

Accuracy of Suture Adjustment in Adjustable Strabismus Surgery Evaluated at the Initial Postoperative Examination

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Purpose: To clarify the efficacy of sliding-noose type adjustable suture strabismus surgery, we evaluated the accuracy of suture adjustment based on data from the initial postoperative examination performed 1–4 weeks after the surgery.

Methods: Thirty-four patients with various types of strabismus participated [age range, 12–79 years; range of far deviation, 4–123 prism diopters (PD)]. Under sub-Tenon anesthesia, a recession (with or without a resection or muscle transposition) was performed with an adjustable suture (Guyton's procedure), and the suture was adjusted 6–24 hours after surgery.

Results: Twenty-six (76%) patients required suture adjustment one to eight times. In 50% and 75% of our patients, the errors from individual target angle were within ± 0.8 and ± 2.0 PD, respectively, whereas 2 (6%) patients with esotropia showed an undercorrection larger than 10 PD. The error distribution was almost the same throughout the range of preoperative deviation.

Conclusion: By using an adjustable suture with a sliding noose, pinpoint alignment of the eyes can be achieved in more than half of the cases, at least in the early postoperative period. **Jpn J Ophthalmol 2002;46:279–284** © 2002 Japanese Ophthalmological Society

Key Words: Adjustable suture, binocularity, strabismus, strabismus surgery.

Introduction

Adjustable suture strabismus surgery was regarded as a milestone in strabismology, along with Botulinum toxin treatment and the discovery of the orbital pulley structure.¹ After the report 20 years ago by Jampolsky,² in Western countries, techniques for this surgery have been improved in many respects, and indications for its application have expanded to almost all kinds of strabismus, including infantile esotropia.^{3–5} However, the advantage of adjustable surgery over conventional strabismus surgery has been argued mainly based on re-operation rates,^{5–9} and there are few available data regarding the expected

accuracy of suture adjustment when adopting the adjustable suture for strabismus surgery.

On the other hand, in Japan at present, only a few clinicians apply adjustable surgery to limited cases, such as dysthyroid myopathy patients.^{10,11} That is probably because problems associated with the adjustable surgery, eg, a rather complicated procedure or pain at the time of the suture adjustment, were exaggeratedly reported at its inception. However, the construction of an adjustable suture appearing in the reports in Japan was mainly the so-called “bow-tie” technique without a sliding noose.^{10–13} Furthermore, neither the timing nor method of suture adjustment has been different from the modern techniques widely used in the United States.^{14,15}

In this study, to reevaluate the efficacy and usefulness of adjustable strabismus surgery, we applied it with a sliding noose (Dr. Guyton's procedure, [15]) to young and adult patients and examined the accuracy

Received: June 13, 2001

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of the suture adjustment based on the initial postoperative examination.

Materials and Methods

Subjects

Thirty-six consecutive patients with various types of strabismus who consented to undergo adjustable suture strabismus surgery at Okayama University Medical School Hospital in 2000 participated. We excluded 2 patients for whom the cover tests were not reliable due to their poor visual acuity, or if we were not able to make full correction even with the maximum recession. The age range was from 12 to 72 years (mean \pm SD age = 42 ± 21 years).

The primary strabismic deviations treated with adjustable sutures were 9 eso-, 10 exo-, and 15 vertical deviations. The amount of deviation ranged from 4 to 123 prism diopters (PD; mean \pm SD: 23 ± 21 PD). The diagnoses included superior oblique palsy (n = 5), hypertropia (n = 5), intermittent exotropia (n = 4), abducens nerve palsy (n = 3), restrictive strabismus following retinal detachment surgery (n = 3), oculomotor palsy (n = 2), infantile esotropia (n = 2), dissociated vertical deviation (n = 2), consecutive esotropia (n = 2), supranuclear palsy (n = 1), dysthyroid myopathy (n = 1), mitochondrial encephalomyopathy (n = 1), residual exotropia (n = 1), and constant exotropia (n = 1). Surgical methods included, as a single recession, the inferior rectus (n = 9), the superior rectus (n = 6), the lateral rectus (n = 4), and the medial rectus muscle (n = 1) recessions. They also included combined recession with a resection on the antagonist (n = 11), muscle transposition of Hummelsheim (n = 1), and horizontal resection-recession surgery on the other eye (n = 1).

