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Factors influencing the result of superior oblique weakening procedures in patients with superior oblique overaction in horizontal strabismus

수평사시가 동반된 상사근기능항진 환자에서 상사근 약화술 결과에 영향을 미치는 인자

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Factors influencing the result of superior oblique weakening procedures in patients with superior oblique overaction in horizontal strabismus

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ABSTRACT

Background: Few studies have evaluated the surgical outcome of superior oblique weakening procedures in patients with superior oblique overaction associated with horizontal strabismus. This study aimed to evaluate the outcome of superior oblique muscle weakening and the influencing factors in patients with superior oblique overaction.

Methods: The medical charts of 37 patients (55 eyes) with superior oblique overaction associated with horizontal strabismus who were treated with a superior oblique weakening procedure (superior oblique posterior tenectomy or superior oblique suture spacer) at the Seoul National University Hospital from January 2010 to June 2017 were retrospectively reviewed. The following data were collected: preoperative and postoperative superior oblique overaction, angle of deviation at a distance, stereopsis. Surgical success was defined as the complete absence of superior oblique overaction 1 month after surgery. Failure of operation was defined as the incomplete reduction or elimination of superior oblique overaction after surgery. Superior oblique overaction was graded using, a 6-point scale ranging from +0.5 to +3, and pre- and postoperative grades were recorded for all patients. Also to investigate factors influencing the surgical result, the following

data were collected: Surgical results of associated horizontal strabismus, surgical success rate according to the grade of superior oblique overaction, comparison by surgical method, comparison of unilateral group and bilateral group, comparison of the success group and failure group.

Results: Horizontal strabismus procedure was successful in 31 patients (83.8%) while failure was reported in 6 patients. Surgical success rate showed a trend of declining according to the grade of superior oblique overaction (p = 0.068). Surgical success was achieved in 15 (65.2%) eyes in the suture spacer group and 23 (71.9%) eyes in the posterior tenectomy group. Surgical success was achieved in 13 (68.4%) eyes in the unilateral group and 25 (69.4%) eyes in the bilateral group. The surgical success rate of the superior oblique weakening procedure was 69.1% (38/55 eyes) in this study. Dissociated vertical deviation exhibited a significant negative association with the surgical success rate ($p < 0.001$).

Conclusions: The surgical success rate of the superior oblique weakening procedure in the patients with superior oblique overaction associated with horizontal strabismus was 69.1% (38/55 eyes) which was similar to previous studies. Associated dissociated vertical deviation can affect the surgical success of the superior oblique weakening procedure.

Keywords: Superior oblique overaction, Superior oblique weakening procedure, Dissociated vertical deviation

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Introduction

Coexistence of A or V pattern with horizontal strabismus is seen in 12.5% to 50% of cases.[1] When superior oblique overaction coexist with horizontal strabismus, A pattern strabismus can occur, in which angles when upgaze and downgaze are different, due to abduction function of superior oblique when downgaze.

Correction of horizontal strabismus without considering the A pattern strabismus can cause asthenopia, diplopia and abnormal head posture A pattern strabismus occurred due to superior oblique overaction can be managed with superior oblique weakening procedure. In case of inferior oblique muscle palsy, and Brown syndrome, superior oblique weakening procedure can be performed, too. Superior oblique weakening procedures include the superior oblique muscle tenectomy, tenotomy, Z-tenotomy, silicone expander, and suture spacers.

Earlier studies have reported a 65% success rate of superior oblique lengthening using silicone expanders in Brown syndrome, 67% success of using suture spacer in Brown syndrome, and 75% success rate of superior oblique lengthening procedures with silicone expanders in A-pattern strabismus.[2-4] Other studies have reported A-pattern collapse after a superior oblique weakening procedure in 60% to 84% of patients.[5-7]

However, there have been few studies on the surgical outcome of superior oblique weakening procedures for the superior oblique

overaction associated with exotropia or esotropia.

Therefore, this study was done to investigate the clinical outcome and factors affecting the outcome of the superior oblique weakening procedure in patients with superior oblique overaction associated with horizontal strabismus.

