

A Comparative Study of Surgical Outcomes between the Adjustable Suture Technique and Conventional Technique in Strabismus Surgery

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Objective: To compare the success rate between adjustable suture technique and conventional technique in rectus muscle surgery.

Materials and Methods: The present study was a retrospective review of patients aged 10 and above underwent rectus muscle surgery between 2010 and 2018. Patients were classified into two groups according to the surgical techniques, the adjustable group and the conventional group. Preoperative and postoperative orthoptic evaluation including angle of deviation, sensory outcomes, and reoperation rate were collected. The primary outcome was surgical success rate at two years postoperatively, with success defined as ocular alignment within 10 prism diopters (PD) for horizontal rectus muscle surgery or within 5 PD for vertical rectus muscle surgery. The secondary outcome was reoperation rate and binocular functions improvement two years post-operation.

Results: One hundred fifteen cases in the adjustable group and 90 in the conventional group were identified. Patients in the adjustable group had a higher success rate achieving the target angle after six months, one year, and two years post-operation compared to the conventional group at 77.4% versus 70% ($p=0.23$), 73.9% versus 65.6% ($p=0.19$), and 72.2% versus 60% ($p=0.066$), respectively, but there was no statistically significant difference. Sensory improvement was seen in 43.4% of patients in the conventional group and 42.6% in the adjustable group ($p=0.54$). Median stereopsis improvement was seen in both groups at 80 to 45 seconds of arc in the adjustable group and 100 to 60 seconds of arc in the conventional group ($p=0.67$). The reoperation rate was 18.9% in the conventional group and 19.1% in the adjustable group ($p=0.97$).

Conclusion: The adjustable suture technique presented a superior success rate compared to conventional technique though there was no statistically significant difference. A longer follow-up period and larger sample size might be needed to demonstrate statistically significant difference between the two techniques. No significant difference in binocular functions, sensory improvement, or reoperation rate was seen in the present study.

Keywords: Strabismus surgery; Adjustable suture; Conventional suture; Surgical outcome

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Strabismus surgery is a frequently performed operation. The objective is to achieve motor alignment and sensory improvement, with the least number of procedures. In surgical options, two suture techniques, adjustable and non-adjustable (conventional) sutures, are available for extraocular muscle surgery^(1,2). Adjustable sutures are indicated in cases where the outcome of surgery is considered

less predictable, such as in restrictive myopathies or in patients who have undergone a previous strabismus operation. Moreover, the utilization of an adjustable suture technique has potential to mitigate the occurrence of both overcorrection and under correction in the immediate postoperative period. This technique is particularly recommended in situations where surgical outcomes are anticipated to be uncertain⁽³⁾. Adjustable sutures allow re-adjustment of ocular alignment in the post-operative period, and thus, increase the likelihood of success, and decrease rate of reoperation^(1,4,5). According to several previous studies^(2,6,7), both techniques share an equal success rate.

A systemic Cochrane Database review in 2013⁽²⁾ stated that: "In terms of accuracy of long-term ocular alignment, the authors found studies supporting the benefit of the adjustable technique over the non-adjustable technique^(4,5,8) with others suggesting the non-adjustable method was more advantageous^(9,10),

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and some studies reporting both techniques to be equally as effective⁽¹¹⁻¹⁶⁾”.

However, to the best of the authors’ knowledge, there is no research studying long-term postoperative success up to 24 months. Hence, the aim of the present study was a retrospective study to determine if adjustable sutures or conventional sutures were associated with accurate long-term ocular alignment.

Materials and Methods

The present study was approved by the Committee for the Protection of Human Participants in Research of the Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand [Siriraj Ethics Committee number 319/2563 (IRB2)]. A retrospective chart review was performed. The data of patients that underwent strabismus surgery operated by senior staff at Siriraj Hospital between 2010 and 2018 were extracted from Siriraj Hospital electronic medical record. All the operations were performed by the same surgical team, which consisted of four pediatric and adult strabismus ophthalmologists. Surgery involving recession, resection, advancement, and plication of muscles, or a combination of these using adjustable sutures or the conventional technique on rectus muscles were included. Patients with esotropia, exotropia, hypertropia, and hypotropia who underwent primary strabismus surgery with a minimum follow-up period of 24 months were also included. The exclusion criteria were patients aged less than 10 years and patients with systemic or neurological disorders affecting cooperation for measurements due to difficulties associated with young age. Patients who underwent oblique muscle surgery, strabismus surgery involving botulinum toxin injection, combined surgery with oblique muscle or posterior fixation suture, or strabismus surgery involving muscle transposition technique were also excluded.

Subjects were classified into two groups, adjustable and conventional. The sample size was calculated based on previous study⁽¹⁷⁾ using a chi-square test for two proportions with a continuity correction formula and power of 80%. Hence, a total of 90 patients were required in each group.