Surgical Procedure

Under topical anesthesia of 4% lidocaine (Xylocaine) and a sub-Tenon injection of 2% lidocaine, one of the authors performed the surgery. During the surgery, viscoelastic material (Artz, Kaken, Tokyo) was placed on the cornea to prevent exposure keratitis. First, the muscle was captured with a Jansen hook through a limbal conjunctival incision, and the check ligament and the intermuscular membranes were dissected adequately. Second, a double-armed locking bite was placed on the muscle with 6-0 Vicryl (S29; Alcon, Ft. Worth, TX, USA), and the muscle was detached from its insertion. The central bite of the suture was placed 3 mm posterior from the insertion to minimize measurement error due to transformation (bending) of the muscle edge (Figure

1a). Third, both ends of the suture (main suture) were passed through the sclera at the insertion, and a sliding noose was made with 6-0 Vicryl (Figure 1b). Vicryl is absorbed in several months, and we do not have much of a problem with postoperative irritation or granuloma caused by the suture. The amount of recession was determined based on far deviation under full refractive correction with our routinely used dose-response table, and a fudge factor¹⁵⁾ of 0.75 mm was added to it. Fourth, we made a control suture at the insertion with 5-0 Dacron and measured the distance between the insertion and the sliding noose with calipers, while pulling the control suture. Finally, the conjunctival flap was sutured with 8-0 silk (Alcon).

Adjustment of Suture

The suture adjustment was performed under topical anesthesia of 0.4% oxyprocaine (Benoxil; Santen, Osaka) 6–24 hours after the surgery. We used the objective and subjective prism and the alternate-cover test was performed with a penlight at 5 m and full refractive correction, keeping the patient in a sitting position. Target angles of adjustment were an overcorrection of 8 PD for exodeviations and orthophoria for eso- and vertical deviations. When the target angle was not obtained, we adjusted the suture, after placing the patient in a supine position, and then we checked the alignment again in a sitting position. We repeated this procedure until the target deviation was established, and then tied the sutures.

Evaluation of Suture Adjustment Accuracy

The initial postoperative examination was performed 1–4 (mean = 2.8) weeks after the surgery by orthoptists. Among their data, we used the far deviation under refractive correction and regarded the difference between the observed deviation and the target angle as the error of suture adjustment, analyzing its accuracy by quantile analysis with a weighted average of the values (JMP; SAS Institute, Cary, NC, USA).

Results

The relationship between preoperative amounts of strabismic deviation and the errors from individual target angles is shown in Figure 2. The errors were distributed evenly throughout the preoperative deviations of 4–123 PD. Two patients had large undercorrections (13 and 20 PD), but misalignments were corrected within ± 5 PD in the other 32 patients (94%).

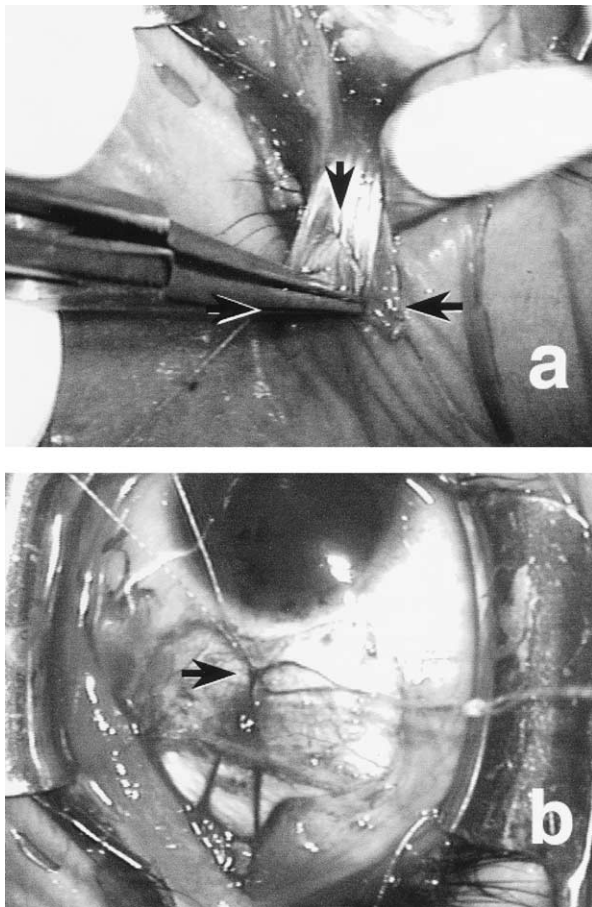


Figure 1. Procedure of adjustable surgery with a sliding noose. (a) A double-armed locking bite (6-0 Vicryl) was centrally placed 3 mm posterior from the insertion to minimize measurement error due to bending of the muscle's edge. The capsule of the muscle in the back was removed to prevent postoperative muscle slippage. (b) By pulling a control suture (not shown), we set the sliding noose back to the insertion.