Materials and Methods

1. Surgical procedures

This study was approved by the Institutional Review Board of Seoul National University Hospital in Korea. (No. 1802-082-923) This study protocol followed the tenets of Declaration of Helsinki. The medical charts of 37 consecutive patients (55 eyes) with superior oblique overaction associated horizontal strabismus, who underwent a superior oblique weakening procedure (superior oblique posterior tenectomy or superior oblique suture spacer) between January 2010 and June 2017 were retrospectively reviewed. Superior oblique posterior tenectomy was performed between January 2010 and August 2013, while the superior oblique suture spacer was performed between September 2013 and June 2017. As most surgeons believed that it would be better to avoid removing part of the muscle, a suture spacer was instead considered for the surgical techniques. Regardless of the grade of superior oblique overaction, posterior tenectomy or suture spacer was chosen by the time of the surgery. The

surgical modality was not changed according to the grade of superior oblique overaction. Superior oblique weakening procedure were performed with correction of horizontal strabismus, in all cases. Exotropia was corrected with bilateral rectus recession or medial rectus resection and lateral rectus recession. Esotropia was corrected with medial rectus recession. All surgeries were performed by the same surgeon (SJK).

2. Inclusion and exclusion criteria

Patients with superior oblique overaction associated with exotropia and esotropia were included. Those with Brown syndrome and double elevator palsy were excluded. While patients with primary superior oblique overaction were included in this study, those with secondary superior oblique overaction due to inferior oblique paresis were excluded. I also excluded patients with a history of vertical rectus muscle surgery or oblique muscle surgery.

3. Patients characteristics

The following data were collected: sex, age at time of surgery, refractive error determined using cycloplegic refraction, dissociated vertical deviation, and fundus torsion were assessed using fundus photography, preoperative and postoperative superior oblique overaction, angle of deviation at a distance.

The prism and alternate cover test were performed at 6 meter for cooperative patients, and the Krimsky test was performed for uncooperative patients.

Superior oblique overaction was graded using a 6-point scale ranging from +0.5 to +3. During testing for the version of both eyes, the patients were instructed to look downward and 30° laterally in both directions. When both eyes were parallel, they were considered normal and without superior oblique overaction. However, when the adducted eye was directed vertically downward, the superior oblique overaction was defined as grade +3. The intermediate ranges were graded +1 and +2, respectively. A grade of +0.5 was assigned in cases of minimal overaction.

The dissociated vertical deviation was distinguished by observation of the following: (1) characteristic elevation and excyclotorsion of the involved eye under cover and (2) absence of hypotropic movement of the other eye in any field of gaze. All measurements were made by the same observer (SJK).

Cycloplegic refraction was performed with 1% cyclopentolate hydrochloride. Refractive errors measured by cycloplegic refraction were recorded as spherical equivalents.

Ocular torsion was assessed by fundus photography, and Retcam (RetCam Clarity Medical Systems Inc, Pleasanton, CA) before the surgery. Retcam was conducted in pediatric patients who were unable to cooperate with patients laying in a supine

position while under chloral hydrate-induced sedation. The amount of ocular torsion was determined by measuring the disc fovea angle (DFA), using public domain software (Image J ; National Institutes of Health, Bethesda, MD). The DFA is defined as the angle between a horizontal line extending from the center of the optic disc and a line from the center of the disk to the fovea.

Stereopsis was measured using the Titmus Fly Stereo Test (Stereo Optical, Chicago, IL), in cooperative patients, before and after surgery.

All surgical procedures were conducted by the same surgeon (SJK) under general anesthesia. Surgical success was defined as the complete absence of superior oblique overaction 1 month after surgery. Failure of operation was defined as the incomplete reduction or elimination of superior oblique overaction after surgery.

This study evaluated the surgical success rate of superior oblique weakening procedure, factors influencing the surgical response, and success rate by the grade of superior oblique overaction. I also compared the surgical success rate and factors, according to the procedure (posterior tenectomy, suture spacer). I also compared by comparing the data of patients who underwent the unilateral and bilateral superior oblique muscle weakening procedures. Finally, I compared the difference between the surgical success and failure groups.

4. Statistical analysis

Statistical analyses were performed using SPSS Statistics 19.0 (IBM Corp., Armonk, NY). P-value < 0.05 was considered to be statistically significant. The independent Student's t-test, chi-square test, Fisher's exact test, and the Mann-Whitney U test, Linear by linear association were used for statistical analyses.

Results

1. Demographics

Among 37 consecutive patients (55 eyes) with superior oblique overaction, 19 patients (19 eyes) underwent the unilateral superior oblique weakening procedure and 18 patients (36 eyes), underwent the bilateral procedure. Seventeen patients (23 eyes) were treated with the superior oblique suture spacer approach, and 20 patients (32 eyes) were treated with superior oblique posterior tenectomy (Table 1).