Data on patient demographics, preoperative and postoperative orthoptic evaluation, including angle of deviation, type and magnitude of strabismus, sensory status, binocularity and stereoacuity status, and reoperation rate were collected.

The primary outcome was surgical success after two years, defined as ocular alignment within

10 prism diopters (PD) in the primary position for horizontal rectus muscle surgery, or 5 PD for vertical rectus muscle surgery. For the adjustable group, adjustments were made immediately after operation or the next day. The angle of deviation was measured in PD, using the alternating prism-cover-test or Krimsky reflex when vision in one eye was less than 6/60. The secondary outcome was the reoperation rate and binocular function improvement two years post-operation. The binocular function was recorded in case the patient had suppression, diplopia or fusion using the Worth-4-dot test or red glass test. Improvement in binocular function was defined as change in binocular status from suppression to diplopia or fusion, and diplopia to fusion. Stereoacuity was recorded using the contour-based test (Wirt circle and Titmus stereo fly test).

All statistical calculations were performed using IBM SPSS Statistics, version 28.0 (IBM Corp., Armonk, NY, USA). Statistical analysis was performed using the chi-square test to compare the success rate between the two groups. Mean (standard deviation, SD) and median (interquartile range, IQR) were used for continuous descriptive demographic data. To compare general data between the two groups, the authors used the chi-square test, unpaired t-test, and Mann-Whitney U test for data analyses. A p-value less than 0.05 was considered statistically significant.

Results

The present study included 115 patients in the adjustable suture group and 90 patients in the conventional suture group. At the time of surgery, the mean age was 38.8 ± 17.6 years in the adjustable technique group and 25.7 ± 17.1 years in the conventional technique group. The difference in mean age between the groups was statistically significant ($p < 0.001$). The etiology of strabismus was divided into five categories, restrictive, paralytic, sensory, concomitant, and others such as left hypertropia, right hypertropia, and arteriovenous malformation with statistical difference between adjustable and non-adjustable group ($p = 0.03$). The preoperative angle of deviation was 39.0 ± 17.1 PD in the adjustable group and 42.5 ± 17.1 PD in the conventional technique group. The difference in preoperative angle of deviation was not statistically significant ($p = 0.145$). Table 1 summarizes the demographic data of the study population.

Successful motor alignment was achieved by 89 patients (77.4%), in the adjustable group and 63

Table 1. Patient demographic data

	Adjustable (n=115)	Non-adjustable (n=90)	p value
Age (years); mean±SD	38.8±17.6	25.7±17.1	<0.01*
Female; n (%)	68 (59.1)	51 (56.7)	0.78
Etiology of strabismus; n (%)			0.03*
Restrictive	17 (14.8)	6 (6.7)	
Paralytic	22 (19.1)	9 (10.0)	
Sensory	17 (14.8)	10 (11.1)	
Concomitant	56 (48.7)	64 (71.1)	
Others	3 (2.6)	1 (1.1)	
Strabismus type; n (%)			0.09
ET	39 (33.9)	37 (41.1)	
XT	54 (47.0)	48 (53.3)	
Hypertropia	13 (11.3)	4 (4.5)	
Hypotropia	9 (7.8)	1 (1.1)	
Amblyopia; n (%)			0.37
No	98 (85.2)	68 (75.6)	
Strabismic	13 (11.3)	18 (20.0)	
Refractive	3 (2.6)	3 (3.3)	
Deprivation	1 (0.9)	1 (1.1)	
Preoperative angle; mean±SD	39.0±17.1	42.5±17.1	0.15
Binocularity; n (%)			0.02*
No	52 (45.2)	25 (27.8)	
Suppression	15 (13.0)	22 (24.4)	
Diplopia	39 (33.9)	31 (34.4)	
Fusion	9 (7.9)	12 (13.4)	
Stereopsis; median (IQR)	80 (40 to 100)	100 (40to200)	0.21
Eye; n (%)			<0.01*
Right	43 (37.4)	19 (21.1)	
Left	47 (40.9)	15 (16.7)	
Both	25 (21.7)	56 (62.2)	

ET=esotropia; IQR=interquartile range; SD=standard Deviation; XT=exotropia

* p<0.05, statistical significance

patients (70.0%) in the conventional group after six months, and by 85 (73.9%) and 59 (65.6%) patients in the adjustable group and conventional group after 12 months, respectively. At 24 months, the success rate was 83 patients (72.2%) in the adjustable group and 54 patients (60.0%) in the conventional group as shown in Figure 1. Additionally, at 24 months, 58.7% of patients in the adjustable group displayed orthotropia compared to only 48.7% in the conventional group. Overall, the adjustable group had a higher likelihood of achieving good ocular alignment. However, the success rate of motor alignment was not statistically different in both groups even at 24 months (p=0.066). No surgical complications occurred in either group. Moreover, in subgroup analysis of adjustable and non-adjustable groups, the success rates for different etiology of strabismus are summarized in Table 2.

