a comparative case series. The statistician decided the numbers on the basis of average number of cases of squint operated in 6 months (study period), about 300 cases and assuming the expected prevalence to be about 25% (c.i, 13 to 40%). A sample of 36 was required with power of study 80% and alpha 5%. We planned equal number of cases in each group, but is also a known fact that V patterns with bilateral inferior oblique over action (IOOA) are more common than A patterns with bilateral superior oblique over action (SOOA). Each group was further subdivided into two types of oblique muscle weakening procedure which was done randomly using chit system. During randomization, each group was assigned two types of weakening procedures in equal halves and the chits were prepared accordingly.

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Thirty - six consecutive cases of horizontal strabismus with bilateral oblique muscle over action were recruited for the study from the squint and amblyopia clinic of our center. Sixteen cases (32 eyes) had bilateral SOOA with significant A pattern which was (defined as a difference of more than 10 prism diopter (pd) in the horizontal deviations in the up and down gazes, the deviation in the up gaze more than the deviation in the downgaze in esodeviations and vice versa in exodeviations. These cases were randomly assigned to one of the two treatment groups (8 cases each) of superior oblique weakening procedures- superior oblique silicone expander (SE) and translational recession (TR). Twenty cases (40 eyes) had bilateral IOOA with significant V pattern (defined as a difference of more than 15 pd in the horizontal deviations in the up and down gazes, the deviation in the up gaze more than the deviation in the downgaze in exodeviations and vice versa in esodeviations). These cases were randomly assigned to one of the 2 treatment groups (10 cases each) of inferior oblique weakening procedures- Fink's recession (FR) of 10 mm and modified Elliot and Nankin's (MEN) inferior oblique anteropositioning. All cases underwent appropriate horizontal muscle surgery (without vertical displacement) in addition.

The study protocol was explained to the patients and their parents (in case of minors) and an informed consent was obtained. The study was performed as part of the doctoral thesis of one of the authors and was approved by the Ethics Committee set up by the institute. Patients were excluded if they had a previous ocular surgery or if they were not cooperative for orthoptic evaluation.

All the subjects included in the study underwent a complete orthoptic workup including measurement of cyclotorsion by objective and subjective methods before and after the surgery. The binocular status in all the cases was assessed by the Bagolini's striated glass. Subjective cyclotorsion was measured by synoptophore using the vertical slit after-image slides, the details of which have been given by Sood et al.[6]

Objective cyclodeviation was determined from the fundus photograph after measurement of the disc- fovea angle. The fundus was photographed[7,8] monocularly after dilating the pupil with the non-fixating eye patched. A spirit level fixed to the head ensured a proper head posture (horizontal intercanthal plane) while the fundus was photographed. The subject was asked to fixate on the camera's internal fixation marker and the photograph of the 50° field of the posterior pole centered on the fovea was obtained on a 400 ASA film. A 5″ by 9″ size positive print was developed and the disc fovea angle (between the line joining the fovea to the geometric center of the disc and the horizontal line passing through the geometric center) was measured from the print using a protractor. This angle was used as a measure of objective torsion.

Surgical technique

Superior oblique SE: after performing a superior oblique tenotomy, a 7 mm segment of No 240 silicone retinal band was inserted between the cut ends of the tendon 3 mm nasal to the superior rectus muscle - details of which are described elsewhere.[9]

Superior oblique TR: the superior oblique tendon was disinserted and reinserted to the sclera at a predetermined site. 6 mm nasal to the superior rectus and 12 mm from the limbus, thereby placing it at the equator- details of which are described elsewhere.[9]

FR (10 mm) recession: the inferior oblique muscle was disinserted and the anterior end was reinserted to the sclera 2 mm inferior to a point 6 mm inferior and 6 mm posterior to the inferior edge of the lateral rectus insertion. The posterior end was fixated 5 mm posterior to the anterior point.[10]

Modified Elliot and Nankin's inferior oblique anteropositioning: the anterior end of the disinserted inferior oblique tendon was placed just lateral to the insertion of the inferior rectus (zero-station).[10] The posterior end was placed 5 mm posterior, along the lateral border of the inferior rectus.