Three patients (6 eyes) had esotropia, while 34 patients (49 eyes) had exotropia. The mean age was 91.81 ± 59.37 months. The male-female ratio was 16 (25 eyes) : 21 (30 eyes).

2. Surgical results of associated horizontal strabismus

Horizontal strabismus procedure was successful in 31 patients (83.8%) while failure was reported in 6 patients (surgical success

was defined when values ≤5 and ≤10 prism were observed esotropia and exotropia, respectively).

There was no significant correlation with between successful horizontal strabismus procedure and superior oblique weakening procedure (p = 0.162, Fisher's exact test).

3. Surgical success rate according to the grade of superior oblique overaction

Surgical success rate according to the grade of superior oblique overaction was evaluated. Though the p-value did not show significance, surgical success rate showed a trend of declining in severe superior oblique overaction (p = 0.068, linear by linear association) (Table 2).

4. Comparison by surgical method

Similary, no significant differences in patient characteristics and surgical success rate were found between the superior oblique posterior tenectomy and superior oblique suture spacer groups. However, preoperative superior oblique overaction showed significant difference between the two groups (p = 0.002, Mann-Whitney U test) (Table 3).

5. Comparison of unilateral group and bilateral group

In contrast, the occurrence of ocular incyclotorsion significantly

differed between the unilateral and bilateral groups (p = 0.013). However, the groups did not differ significantly in any other factors, such as type of surgical procedure, age during surgery, refractive error, dissociated vertical deviation, preoperative superior oblique overaction, and associated horizontal strabismus (either exotropia or esotropia). Moreover, no difference was identified in the surgical success rate between the two groups (Table 4).

6. Comparison of the success group and failure group

There were no significant differences in any variable except dissociated vertical deviation between the surgical success and failure groups. There was a statistically significant difference in the dissociated vertical deviation ($p < 0.001$) between the two groups, and the rate of surgical success decreased with an increase in dissociated vertical deviation.

Comparison of success group and failure group according to the surgical method was not performed due to small number of cases.

7. Stereopsis

Stereopsis was measured for 16 of 37 patients at 1 month before and 1 month after the surgery. Ten patients (62.5%) showed an increase of more than two octaves, while the remaining six (37.5%) showed a change lower than two octaves.

Discussion

Superior oblique posterior tenectomy and the superior oblique muscle suture spacer approach are widely used procedures for superior oblique weakening.[8] Earlier studies have suggested that they are effective in weakening superior oblique overaction and also for correcting the A-pattern.[5,9]

The surgical success rate of the superior oblique weakening procedure was 69.1% (38/55 eyes) in this study. Although the improvements in the A-pattern after surgery were not investigated, I evaluated the superior oblique overaction with detailed grading at duction and version.

Superior oblique weakening procedures cannot guarantee binocular vision due to the ocular torsion after surgery for the superior oblique overaction associated with exotropia or esotropia. However, this study showed that 62.5% (10/16) of patients experienced an increase in stereopsis and no patient showed a decrease in stereopsis.

The normal range of DFA is 5.6° - 8°.[10-14] DFA was 3.08° ± 7.00° in the unilateral group, indicative of mild incyclotorsion. However, it was -2.74° ± 6.60° in the bilateral group, indicative of greater incyclotorsion, which is evident of superior oblique overaction. Incyclotorsion was naturally greater in the bilateral group.

There were no significant differences in the patient

characteristics and surgical success rates between the superior oblique suture spacer and posterior tenectomy groups. However, preoperative superior oblique overaction showed significant difference between the two groups. There were no significant differences in any variable except the dissociated vertical deviation between the surgical success and failure groups.

The cause of dissociated vertical deviation is unknown. Several etiological theories have been proposed, including superior rectus hypofunction, anomalous impulses from an involuntary divergence center, aberrations of postural tonus mechanisms of the extraocular musculature, bilateral paresis of the depressor muscles, and deficiency in the optomotor impulse from the inferonasal retinal quadrants.

Dissociated vertical deviation may also result from superior oblique hypofunction or an alternating innervational insufficiency of the superior oblique muscles.[15-17] According to Wright et al. [18], superior oblique weakening procedures can cause complications in patients with preexisting dissociated vertical deviation, as the weakening of the superior oblique can exacerbate dissociated vertical deviation.