In terms of sensory outcomes, binocularity and stereoacuity were documented before operation and two years post-operation. Improvement in binocular function was defined as a change in binocular status from suppression to diplopia or fusion, and diplopia to fusion. Improved binocular function was observed in 23 patients (42.6%) in the adjustable group and 23 patients (43.4%) in the conventional group (p=0.540). Binocular regression, which referred to a decrease in the level of binocular function or fusion greater than that of diplopia, was noted in both groups. Specifically, two patients in the adjustable group experienced binocular function regression from diplopia to suppression, while one patient in the conventional group exhibited regression from fusion to suppression. However, data of sensory outcomes were not available in all subjects. Data from only

Table 2. Success rate in different etiology of strabismus

	Adjustable suture; n (%)			Non-adjustable suture; n (%)		
	6 months	12 months	24 months	6 months	12 months	24 months
Restrictive	8 (47.1)	9 (52.9)	9 (52.9)	4 (66.7)	5 (83.3)	4 (66.7)
Paralytic	20 (90.9)	17 (77.3)	18 (81.8)	3 (33.3)	2 (22.2)	2 (22.2)
Sensory	14 (82.4)	12 (70.6)	11 (64.7)	9 (90.0)	9 (90.0)	7 (70.0)
Concomitant	45 (80.4)	44 (78.6)	44 (78.6)	46 (71.9)	43 (67.2)	41 (64.1)
Others	2 (66.7)	3 (100)	1 (33.3)	1 (100)	0 (0.0)	0 (0.0)
Total	89 (77.4)	85 (73.9)	83 (72.2)	63 (70.0)	59 (65.6)	54 (60.0)

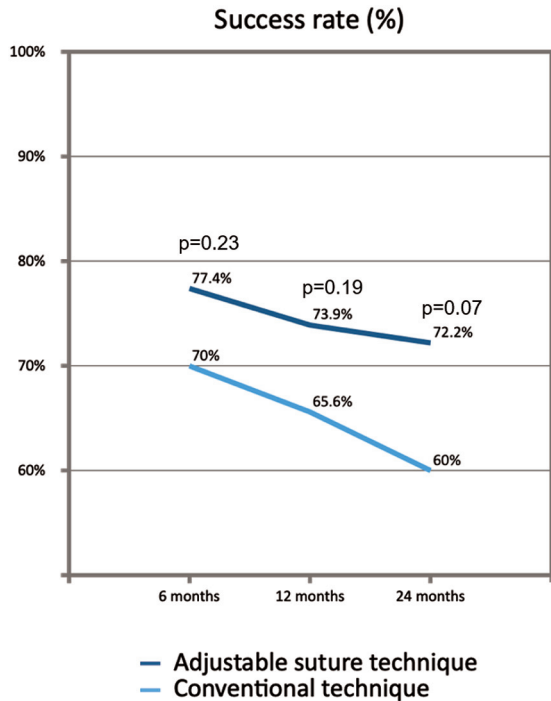


Figure 1. Long-term postoperative success rate in the adjustable suture technique and conventional technique.

54 patients in the adjustable group and 53 in the conventional group were collected. The reasons for missing binocular function data depended on whether the Worth-4-dot test or red glass test was performed, or if the patient had only one functional eye.

Stereoacuity was recorded in seconds of arc, using median to represents data in each group. Median stereopsis improvement was seen in both groups at 80 to 45 seconds of arc in the adjustable group and 100 to 60 seconds of arc in the conventional group ($p=0.67$). Only 16 patients in the adjustable group, and 18 in the conventional group were eligible for data collection, since only patients with binocular fusion function could take the stereoacuity test.

Reoperations were performed in 19.1% of

patients in the adjustable suture group, and 18.9% in the conventional group ($p=0.965$). The median duration until reoperation was 18 months (IQR 8.75 to 39.25) in the adjustable group and 8 months (IQR 6.0 to 22.0) in the conventional group ($p=0.045$).

Discussion

Strabismus surgery is a frequently performed operation to achieve motor alignment and secondary improvement. For suture techniques, there are two choices, adjustable and non-adjustable sutures⁽¹⁾. Previous studies compared the benefits between the adjustable and non-adjustable sutures^(4,5,7,12,15,18). Some studies supported the adjustable technique over non-adjustable technique^(4,5). Some studies reported both techniques to be equally effective^(11,13,14). To the best of the authors' knowledge, there was only one randomized controlled trial comparing outcomes of the adjustable suture and the conventional technique and the results reveal a minor likelihood of improvement with adjustable sutures⁽⁷⁾. Therefore, the present study demonstrated long-term accurate postoperative ocular alignment success up to 24 months.