The quantile analysis (Table 1) shows that the error from the target angle was, as a whole, within ± 0.8 PD in 50% of the patients and ± 2.0 PD in 75% of the patients. In the comparison of the errors among the three types of deviation, the esodeviation group tended to have poor results at all of the 50%, 75%, and 90% points, but no significance was observed ($P = .37$, Kruskal-Wallis test). In the comparison between single and combined recessions, the combined recession group showed a larger error at the 90% point, but again there was no significance ($P = .80$, Wilcoxon test).

Twenty-six (76%) patients required suture adjustment one to eight times. During the adjustment, few patients complained of pain or discomfort, and we were thus able to repeat the adjustment until the tar-

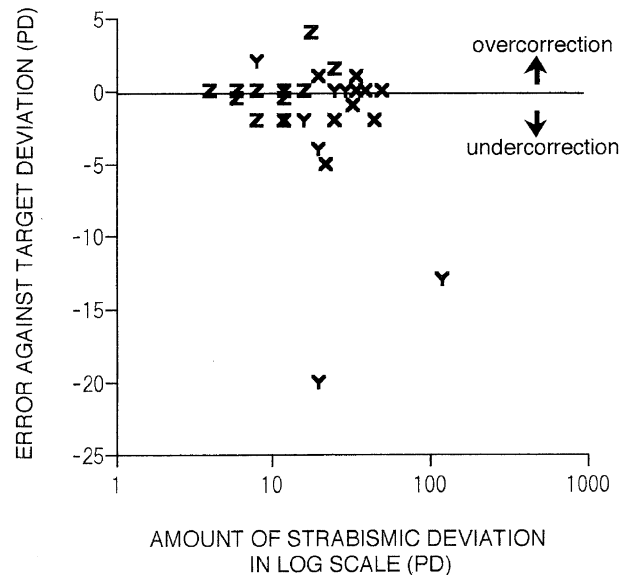


Figure 2. Relationship between amount of strabismic deviation and errors from the individual target angles (far deviation with refractive correction). X, Y, and V indicate exo-, eso-, and vertical deviations, respectively. The accuracy of the suture adjustment was almost the same in the preoperative deviation range (4–123 PD). The strabismic deviations were corrected to within ± 5 PD in 32 patients (94%), whereas 2 patients (6%) had an undercorrection larger than 10 PD.

get deviation was established (eight times at most). However, blurring, perhaps due to exposure keratitis or abnormal retinal correspondence, occasionally made the cover tests difficult.

Discussion

Using sliding-noose type adjustable surgery, we established a pinpoint alignment of the eyes, within ± 2 PD, in 75% of our patients, at least in the early postoperative period, although we had patients whose amount of surgical correction was generally difficult to determine, including restrictive strabismus and dysthyroid myopathy patients. Additionally, in 32 of our 34 patients (94%), the strabismic deviations were reduced to a small enough size from a cosmetic viewpoint, within ± 5 PD.¹⁶ It was reported that adhesion of the muscle to the sclera begins 24 hours after surgery, and that the strength of the connection has fully recovered in 3 weeks.¹⁷ Accordingly, the results in this study, 2.8 weeks on average after the surgery, are a good indicator for the accuracy of suture adjustment itself, although changes in muscle torque and stiffness of the surrounding connective tissue may alter the ocular alignment successively.

Table 1. Accuracy of the Suture Adjustment at Each Quantile Point

	No.	Errors from Individual Target Angles at Each Quantile Point*			Amount of Correction*	
		50%	75%	90%	Mean \pm SD	Range
Esodeviation	9	2.0 PD	8.5 PD	20.0 PD	27.4 \pm 32.5 PD	0-123 PD
Exodeviation	10	1.0 PD	2.0 PD	4.7 PD	30.7 \pm 12.6 PD	10-50 PD
Vertical deviation	15	0.0 PD	2.0 PD	2.8 PD	11.0 \pm 6.7 PD	4-27 PD
Simple recession	20	0.8 PD	2.0 PD	4.0 PD	12.2 \pm 6.3 PD	4-27 PD
Combined recession	14	0.5 PD	2.0 PD	16.5 PD	34.0 \pm 25.7 PD	0-123 PD
Total	34	0.8 PD	2.0 PD	4.5 PD	21.1 \pm 20.1 PD	0-123 PD

*PD: prism diopters.

The principle of strabismus surgery is to correct ocular misalignment by shifting insertion sites of the extraocular muscles and changing their torque. However, the eye position is, in fact, influenced by many other biometrical factors: elasticity of the muscles, positions of the pulleys, elasticity of the connective tissue, length of the muscles and eyeball, and so on.¹⁸ Accordingly, the surgical effect differs among patients, even if we perform exactly the same surgery. This could be a big problem when we treat patients whose biometric parameters markedly differ from the normal values, such as restrictive strabismus or dysthyroid myopathy patients. Furthermore, we cannot ignore those factors, even in the general types of strabismus, when we expect higher reliability in strabismus surgery. It is difficult to measure those parameters directly, but their influence could be calibrated by postoperative adjustment of the suture. Our suture adjustment accuracy (± 2 PD), which was achieved in more than half of the patients, corresponded to the limits of ocular misalignment that can be detected with the cover tests,¹⁹ supporting the methodological rationality of adjustable suture surgery.

