·Clinical Research·

Effectivity of intraoperative adjustable suture technique in horizontal strabismus

Ayse Gul Kocak Altintas[1], Hasan Basri Arifoglu[2], Inci Kocak Midillioglu[3], Elif Damar Gungor[4], Saban Simsek[5]

[1]S.B. Ulucanlar Eye Training and Education Hospital, No: 59 06340 Altindag, Ankara, Turkey
[2]Department of Ophthalmology, S.B. Kayseri Training and Education Hospital, Sanayi Mah. Atatürk Boulevard Hastane Street No:78 38010 Kayseri, Turkey
[3]Davis Eye Clinic, 4860 Y St., Suite 2400, Sacramento, CA 95817, USA
[4]Department of Ophthalmology, S.B. Malatya State Hospital, Ankara cd. Özalper mh. No:4, Malatya, Turkey
[5]Department of Ophthalmology, S.B. Haydarpaşa Numune Training and Education Hospital, Tibbiye Cad. No: 40 Üsküdar, istanbul, Turkey
Correspondence to: Hasan Basri Arifoglu, Department of Ophthalmology, S.B. Kayseri Training and Education Hospital, Sanayi Mah. Atatürk Boulevard Hastane Street No: 78 38010 Kayseri,Turkey. habasa@yahoo.com
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Abstract

• AIM: To compare the long –term effectivity of intraoperative adjustable suture technique with traditional non–adjustable strabismus surgery.

• METHODS: Two hundred and thirty –three patients, who underwent strabismus surgery either with traditional procedures or one–stage intraoperative adjustable suture technique, were included in our long –term follow –up study. One hundred and eighteen patients were evaluated in traditional surgery group (TSG) and 115 who underwent adjustable suture were in the one –stage intraoperative adjustable surgery group (ASG). In this group 9 patients had paralytic strabismus and 16 had reoperations, 2 patients had restrictive strabismus related to thyroid eye disease. The mean follow up in the TSG was 26.2 months and it was 24.8 months in the ASG group.

• RESULTS: In patients with exotropia (XT) the mean correction of deviation for near fixation in ASG (32.4±13.2PD) and in TSG (26.4±8.2PD) were similar (P=0.112). The correction for distant fixation in ASG (33.2±11.4PD) and TSG (30.9±7.2PD) were not significantly different (P=0.321). In patients with esotropia (ET) even the mean correction of deviation for both near (31±12PD) and distant (30.6±12.8PD) fixations were higher in ASG than in TSG, for both near (28.27±14.2PD) and distant (28.9±12.9PD) fixations, the differences were not significant (P=0.346, 0.824 respectively). The overall success rate of XT patient was 78.9% in TSG and 78.78% in ASG, the difference was not significant (P=0.629). The success rates were 78.75% in TSG and 75.51% in ASG in ET patient, which was also not significantly different (P=0.821).

• CONCLUSION: Although patients in ASG had more complex deviation such as paralysis, reoperations and restrictive strabismus, success rates of this tecnique was as high as TSG which did not contain complicated deviation. One –stage intraoperative adjustable suture technique is a safe and effective method for cooperative patient who has complex deviation.

• **KEYWORDS:** adjustable suture; strabismus surgery; esodeviation; exodeviation
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INTRODUCTION

Adjustable suture technique allows for exact correction of deviation in strabismus surgery mainly in complex squint such as paralytic strabismus, restrictive myopathies, reoperations or long-standing deviations in which elastic and dynamic forces had changed and the dose response correlation is variable [1-3]. This technique has opportunity to place the eyes in desired position either at the time of surgery or within a few hours after the operations. To plan the ideal postoperative long term result, it must be considered the most likely drift pattern of the deviation, so that the final result will be optimal. Although the adjustable suture technique reduces the rate of immediate over or undercorrection, it has been reported that adjustable suture technique also lead to improved long-term surgical success rates comparing to non-adjustable traditional procedures[4-6].

In this study we evaluate the long term results of both one-stage intraoperative adjustable suture technique and traditional non-adjustable strabismus surgery.

Table 1 Types of ET and XT patients who underwent surgery

TSG		ASG	
ET *n*=80	29 infantile ET 27 basic ET 23 partially accomodative ET 1 residual ET	ET *n*=49	21 basic ET 11 partially accomodative ET 8 paralytic ET (6^{th} nerve palsy) 7 residual ET 2 restrictive ET
XT *n*=38	24 constant XT 9 intermittant XT 5 divergent excess type XT	XT *n*=66	20 constant XT 17 intermittant XT 19 divergent excess type XT 1 paralytic XT (3^{rd}+4^{th} nerve palsies) 9 residual XT

ASG: Adjustable surgery group; TSG: Traditional surgery group; XT: Exotropia; ET: Esotropia.