In the present study, the result showed no statistically significant differences between adjustable and non-adjustable sutures. However, the success rate of adjustable suture at 24 months postoperatively seemed to be higher than non-adjustable technique at 72.2% and 60.0%, respectively ($p=0.06$). The present study result correlated with a previous report which the adjustable sutures had significant better final results than the conventional techniques⁽⁵⁾. Moreover, the failure in adjustable group reduced overtime as shown in Figure 1, by the way still higher than in non-adjustable group. It would be more informative if longer follow-up period was performed to confirm the efficacy of the two different types of strabismus surgeries.

The demographic data of patient population was also analyzed, including the mean age of patients in

each group. The mean age of patients that underwent adjustable suture surgery was 38.8 years, which was higher than that of the conventional technique group, which was 25.7 years with statistically significant difference ($p < 0.001$). Since all patients in the study cooperated with deviation measurement, the age might least likely impact the surgical outcome. In addition, the earlier study⁽¹⁸⁾ stated that patient's age did not influence final postoperative deviation. Moreover, in the present study, preoperative binocularity was identified as another factor that might impact motor outcomes, particularly in exotropia cases. The adjustable suture group had a higher percentage of patients (45.2%) with no preoperative binocularity compared to the conventional technique group (27.8%), and the difference in binocular function between the two groups was statistically significant ($p = 0.021$). It is established that binocular function is crucial for maintaining both motor and sensory fusion, and as such, the absence of binocular fusional ability can have a negative impact on the surgical outcome⁽¹⁹⁾. Despite a higher percentage of patients lacking binocular fusional ability, the adjustable suture technique showed a greater likelihood of achieving orthotropia at 24 months (58.7% versus 48.7%) compared to the conventional technique. These results provide support for the use of adjustable suture as a preferred technique for rectus muscle surgery, particularly in cases where a more predictable outcome is desired.

In terms of binocular improvement, surgical re-alignment is the first step in providing conditions necessary for re-establishing full binocular function in strabismus patients⁽²⁰⁻²⁴⁾. The present study showed patients who underwent either adjustable suture or conventional technique strabismus surgery had significant improvement of binocular functions at 24 months (42.6% and 43.4%), respectively. Stereoacuity also improved in both groups. From the present study, the authors concluded that the adjustable suture or conventional technique can be a benefit to binocularity, including reduced suppression, better fusion, and improvement in stereopsis. No difference in reoperation rate was found between the two groups. However, the adjustable suture group led to a significantly longer duration of time until reoperation (18 months versus 8 months). This concordantly goes with lower tendency of failure in the adjustable suture group. However, patient decision is a confounding factor affecting the decision to reoperate.

There were limitations in the present study. Because of its retrospective nature, it was inevitable

to have control bias, confounding factors, and incomplete data. Additionally, sensory outcome data was only collected from a limited number of patients, as some were unable to perform the required tests such as Worth-4-dot test or red glass test or had only one eye. Because the ages and etiology of strabismus in both groups showed significant differences, it is important to exercise caution in interpreting the results. Previous research has indicated that the outcome of surgical correction of strabismus can vary based on factors such as the subtype of strabismus, age at onset, and age at surgical correction, with some patients failing to regain normal binocular function⁽²⁵⁻²⁷⁾.

In conclusion, the results of the present study indicate that the adjustable suture technique showed a higher rate of success compared to the conventional technique, although the difference was not statistically significant. It is important to note that the specific surgical procedure for rectus muscle surgery depended on the surgeon's expertise and must be individualized to meet the patient's needs and preferences. Additionally, the present study only had follow-up period of 24 months, and it is possible that the outcomes may have changed with a longer follow-up period. Further studies with larger sample sizes and longer follow-up periods are necessary to validate the present study findings and to determine the long-term efficacy and stability of the two surgical techniques.

What is already known on this topic?

Strabismus surgery is a frequently performed operation. Adjustable sutures are indicated in cases in which the outcome of surgery is considered less predictable. Adjustable sutures allow re-adjustment of ocular alignment in the postoperative period, as a result, increase the likelihood of success and decrease the rate of reoperation. In previous studies, adjustable and non-adjustable suture techniques share an equal success rate.

What this study adds?

In this study, the authors report on results comparing the long-term operative success up to 24 months of the adjustable suture technique and conventional technique in rectus muscle surgery. The results showed that the adjustable suture technique was associated with higher success compared to the conventional technique for rectus muscle surgery.

Conflicts of interest

The authors declare no conflict of interest.

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