Postoperatively the subjects were reevaluated at 3 months and complete orthoptic workup including torsion measurements were performed. The index of surgical effect on torsion (ISE) was calculated as

ISE = (correction achieved/ preoperative torsion) × 100

Statistical analysis was performed using the STATA 6.0 intercooled version software (STATA, STATA Corp, Houston, TX). Statistical analysis was performed on the means of the torsion measures preoperatively and postoperatively. Owing to small sample sizes, nonparametric tests were used to check the statistical significance of the differences between groups. The Wilcoxon matched pair signed-rank test was used for evaluating differences between the objective and subjective measures of torsion and the Mann Whitney U test for the differences between the procedures. Results were considered statistically significant if the P value was less than 0.05.

Results

Of the 36 cases included in the study, 13 were males and 23 females. The mean age was 13.2 years (range 5 to 24 years). The mean preoperative ocular torsion [Table 1] for inferior oblique weakening procedures measured on the synoptophore was 1.2±1.9° for patients undergoing FR and 3.6± 2.6° for patients undergoing the MEN recession. The correction achieved was 2.1±1.9° and 3.8±2.3° respectively. The ISE was 113% and 115% respectively for patients in the FR and MEN group, the differences in torsion between the 2 groups was not statistically significant ($P=0.93$). Same results were obtained by the objective measurements from fundus photographs [Table 2], which showed a mean preoperative extorsion of 9.8° in the FR group and 11.4° in the MEN group with a postoperative torsional change of 2.5° and 4.7° respectively, the difference not being statistically significant.

The mean preoperative ocular torsion [Table 1] for superior oblique weakening procedures measured on the synoptophore was 1.4±0.9° for patients in the SE group and 2.0± 1.1° for patients in the TR group. The correction achieved was 1.5±0.9° and 5.5±3.9° respectively The ISE was 107% and 296% respectively for patients in the SE and translation recession group. The TR surgery induced a greater torsional change than the SE, the difference being statistically significant ($P<0.001$). This result was also confirmed by the objective method.

Significant differences in torsion measurements by the objective and the subjective methods were noted for in all the groups.

Table 1: Net torsional change in the primary position induced by surgery (subjective changes—measured on the synoptophore)

Surgery	No. of eyes	Preop torsion (Degrees) Mean ± SD	Postop torsion (Degrees) Mean ± SD	Correction (Degrees) Mean ± SD	Mean ISE (%)	Direction of change	*P* value
IO Fink's recession	20	−1.2 ± 1.9°	+0.9°	+2.1 ± 1.9°	113	Intorsion	0.93
IO modified Elliot and Nankin	20	−3.6 ± 2.6°	+0.2°	+3.8 ± 2.3°	115	Intorsion	
SO silicone expander	16	+1.4 ± 0.9°	−0.07°	−1.5 ± 0.9	107	Extorsion	0.001
SO translation recession	16	+2.0 ± 1.1°	−3.5°	−5.5 ± 3.9°	296	Extorsion	

IO - Inferior oblique; SO - Superior oblique; Preop - Preoperative; Postop - Postoperative; SD - Standard deviation; ISE - Index of surgical effect; + indicates intorsion/ intorsional changes; −indicates extorsion/ extorsional changes

Table 2: Net torsional change in the primary position induced by surgery (objective changes—fundus photograph)

Surgery	No. of eyes	Preop torsion (Degrees) Mean ±SD	Postop torsion (Degrees) Mean ±SD	Correction (Degrees) Mean ±SD	Mean ISE (%)	Direction of change	*P* value
IO Fink's recession	20	−9.8° Ext*	−7.3° Ext*	+2.5°	25.5	Intorsion	0.8
IO modified elliot and nankin	20	−11.4° Ext*	−6.7° Ext*	+4.7°	41.2	Intorsion	
SO Silicone expander	16	4.9° Int*	−1.1° Ext*	−6°	122.4	Extorsion	0.002
SO translation recession	16	8° Int*	−3.3° Ext*	−11.3°	141.2	Extorsion	

Int* - Intorsion; IO - Inferior oblique; SO: Superior oblique; preop: preoperative; SD: standard deviation; Ext*=extorsion; postop: postoperative; ISE: Index of surgical effect; + indicates intorsion/ intorsional changes; −indicates extorsion/ extorsional changes.