SUBJECTS AND METHODS

Subjects Two hundred and thirty-three patients underwent strabismus surgery either with conventional procedures or one-stage intraoperative adjustable suture technique was included in our retrospective long-term follow up evaluation.

Methods All patients had a complete preoperative ophthalmic assesment including best corrected visual acuity, ocular motility evaluation and measurement of ocular deviations by cover test for both near and distance. Fusion was tested with Bagolini lenses and Worth Four Dot Test. Stereopsis was evaluated with the Randot or TNO Test.

Adjustable suture technique was used only for a patient who sufficiently cooperate to manipulation intraoperatively and only for recession procedure. Patients who had paralytic strabismus, restrictive strabismus such as related thyroid eye disease, previously operated eyes, large angle deviations, long-standing strabismus with consequent contracture of extraocular muscle underwent one-stage intraoperative adjustuble surgery.

In adjustable surgery group (ASG) 49 patients had esotropia (ET) and 66 patients had exotropia (XT), while in the traditional surgery group (TSG) 80 patients had ET and 38 patients had XT. Combined hypertropia and XT were observed in two patients in ASG.In TSG out of 80 patients with ET, 29 had infantile ET, 27 had basic ET, 23 had partially accomodatif ET and 1 case had residual ET. In same group out of 38 patients with XT, 24 had constant XT, 9 had intermittant XT and 5 had divergent excess type XT. In ASG out of 49 ET patients, 21 had basic ET, 11 had partially accomodatif ET, 8 had paralytic ET, 7 cases had residual ET and 2 had restrictive strabismus related to thyroid eye disease. In this group out of 66 XT patients 20 had constant XT, 17 had intermittant XT, 19 had divergent excess type XT, 1 had paralytic and 9 had residual XT (Table 1).

In ASG out of 9 patients who had paralytic strabismus, 8 had 6^{th} nerve palsy and one patient had combined 3^{rd} and 4^{th} nerve palsies. No patient had paralytic strabismus in the TSG. Sixteen patients had history of extraocular muscle operations before intra operative adjustable surgery, 7 of whom had surgery for ET and 9 of whom had XT. Only one young patient with residual ET underwent reoperation at the age of 8 with non-adjustable tecnique. Two patients had sensory strabismus among ASG and no one had sensory strabismus in TSG, 23 patients had long standing deviation which was more than 15 years and no one had long standing deviation in TSG. Complex cases which have unpredictable surgical outcomes were significantly higher in ASG than TSG.

Surgical technique Traditional technique was performed under either general or retrobulbar anesthesia. Anterior subtenon anesthesia was prefered for one-stage intraoperative surgery in which ocular motility and eye position was not changed. A limbal conjunctival approach was used for all patients. The muscle was hooked and dissected. In traditional surgery, separeted 6-0 double vicryl (polyglactin 910; Ethicon, New Brunswick, NJ,USA) sutures were placed on the each side of the muscle edge. In one-stage intraoperative adjustable surgery, double armed locking bites of same one piece suture were passed on both sides of the muscle insertion and tied. The muscle was then disinserted from its original insertion side on both techniques.

In traditional surgery, recessed muscle was inserted on the sclera at certain amount of posterior from its original insertion. The surgery plans were done according to American Academy guidelines for each patient in either group [7]. In intraoperative adjustable suture surgery the needles were passed through the sclera on the original insertion side. The muscle was left hanging back and recession was performed to desired amount of recession [7]. A bow knot was placed using double throw followed by a simple bow (Figure 1). After performing later stages of surgery such as resection of antagonistic muscle, the suture adjustment was done. Due to intact muscular movement with the help of anterior subtenon anesthesia, measurement of ocular deviation by prism alternate cover and uncover tests could be achieved intraoperatively (Figure 2). All surgeries with one stage intraoperative suture technique were performed by same surgeon (AKA) while traditional technique was performed by all authors.

Our goal was to exact alingment in esodeviation (ET) with fusion, as minimal overcorrection (2-4PD) for exodeviation (XT) and minimal undercorrection for esodeviation with low visual acuity and lack of fusion due to ambliyopia. If the

Table 2 Preoperative and postoperative deviations in each group both for distant and near fixations in patients with XT and ET