In this study, the success rate of the superior oblique weakening procedures significantly decreased with the presence of dissociated vertical deviation. Superior oblique overaction accompanied with dissociated vertical deviation seems to have a different etiology than superior oblique overaction alone. Although

the cause of superior oblique overaction in patients with horizontal strabismus and the cause of accompanying dissociated vertical deviation are unknown. It can be assumed that surgical outcomes could worsen when superior oblique overaction and dissociated vertical deviation coexist.

This study has a few limitations. First, this was a retrospective study. Second, the A-pattern was not evaluated. Third, Retcam, rather than fundus photography, was used for noncompliant pediatric patients. To the best of our knowledge, the cyclotorsion induced by choral hydrate has not been reported ever. However, given that cyclotorsion was possible in the supine position[19], the failure to control for this variable was included as a limitation of this study. An internal fixator was not used for accurate measurement of ocular torsion and postoperative torsional change was not evaluated. Finally, the effect of horizontal strabismus surgery on the surgical result of superior oblique weakening procedure was not evaluated.

Conclusions

The surgical success rate of the superior oblique weakening procedure in the patients with superior oblique overaction associated with horizontal strabismus was 69.1% (38/55 eyes) which was similar to previous studies. Associated dissociated vertical deviation can affect the surgical success of the superior oblique weakening procedure.

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Table 1. Surgical methods and number of patients (eyes)

	Unilateral group	Bilateral group	Total
Suture spacer group	11 (11)	6 (12)	17 (23)
Posterior tenectomy group	8 (8)	12 (24)	20 (32)
Total	19 (19)	18 (36)	37 (55)

Table 2. Surgical success and failure according to the grade of superior obliqud overaction

Preoperative superior oblique overaction	Surgical success (within success %)	Surgical failure (within failure %)	Total
+1.0	16 (42.1%)	4 (23.5%)	20
+1.5	5 (13.2%)	0 (0%)	5
+2.0	17 (44.7%)	13 (76.5%)	30
total (within superior oblique overaction %)	38 (69.1%)	17 (30.9%)	55

linear by linear association $p < 0.05$, $p = 0.068$

Table 3. Comparison according to the method of superior oblique weakening.

	Total	Suture spacer group	Posterior tenectomy group	*P*-value
Sex (M: F) (n = 37)	16 : 21	7 : 10	9 : 11	0.815
Age at operation (months) (n = 37)	91.81 ± 59.37	84.06 ± 41.24	98.40 ± 71.74	0.472
Associated horizontal strabismus (PD) (n = 37)	20.19 ± 18.98	18.35 ± 18.07	21.75 ± 20.04	0.595
Surgical success (success: fail)	38 : 17 (69.1% : 30.9%)	15 : 8 (65.2% : 34.8%)	23 : 9 (71.9% : 28.1%)	0.598
Refractive error (spherical equivalent)	0.36 ± 2.34	0.20 ± 2.13	0.48 ± 2.50	0.656
DVD (positive: negative)	23 : 32	9 : 14	14 : 18	0.732
Preoperative SO overaction (+0.5 to +3)	1.59 ± 0.47	1.83 ± 0.32	1.42 ± 0.49	0.002[a]
Torsion (−: intorsion, +: extorsion) degree (n = 43)	-1.23 ± 6.38	-0.32 ± 6.69	-1.50 ± 7.64	0.597

PD = prism diopters, SO = superior oblique, DVD = dissociated vertical deviation
[a] $p < 0.05$ Mann-Whitney U test

Table 4. Comparison of the unilateral group and bilateral group

	Total	Unilateral group	Bilateral group	*P*-value
Sex (M: F) (n = 37)	16 : 21	7 : 12	9 : 9	0.419
Age at operation (months) (n = 37)	91.81 ± 59.37	79.63 ± 46.26	104.67 ± 68.70	0.204
Associated horizontal strabismus (PD) (n = 37)	20.19 ± 18.98	20.89 ± 17.85	19.44 ± 20.60	0.820
SO weakening procedure (suture spacer: posterior tenectomy)	23 : 32	11 : 8	12 : 24	0.079
Surgical success (success: fail)	38 : 17	13(68.4%) : 6(31.6%)	25(69.4%) : 11(30.6%)	0.938
Refractive error (spherical equivalent)	0.36 ± 2.34	0.05 ± 1.46	0.53 ± 2.70	0.400
DVD (positive: negative)	23 : 32	7 : 12	16 : 20	0.587
Preoperative SO overaction (+0.5 to +3)	1.59 ± 0.47	1.60 ± 0.43	1.58 ± 0.50	0.866
Torsion (−:intorsion, +:extorsion) degree (n = 43)	−1.23 ± 6.38	3.08 ± 7.00	−2.74 ± 6.60	0.013[a]

PD = prism diopters, SO = superior oblique, DVD = dissociated vertical deviation
[a] $p < 0.05$ independent t-test

Table 5. Comparison of the success group and failure group.