Table 3, summarizes the torsional changes at a glance. The objective torsion has been adjusted considering 7°exodeviation as zero, so that it can be compared with the subjective cyclodeviation.[7]

Summary of results

1. The synoptophore was useful for measuring the uniocular cyclodeviation in cases of alternate suppression using the after-image slides oriented vertically.
2. Superior oblique TR causes significantly more extorsional change than the SE surgery (*P*=0.01)
3. Both the inferior oblique weakening procedures (FR and MEN) produced almost equitable amounts of intorsional shift, with no significant differences between these two groups (*P*=0.93).
4. Objective methods by fundus photography showed more torsion compared to subjective measurements, implying a partial compensation by sensory adaptation.

Discussion

Cyclodeviation is a well-known feature of oblique muscle disorders.[1-4] The symptoms resulting from cyclodeviations vary and depend on the age of onset, the etiology of the disorder, the amount of cyclotorsion, the level of cyclofusion and sensory adaptation of the visual system.[3,4] Cyclotropia of the congenital variety are often asymptomatic as the subject utilizes adaptive physiological and psychological mechanisms to offset the cyclodisparity between the images. None of the cases in our study were symptomatic with regard to the cyclotropia. Uncontrolled oblique muscle surgery in cases of horizontal strabismus with well-adapted cyclodeviations may induce torsional disparities through over or under corrections. If these disparities exceed the cyclofusional reserve, the patient may become symptomatic for cyclodiplopia. It may also hinder the development of fusion and finer stereopsis.[4,11,12] Hence, it is important to know the cyclotorsional changes produced by the different surgical procedures on the oblique muscles.

Table 3: Torsional change in the primary position (values in degrees)

Surgery	A Preop obj. (Adjusted)*	B Preop subj.	C Sensory adaptation (A-B) (Adjusted)*	D Postop obj. (Adjusted)*	E Surg change (D-A)	F Postop sub. (Adjusted)*	G Sensory adaptation (D-F)
IO Fink's recession	−9.8 (−2.8)*	−1.2	−8.6 (−1.6)*	−7.3 (−0.3)*	+2.5	+0.9	−8.2 (−1.2)*
IO modified elliot and nankin (+0.05)*	−11.4 (-4.4)*	−3.6	−7.8 (−0.8)*	−6.7 (0.3)*	+4.7	+0.25	−7.0
SO silicone expander	+4.9 (+11.9)*	+1.4	+3.4 (+10.5)*	−1.1 (+5.9)*	-6.0	0.07	−1.2 (+5.8)
SO translation recession	+8.0 (+15.0)*	+2.0	+6.0 (+13.0)*	−3.3 (+3.7)*	−11.3	−3.5	+0.2 (+7.2)

Int*: intorsion; IO - Inferior oblique; SO: Superior oblique; preop: preoperative; Obj: objective; Ext*: extorsion; postop: postoperative; Subj: subjective; All figures indicate mean cyclodeviation in degrees; + Indicates intorsion/ intorsional changes; −Indicates extorsion/ extorsional changes; *Figures in parenthesis are values of objective cyclodeviation assuming normal subjects have 7° extorsion.

It is understood that horizontal muscle surgery alone does not alter the cyclodeviations, unless accompanied by vertical transpositioning or differential (slanting) recessions or resections. Thus associated horizontal procedures were not considered to be responsible for the cyclodeviations.

Cyclodeviations can be measured by numerous methods, only a few being useful clinically.[5,8] The subjective methods include the double Maddox rod (DMR),[7] the Polaroid dissociation stereo projector (PDS)[4] and the synoptophore,[6] which was found to be useful in this group of patients for measuring cyclodeviations. The advantages of the synoptophore include a better control of the patient's head, simultaneous correction of the horizontal and vertical deviations and ability to measure even small amount of cyclotorsion. The synoptophore however, is considered less physiological than the PDS, as it is more dissociative.

