·Clinical Research·

Inferior oblique weakening surgery on ocular torsion in congenital superior oblique palsy

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Received: 2014-03-30 Accepted: 2014-09-24

Abstract

• **AIM: To investigate changes in fundus excyclotorsion after inferior oblique myectomy or myotomy.**

• **METHODS: The records of 21 patients undergoing strabismus surgery by a single surgeon between 2009 and 2012 were examined. Only patients who had undergone an inferior oblique myectomy or myotomy, with or without horizontal rectus muscle surgery, were evaluated. Digital fundus photographs were obtained, and the angle formed by a horizontal line passing through the optic disc center and a reference line connecting the foveola and optic disc center was measured. Associated clinical factors examined include age at the time of surgery, presence or absence of a head tilt, degree of preoperative vertical deviation, torsional angle, inferior oblique muscle overaction/superior oblique muscle underaction, and surgery laterality. Whether the procedure was performed alone or in combination with a horizontal rectus muscle surgery was also examined.**

• **RESULTS: Mean preoperative torsional angle was 12.0±6.4°, which decreased to 6.9±5.7° after surgery (*P*<0.001, paired *t*-test). Torsional angle also decreased from 15.1±7.0° to 6.2±4.3° in the myectomy group (*P*<0.001, paired *t*-test) but there were no significant changes in the myotomy group (*P*=0.093, Wilcoxon signed rank test). Multivariable linear regression analysis showed that preoperative torsional angle, degree of inferior oblique overaction, and age at surgery independently and significantly affected postoperative torsional angle.**

• **CONCLUSION: Mean torsional angle decreased after inferior oblique myectomy. Degree of preoperative torsional angle, inferior oblique overaction, and age at surgery influence postoperative torsional angle.**

• **KEYWORDS:** oculomotor muscles; strabismus; superior oblique palsy; torsion abnormality

DOI:10.3980/j.issn.2222-3959.2015.03.24

Lee J, Suh SY, Choung HK, Kim SJ. Inferior oblique weakening surgery on ocular torsion in congenital superior oblique palsy. *Int J Ophthalmol* 2015;8(3):569-573

INTRODUCTION

Superior oblique palsy (SOP) can be congenital or acquired, unilateral or bilateral, and is the most common cause of isolated vertical deviation [1,2]. Surgical treatment of SOP and secondary inferior oblique overaction (IOOA) can be accomplished by inferior oblique (IO) weakening plus additional vertical rectus and horizontal muscle surgery, as needed[3]. Many SOP patients have ocular extorsion and fusional cyclovergence, which is related to SOP or secondary IOOA[4-6].

Ocular torsion can be measured both subjectively and objectively [7]. Subjective torsion measurements are typically similar to objective ones in patients with bifoveal fusional potential [8]. However, subjective measurement methods can lead to erroneous results, especially in children who often do not cooperate as well as adults. Hence, objective measurement methods, including digital fundus photography, are preferred. Using fundus photography, the amount of excyclotorsion has been assessed with the degree of IOOA in Korean population[9].

It is generally accepted that ocular excyclotorsion from SOP is reduced by IO anteriorization or recession [10-12]. However, there are few reports regarding the efficacy of IO myectomy or myotomy on ocular torsion, compared to IO anteriorization. Arici and Oguz[10] recently reported the effect of IO myectomy and compared this with the effects of a

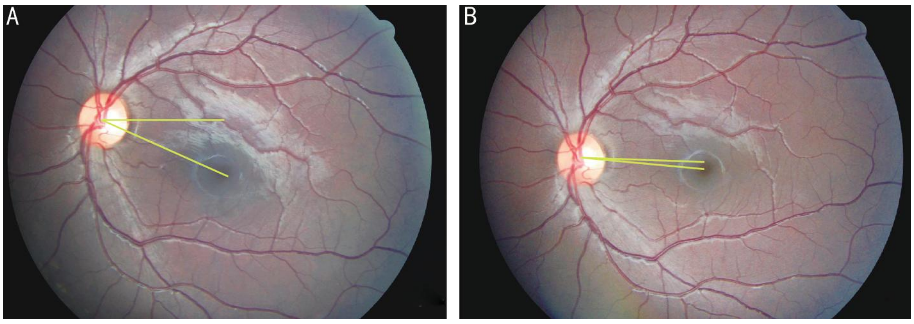

Figure 1 Digital fundus photographs and overlying imaginary lines to measure the ocular torsional angle in the same patient A: A preoperative photograph showing marked excyclotorsion; B: A postoperative photograph showing a marked diminution of the torsional angle.

superior oblique tuck or other IO weakening procedures. Unfortunately, a fair comparison could not be made because preoperative torsional angles differed for different surgical technique groups. Here, we investigate the change in monocular anatomical torsion following IO myectomy or myotomy and examine potentially influencing clinical factors.