Comparing the results among types of deviation, the esodeviation group had somewhat poorer results, compared with the exo- or vertical deviation groups. We did not make a statistical comparison because of their different backgrounds, but the difference reflects large undercorrections (>10 PD) which appeared in 2 patients with esotropia. One was a case that showed "eat-up," or increasing deviation with time, in the preoperative prism-adaptation test, which indicates that strong abnormal retinal correspondence could substantially reduce the surgical effect in such a short period. The other patient had large angle esotropia (123 PD) and required surgery on three horizontal muscles. Figure 2 shows that surgical accuracy was almost the same regardless of the preoperative amount of strabismic deviation. How-

ever, there was only 1 patient who had strabismus larger than 50 PD, and thus we need more cases to confirm if similar adjustment accuracy could be expected for large angle strabismus or not.

Also, in the comparison between a single adjustable recession and an adjustable recession combined with a resection (or a muscle transposition) on the antagonist, there was no difference in the accuracy at the 50% and 75% points, in spite of large differences in the amount of correction, 12.2 and 34.0 PD, respectively. In the combined recession group, the site of the recessed muscle may be more stable because static torque between the muscles is maintained.¹⁷

Pain during the adjustment has been overstated in Japan, but this could be due to the bow-tie technique that most earlier reporters preferred to use.^{11,13} This technique needs direct manipulations for the muscle insertion and the knot. Unlike this, the adjustment with a sliding noose seems to be suitable for making precise alignment of the eyes by repeating the quick adjustment a little at a time. Accordingly, we usually repeated the adjustment until we did not see any obvious refixation eye movement in the cover tests. Interestingly, the incidence of patients who needed the adjustment, as well as the method of suture adjustment, differs among reporters (39-52%),^{3,20} and our incidence of adjustment was the highest (76%).

In adjustable suture surgery, postoperative drift of the alignment, probably due to histological changes in the muscle(s) and the surrounding connective tissue during the recovery process after the surgical intervention,^{17,20} is more important than in traditional strabismus surgery.²¹⁻²³ Even if the accuracy of the suture adjustment is excellent, the advantage is limited unless the accuracy is reflected in long-term results. We removed the muscle capsule in the back of the muscle, expecting early and firm adhesion of the muscle to the sclera, and to prevent postoperative muscle slippage, following Dr. Guyton's suggestion

(personal communication). A follow-up study will be necessary to confirm the effect of this modification.

Physiological studies indicate that neural mechanisms of vergence adaptation should compensate for gradual changes in muscle torque and elasticity of the surrounding connective tissues once the ocular misalignment is surgically corrected within the fusional range.^{24,25} Separately, postoperative drift of the alignment could be calibrated beforehand in the period of adjustment; for example, a slight overcorrection is recommended in cases of exodeviation,¹⁴ when the drift is predictable. To understand the extent and limitations of vergence adaptation and long-term postoperative drift, it is important to correct ocular misalignment precisely just after the surgery. In these respects, adopting the adjustable suture into strabismus surgery is warranted.

Some reports indicated that there is no difference in outcome of conventional strabismus surgery between specialists and beginners.²⁶ We consider that differences in surgical technique are probably masked by the inter-patient variability in the previously mentioned biometrical parameters. However, it is conceivable that greater experience and superior technique may affect the outcome more evidently in the adjustable surgery because it potentially calibrates the influence of the parameters. For example, exposure keratitis influences the precision of the cover tests, and chemosis or hematoma in the conjunctiva and Tenon tissue could make it difficult to set the sliding noose back far enough. Inadequate dissection of the check ligament or the intermuscular membranes can bias the ocular alignment at the moment of suture adjustment. Accordingly, the results in this study present our personal experience since we started applying the adjustable surgery to clinics, and thus may not be adequate compared to the outcomes achieved by experts in this technique. In other words, it is important to understand how to perform each step of this procedure appropriately, with minimal invasion, to take full advantage of this technique.

The authors thank Professor David L. Guyton (Johns Hopkins Hospital, Wilmer Eye Institute) for helpful suggestions and encouragement.

This paper was published in Japanese in the *Nippon Ganka Gakkai Zasshi (J Jpn Ophthalmol Soc)* 2002;106:149–53. It appears here in a modified form after peer review and editing for the *Japanese Journal of Ophthalmology*.

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