Objective assessment of cyclodeviation is best done by measuring the disc fovea angle on the fundus photograph done using a standard protocol[8] as described above. Foveal location in normal patients is found to be 0.3 to 0.6 disc diameters below a horizontal line extending temporally from the geometric center of the optic nerve head creating a mean angle of 7.25° to 12.5° from the horizontal axis at the geometric center of the optic disc.[8] In their study measuring cyclorotatory changes after inferior oblique muscle recession by subjective and objective methods, Schworm et al.[5] have assumed a 7° excyclodeviation to indicate the subjective zero cyclodeviation. The subjective and 'adjusted' objective measurements still differed indicating adaptation. The possibility of modulation in the sensorial adaptation to cyclotropia was suggested by the differences in the preoperative and postoperative measures of cyclotorsion by the subjective and objective methods.

Our study showed significant differences in the subjective and objective methods of measuring torsional changes, which is highly suggestive of the presence of sensory adaptations. However the differences in the subjective and objective measurements for the superior oblique weakening procedures were lesser than those seen after the inferior oblique weakening procedures [Table 3]. This suggests that the torsional changes induced by oblique muscle weakening procedures are only partially amenable to sensory adaptations, especially when the superior oblique is weakened.

While the postoperative subjective torsion was less than 1° in the FR, MEN and the SE groups, the superior oblique TR group showed a subjective extorsion of -3.5° at 3-month postoperative follow up. A number of patients were symptomatic for ocular torsion.

In our study the extorsional changes in cases with SOOA was 3 times more after the TR surgery as compared to the SE surgery. This can be explained by the loss of the fanning of the superior oblique tendon fibers in the TR surgery. The increased weakening of the intorting action makes it a less physiological superior oblique weakening surgery. Harada et al.[13] evaluated the effects of anterior partial recession of the superior oblique muscle in cases of cyclovertical muscle abnormalities causing torsional problems. They reported that a 6 mm recession of the superior oblique produced a mean extorsion change of 12°. To the best of our knowledge, this is the first report in literature to have reported the torsional effects of the superior oblique recession surgery.

There are numerous studies on the effect of inferior oblique weakening procedures on ocular torsion. Harada et al.,[13] evaluated the effect of anterior partial recession of the inferior oblique on the torsional status and found a 1° change for every 1 mm recession. Kushner[14] evaluated the cyclorotatory effects following oblique muscle surgery objectively by noting the axis of astigmatism and concluded that bilateral weakening of the inferior oblique by recession caused an intorsion of the axis of astigmatism of about 9.75°. Santiago et al.[15] have shown overall net change of 6.2± 4.8° in excyclotorsion after anterior transposition of the inferior oblique adjacent to or anterior to the inferior rectus insertion on objective measurement using fundus photograph. Our findings also compared favorably with the above studies. Both the procedures produced an equitable amount of intorsional shift, which is within the normal physiological range. FR is a generalized weakening procedure, weakening all the functions (elevation, abduction and extorsion) of the inferior oblique equally. MEN procedure is also a generalized weakening procedure but was expected to have an increased effect on weakening the elevation and strengthening the extorsion because of the anteropositioning. However, it appears that the slack induced by the recession, neutralizes any significant increase in the extorsion produced by the anteropositioning. This also corroborates with the observations form a previous study from the same center[9] wherein we compared Parks' method and the MEN anteropositioning with pure anteropositioning. While Parks' method produced a torsion change of 3±2.5° and the MEN procedure, a change of 3.9±3.2°, 'pure' anteropositioning produced a torsional change of 0.36± 0.9°.

Some limitations of our study are a small sample size and inability to use subjective methods like DMR, due to the lack of binocularity. Further studies in acquired oblique muscle anomalies with binocularity may add to more useful data in a field with very few studies available.

We conclude that significant differences are seen in the measurement of cyclotorsion by subjective and objective methods, implying the presence of compensatory mechanisms. The torsional changes produced by different oblique muscle weakening procedures vary, with the maximum effect seen in the translation recession of the superior oblique. To prevent symptoms of postoperative cyclotorsion it is important to choose procedures according to the amount of torsional changes produced by them.

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