SUBJECTS AND METHODS

A retrospective analysis was performed on records from patients with congenital (unilateral or bilateral) SOP undergoing IO myectomy or myotomy, with or without horizontal rectus muscle surgery, by a single surgeon (Kim SJ) between 2009 and 2012. An SOP diagnosis was made based on the presence of characteristic superior oblique underaction (SOUA), IOOA, and/or head tilt. The total number of cases wereas 350 eyes with 224 patients, however, only but pre- and postoperative fundus photographs of 331 eyes from 21 cooperative children with pre- and postoperative fundus photographs were eligible and included in analyses. Major exclusion criterion was lack of cooperation for obtaining pre- and postoperative fundus photographs. Patients with sensory strabismus or paralytic strabismus other than trochlear nerve palsy were also excluded. This study adhered to tenets of the Declaration of Helsinki and our local ethics committee reviewed and approved the study.

The degree of vertical deviation in the primary position, digital fundus photography, the degree of IO overaction and SOUA, and the direction of head tilt were obtained pre- and postoperatively in all patients. The vertical deviation was measured with alternate prism cover test in cooperative children. The severity of IOOA was rated between 0 and +4, according to the upper deviation of the pupil in adduction. A score of 0 was given for none, +1 for 1 mm, +2 for 2 mm, +3 for 3 mm, and +4 for 4 mm of deviation. If pupil deviation corresponded to the middle of 2 adjacent grade levels, assigning a subjective rating of +0.5, +1.5, +2.5, or +3.5 was also permitted. The severity of SOUA was rated in similar way as IOOA was, except it was assessed when the patient was looking inferonasally.

Non-mydriatic fundus photography was performed and archived with the TRC-50x fundus camera (Topcon, Japan). At the beginning of each photographic session, the patient's head was stabilized on the chin rest and headrest by a well-trained examiner. Fundus photographs were taken preoperatively and postoperatively. Following the previously suggested method, the angle between a straight horizontal line passing through the optic disc geometric center and a reference line connecting the macula and the optic disc center (Figure 1) was automatically measured using Adobe Photoshop® CS5 Extended software (Adobe, San Jose, CA, USA)[13].

Methods All operations were performed under general anesthesia. The method for IO muscle surgery (myectomy or myotomy) was selected based on the degree of IOOA and SOUA. An IO myectomy was performed in patients who had a degree of IOOA over 2+ or clinically significant head tilt (over 5 degrees). In case of IOOA 2+, the procedure was selected based on preoperative head tilt. An IO myotomy was performed for a degree of IOOA 2+ or lower without significant head tilt. The indication of IO myotomy was similar to previous reports [14,15]. Preoperative torsional angle was not considered when choosing a surgical method. If a significant amount of esotropia or exotropia was also present, horizontal rectus muscle surgery (*i.e.* bilateral rectus muscle recession, unilateral lateral rectus muscle recession with medial rectus muscle resection) was also performed.

A surgical incision was made at the inferotemporal quadrant of the bulbar conjunctiva. After dissecting Tenon's capsule and isolating the IO muscle, 2 hemostatic forceps were applied separated by approximately 5-10 mm. In case of myectomy, muscle between the hemostats was excised. Meanwhile, in myotomy case, the IO muscles were fully flattened out to expose the full width and seventy-five

Table 1 The preoperative and postoperative degrees of ocular torsion

Groups	No.	Preop. degrees	Postop. degrees	Net change degrees	Reduction (%)	*P*
Overall	21	12.0±6.4	6.9±5.7	5.1±7.9	42.5	<0.001[a]
Myectomy	14	15.1±7.0	6.2±4.3	9.0±6.9	59.6	<0.001[a]
Myotomy[1]	7	9.6 (3.6-19.8)	5.7 (-6.5-14.7)	3.9 (-5.4-13.8)	40.6	0.093
IO only	10	11.3±6.2	5.3±5.3	6.0±7.0	53.1	0.015[a]
With HR surgery	11	14.6±7.0	6.7±5.3	8.2±6.9	56.2	<0.001[a]
Unilateral SOP	11	9.4±4.2	5.0±4.5	4.5±4.3	47.9	0.006[a]
Bilateral SOP	10	15.5±7.1	6.6±5.7	8.9±7.6	57.4	<0.001[a]