	Total	Success group	Failure group	*P*-value
Sex (M: F) (n = 37)	16 : 21	11 : 16	5 : 5	0.716
Age at operation (months) (n = 37)	91.81 ± 59.37	96.10 ± 38.95	90.22 ± 65.93	0.793
Associated horizontal strabismus (PD) (n = 37)	20.19 ± 18.98	24.51 ± 7.75	16.58 ± 3.19	0.291
SO weakening procedure (suture spacer: posterior tenectomy)	23 : 32	15 : 23	8 : 9	0.598
Refractive error (spherical equivalent)	0.36 ± 2.34	0.51 ± 3.23	0.30 ± 1.86	0.797
DVD (positive: negative)	23 : 32	10 : 28	13 : 4	<0.001[a]
Preoperative SO overaction (+0.5 to +3)	1.59 ± 0.47	1.51 ± 0.47	1.76 ± 0.44	0.670
Torsion (−: intorsion, +: extorsion) degree (n = 43)	-1.23 ± 6.38	0.12 ± 7.29	-3.26 ± 6.59	0.150

PD = prism diopters, SO = superior oblique, DVD = dissociated vertical deviation
[a] $p < 0.05$ chi-square test

수평사시에 동반된 상사근기능항진 환자에서 상사근약화술 결과에 영향을 미치는 인자

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배경 : 수평사시에 동반된 상사근기능항진 환자에서 상사근약화술의 결과에 대해서는 많은 연구가 있지 않다. 이 연구는 수평사시에 동반된 상사근기능항진 환자의 수술 결과에 영향을 미치는 인자에 대하여 알아보고자 하였다.

방법 : 2010년 1월에서 2017년 6월까지 서울대학교 병원에서 상사근약화술(봉합사연장술, 뒤쪽힘줄절제술)을 시행한 수평사시 환자들 37명(55안)의 의무기록을 후향적으로 분석하였다. 수술 전후에 상사근기능항진정도, 원거리 수평사시각, 입체시에 대한 정보를 수집하였다. 수술 후 1개월째 상사근기능항진이 남지 않은 경우를 성공군, 상사근기능항진이 남아 있으면 실패군으로 정의하였다. 상사근기능항진은 6단계로 +0.5에서 +3까지 0.5 단계로 구분하였으며 수술 전과 수술 후에 모든 환자의 기록을 분석하였다.

수술 결과에 영향을 미치는 인자를 알아보기 위해 다음과 같은 내용을 분석하였다. 동반된 수평사시각의 수술결과, 상사근기능항진 정도에 따른 수술 성공률, 수술 방법에 따른 비교, 단안군과 양안군에 대한 비교, 수술성공군과 실패군을 비교해 보았다.

결과 : 수평사시수술은 총 31명 (83.8%)에서 성공하였고 6명에서는 실패하였다. 상사근기능항진의 정도가 심할수록 수술 성공률이 떨어지는 경향을 보였다 (p = 0.068). 봉합사연장술군에서 수술 성공률은 15안 (65.2%)였고, 뒤쪽힘줄절제술군에서는 23안 (71.9%)였다. 단안군에서 수술 성공률은 13안 (68.4%)였고 양안군에서 수술 성공률은 25안 (69.4%) 였다. 총 55안 중 38안(69.1%)에서 상사근약화술이 성공하였다. 수술 성공군과 실패군을 비교하였을때 해리수직편위가 있는 경우 수술 성공률이 떨어지는 것을 발견할 수 있었다 ($p < 0.001$).

결론 : 69.1%(33/55안)에서 상사근약화술이 성공 하였고 이전에 보고된 결과들과 비슷한 결과를 보였다. 해리수직편위의 여부는 수술 성공에 영향을 미치는 것을 볼 수 있었다.

주요어 : 상사근기능항진, 상사근약화술, 해리수직편위

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