	Preoperative near fixation	Preoperative distant fixation	Postoperative near fixation	Postoperative distant fixation	Near correction	Distant correction
XT Patient						
ASG	42.5±12 PD (20-80 PD)	44.2±10.2 PD (18-70 PD)	8.9±7.6 PD (0-25 PD)	8.6±7.7 PD (0-25 PD)	32.4±13.2 PD (20-50 PD)	32.3±11.4 PD (25-45 PD)
TSG	33.2±2.2 PD (16-75 PD)	34.9±10 PD (18-55 PD)	5.1±4.9 PD (0-30 PD)	3.4±4.1 PD (0-15 PD)	26.4±8.2 PD (15-45 PD)	30.9±7.2 PD (25-45 PD)
ET Patient						
ASG	42.1±10.6 PD (14-70 PD)	40.2±14.8 PD (18-70 PD)	6.2±8.1 PD (0-25 PD)	10.1±11.4 PD (0-20 PD)	31±12 PD (14-50 PD)	30.6±12.8 PD (18-50 PD)
TSG	35.4±12.1 PD (18-70 PD)	36.2±12.1 PD (18-70 PD)	11.7±10.8 PD (0-30 PD)	7.8±8.6 PD (0-25 PD)	28.2±14.2 PD (18-45 PD)	28.9±12.9 PD (18-45 PD)

ASG: Adjustable surgery group; TSG: Traditional surgery group; XT: Exotropia; ET: Esotropia.

target of correction was not achieved in initial manipulation, adjustment procedure was performed intraoperatively. During the adjustment the effect of the surgery could be decreased or augmented by either tightening or loosening the bow knot. Adjustment procedure was repeated several times until achievement of target deviation.

Postoperative follow-ups were performed on postoperative first day, first week, first month, third month and three months intervals after surgery. Patients whose last follow-up were longer than 12 months included in this study. In last follow up 10PD and less residual deviation is considered as surgical success (Figure 2).

Statistical Analysis Excell calculation table (Microsoft Corporation, Redmond, WA, USA) and Minitab 14 statistics program (Minitab Inc, State Collage, PA) were used to evaluate our success rate. Student's *t*-test was applied to analyse the deviation differences between groups; paired *t*-test was used to evaluate the deviation differences before and after the operation and Chi-square test for the distribution of the surgical success rates between groups.

RESULTS

The mean age of the patient in traditional surgery group (TSG) was 10.34±8.85 years (10 months to 22 years) and 31.6±12.85 (15 to 71 years) years in adjustable suture group (ASG). Patients in ASG were significantly older than TSG (P=0.015). And most of the patients in ASG had long-standing strabismus. The mean follow-up time in TSG was 26.2 months (range of 3-48 months) and it was 24.8 months (range of 3-37 months) in adjustable suture group. The follow-up periods were not significantly different between the groups (P=0.898).

Preoperative and postoperative deviations in each group both for distant and near fixations are given in Table 2. The mean preoperative deviation for near fixation in patients with exotropia in ASG (42.5±12PD) was significantly higher than in TSG (33±2.2PD) (P=0.015) but the difference between mean postoperative deviations of ASG (8.97±7.6PD) and TSG (5.1±4.9PD) was not significantly different (P=0.089). According to this result the adjustable surgery seemed to be more effective for correction of near deviation in exotropia patients.

The mean preoperative deviation of XT patients for distant fixation in ASG (44.2±10.2PD) was higher than that of TSG (34.9 ±10PD) but the difference was not statistically significant (P=0.069). The mean postoperative deviation for distant fixation was significantly less in TSG (3.4±4.1PD) than in ASG (8.6±7.7PD) (P=0.015). According to this result traditional surgery seemed to be more successful for correction of distant deviation in patients with XT. However, in the patients who had XT the mean correction of deviation in near fixation was 32.4±13.2PD in ASG and 26.4±8.2PD in TSG, the difference was not statistically significant (P= 0.112). The surgical correction of distant fixation was not different between ASG and TSG groups too (33.2±11.4PD and 30.9±7.2PD respectively) (P=0.321).

In XT group 30 patients out of 38 (78.9%) had equal and/or less than 10PD of deviation, 15 of them were orthotropic in TSG and 52 patients out of 66 (78.78%) had equal and/or

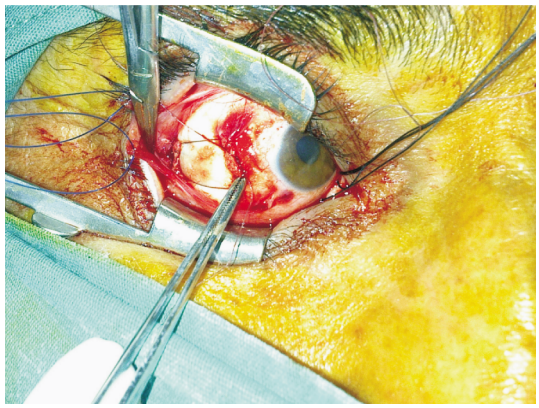

Figure 1 Adjustable suture between lateral rectus and its insertion.

Figure 2 Intraoperative eye movements.

less than 10PD of deviation, 26 of them were orthotropic in ASG, which was considered as surgical success. The success rates of both groups were statistically similar (P=0.629).