IO: Inferior oblique; HR: Horizontal rectus muscles; SOP: Superior oblique palsy. [1]Deviating from a normal distribution, the data are shown as mean with range; [a]Significant difference ($P<0.05$, paired *t*-test).

percent of the muscle's width was partially incised. Both myotomy and myectomy were performed with monopolar electrocautery. The muscle was then released and proximal segment of the muscle retracted into Tenon's capsule. Tenon's capsule was not sutured in both procedures. No acute ocular complications were encountered in any patient.

Statistical Analysis Data are presented as mean±standard deviation. Pre- and postoperative ocular torsional angle were compared using a paired *t*-test or a Wilcoxon signed rank test, as appropriate for the normality of the data set. Changes in vertical deviation and ocular torsional angle were compared using independent *t*-test. Changes in torsional angle according to Knapp's classification[16] of SOP were also compared using Kruskal-Wallis test. Furthermore, various clinical factors (*i.e.* age, postoperative change in head tilt, preoperative SOUA, preoperative IOOA, operation laterality, operation method) were analyzed with multivariable linear regression analysis. A *P*-value<0.05 was considered clinically significant. All analyses were performed using SPSS® Statistics software (version 19.0, IBM, Armonk, NY, USA).

RESULTS

The study group consisted of 12 boys and 9 girls with an average age of 3.48±0.342y (range 11mo to 9y) at the time of surgery. Postoperative fundus photographs were taken 12.81±7.99mo following surgery. Myectomy was performed 21 eyes from 14 patients (67%) and myotomy was done in 10 eyes from 7 patients (33%). Unilateral SOP was present in 11 (52%) patients, while bilateral abnormalities were present in 10 patients (48%). In unilateral cases, the paretic eye was equal to the torted eye in 7 of 11 (64%) patients. Horizontal rectus muscle surgery was concomitantly performed in 11 patients (52%). According to Knapp's classification[16], 10 patients were in class VI (bilateral SOP), 6 in class I (greatest hypertropia in opposite up oblique field), 3 in class III (greatest hypertropia in entire opposite field), and 2 in class IV (greatest hypertropia in entire opposite field and across the lower field).

Pre- and postoperative ocular torsion data are summarized in Table 1. After surgery, mean torsional angle significantly decreased in all patients, except those who had a myotomy. The torsional angle of the fellow eye was normal in unilateral SOP cases and averaged 8.1±2.9 degrees before surgery and 9.2±6.5 degrees after surgery, a small difference that was not clinically or statistically significant ($P=0.642$).

Preoperative vertical deviation in the primary gaze was present in only 12 patients. Net changes in ocular torsion and vertical deviation were not significantly correlated ($P=0.347$). The overall patients were divided into 2 groups; those with full correction of vertical deviation, IOOA, and SOUA and those with partial correction of them. Because no significant difference in postoperative torsional change was found between the two groups, ocular torsional change was not affected the amount of vertical deviation correction (independent *t*-test, $P=0.134$).Also, there was no significant difference of changes in torsional angle among the subgroups with Knapp's classification[16] (Kruskal-Wallis test, $P=0.265$).

Multivariable linear regression analysis [included independent variables: age at surgery, operation laterality, surgical method (myectomy *vs* myotomy, combination of horizontal rectus muscle surgery), preoperative torsional angle, preoperative IOOA, preoperative SOUA, whether the correction of head tilt has been successful] showed that the following variables significantly affected the net change in torsion: subject age, preoperative IOOA, and preoperative torsional angle (regression model $P<0.001$, β-coefficient $P=0.020$, 0.007, and 0.045, respectively). The model showed no definite multi-colinearity in any variable pairs.

DISCUSSION

Ocular excyclotorsion in SOP is known to occur, and various diagnostic and surgical techniques have been introduced to evaluate and correct it [10,11,17,18]. Both IO myectomy and myotomy have the advantages of being relatively simple procedures that spontaneously decide how much corrections are given [19]. Unfortunately, few studies have examined changes in ocular torsion induced by IO myectomy or myotomy. It has been found that IO myectomy resulted in mean reduction of 3.4 degrees in cases of mild ocular torsion [10]. They also performed a superior oblique tuck in severe torsional cases so the effect of myectomy on torsion cannot be concluded from their study. Additionally, it has been reported that the amount of cyclodeviation was 15.3 degrees before surgery and 6.6 degrees after IO myectomy in patients with IOOA, but the work included cases of both primary and secondary IOOA [20]. In the present study, the mean ocular torsional angle was 12.0±6.4° preoperatively and decreased to 6.9±5.7° postoperatively.

The current study demonstrates a remarkable decrease in ocular torsion in cases of unilateral and bilateral SOP. The normal range of torsional angle was reported as 6.39±3.20 degrees in the Korean population, which is similar to the value reported outside of Korea as well [21,22]. In this study, torsional angle of the operated eye was higher than the normal range of Korean population preoperatively and decreased into the normal range postoperatively. In contrast, in the fellow eye, the preoperative- and postoperative-torsional angle were not significantly higher than the normal range. Unfortunately, no significant effect on torsional angle was observed when myotomy was performed. There are no previous reports describing ocular torsion changes with myotomy. Therefore, the effect of myotomy is inconclusive in this study.

Arici and Oguz [10] reported that postoperative ocular torsion reduction may be temporary, beginning a decline 10wk after surgery. However, our fundus photographs were taken only once after surgery, on average, about 1y after surgery. Without utilizing internal fixator, the reliability of ocular torsion measurements from digital fundus photographs could be jeopardized. Fortunately, no significant error of torsional angle has been found, regardless of internal fixator use[23].

We performed combined horizontal rectus muscle and IO surgery in 11 patients and only IO surgery in 10 patients. Postoperative ocular torsion was significantly smaller than preoperative values in both groups, indicating that horizontal rectus muscle surgery does not influence postoperative changes in ocular torsion. This is in agreement with previous reports, that found that horizontal rectus muscle surgery has little effect on IO surgical outcomes [24,25]. Therefore, analyzing all ocular torsion data together, regardless of whether horizontal rectus muscle surgery was performed, is justified.

Na *et al* [26] found that paretic eyes were concordant with torsional eye in 22 of 32 patients (69%), and that torsional amount decreases in torsional eye regardless of concordance in unilateral SOP. In this study, the concordance rate was similar (64%), and evidence of decreasing ocular torsion is present.

Knapp[16] suggested the classical classification criteria for SOP, and it is an interesting concept to be introduced for sub-analysis. However, there was no significant difference among the subgroups because there were lack of subjects and many patients in this study were bilateral (class VI). However, it would be a fascinating subject for further study.

There have been several previous efforts to associate ocular torsion with preoperative clinical parameters, such as vertical deviation and IOOA [17,26,27]. However, clinical parameters associated with net changes in ocular torsion have not been well established. Unfortunately, the "usual suspects" (*i.e.* preoperative vertical deviation angle, full/partial correction of preoperative hypertropia, IOOA and SOUA) were not significantly correlated with changes in ocular torsion. For that reason, we created a linear regression model to analyze the effect of various clinical preoperative factors and age at surgery, preoperative torsional angle, and preoperative IOOA significantly influenced postoperative ocular torsion. It was not surprising that preoperative torsional angle and IOOA were correlated with ocular torsional changes following surgery, but why preoperative SOUA influenced postoperative torsional angle is less understandable. However, we postulate that some portion of SOUA emerged as secondary IOOA, and that preoperative degree of torsion and paresis are not fully reflected in eyes with preoperative SOUA.

Until nowadays, the operator of this study (Kim SJ) has performed myotomy and myectomy in SOP. Recently, IO recession is being performed actively. The myectomy and IO recession seem to show similar results, however, more cases are required for reasonable comparison. After collecting considerable amount of cases, we might report the results into another study.

In conclusion, objective ocular torsion decreases after IO myectomy. However, because of the lack of subjects and retrospective nature of the present study, further studies in a larger group of patients will be needed.

ACKNOWLEDGEMENTS

Foundation: Supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (No.2012R1A1A2004809)

Conflicts of Interest: Lee J, None; **Suh SY,** None; **Choung HK,** None; **Kim SJ,** None.

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