In patients with ET, the mean preoperative deviation for near fixation in ASG (42.1±10.6PD) was statistically significantly higher than TSG (35.4±12.1PD) (P=0.026) (Table 2). The mean postoperative deviation of ASG (6.2±8.1PD) was lower than that of TSG (11.7±10.8PD), but the difference was not statitistically significant (P=0.162). According to this result intraoperative adjustable suture surgery seemed to be more effective in ET patient in near fixation.

In ET group, both the mean preoperative deviation in ASG (40.2±14.8PD) and in TSG (36.2±12.1PD) and the mean postoperative deviations in ASG (10.1±11.4PD) and in TSG (7.8 ±8.6PD) for distant fixation were not statistically significantly different (P=0.128, P=0.169 respectively).

In patient with ET even the mean correction of both near deviation (31±12PD) and the distant deviation (30.6±12.8PD) were higher in ASG than in TSG for both near (28.27 ± 14.2PD) and distant fixation (28.9±12.9PD), the differences were not significant (P=0.346, P=0.824 respectively).

As a surgical success, 30 patients with ET were orthotropic and a total of 63 patients had equal or less than 10PD of residual deviation in out of 80 patients, the success rate was 78.75% in TSG. A total of 37 patients had equal or less than 10PD of residual deviation and 23 patients were orthotropic out of 49 ET patients and the success rate was 75.51% in ASG. The success rates were similar in ET patients (P= 0.821).

Seventy-three patients had undergone monocular recession and resection operation while 45 patients underwent bilateral recession operation in TSG. Eigthy-three patients had undergone monocular recession and resection, 32 patients had two-muscle recession in ASG. Adjustable suture manipulations were performed only on recession procedures.

Fifty patients out of 115 (43.4%) had required intraoperative adjustment, some of them had unpredictable surgical outcome, such as 6 of them had paralytic strabismus, 2 had restrictive strabismus and 9 of whom had undergone operations previously. The amount adjustment was 1mm advancement and 1 to 3mm more recession (median is 2mm). Five patients among 6 had XT and 1 had ET would have risk of postoperative diplopia after full correction of deviation. Therefore, the goal of adjustments was as small amount of residual deviation as possible without the risk of postoperative diplopia. Five patients had more than 10PD of residual XT with the range of 12 to 16PD while 1 patient had 22PD of residual ET. Excluding these five patients with XT who underwent purposely under correction, the success rate would be 86.6%. Therefore the corrected success rate in ASG (86.6%) would be higher than TSG's success rate (78.78%). If 1 ET patient who received intentionally hypocorrection is not included, success rate would be 77.55% in ASG. No one had a risk of postoperative diplopia detected in preoperative evaluation in TSG, so the target of operations was to correct the total amount of deviations as much as possible.

No one had overcorrection in either group but 16 (13.50%) patients in TSG and 12 patients (10.43%) in ASG needed reoperation for under correction after this procedure and reoperation rate was higher in TSG than ASG.

DISCUSSION

Strabismus surgery with the adjustable suture technique allows modification of the muscle position when the postoperative results are not predictable. This technique increases the surgical success and reduces the frequency of reoperation. Surgeons have chance to place the eyes in desired position by augmented or decreased the effect of the surgery by pulling or loosening the sutures either during the operation or in the immediate postoperative period [4-6,8]. Although adjustable suture technique eliminates the rates of immediate over or undercorrection it does not guarantee the optimal alignment in long term[1,8,9].

In our study we compared the long term postoperative success rates of one-stage intraoperative adjustable suture procedure and traditional strabismus surgery. The reported success rates in adjustable suture techniques are changing in different series dependent on ethiology of patients and follow-up period. Robbins *et al* [10] reported satisfactory cosmetic improvement in 84% of patient at the 1 month-3 months follow-up visit in a multicentre review. Wygnanski-Jaffe *et al* [2] observered success rates of 80% in the primary cases and 78% of the reoperations while Weston *et al* [1] reported higher success rates in primary operations (88%) in both ET and XT cases compared to 81% in ET reoperations and 74% in XT reoperations.

In our ASG we included cases with both reoperations and also other complex deviations such as long-standing deviations, paralytic and restrictive strabismus, in which muscle contractures and normal muscle elasticity alterations developes. Preoperative measurements are based on static deviation, without taking into account the dynamic or the elastic forces. These forces are significantly changes in muscules which previously had operation or have restrictions. It is difficult to predict the effect of the same amount of surgical manuplation on muscles which, normal length-tension ratios had been changed. Therefore, surgical success rates were lower in these eyes than eyes with normal anatomic and histologic situation.

Mireskandari *et al* [11] observed higher overall success rate with adjustable suture (77.7%) compared with non adjustable suture (69.1%) in combined group including both in primary strabismus surgery and reoperations. Zhang and coworkers[12]

reported that the success rates of adjustable and non-adjustable suture surgery groups were 74.8% and 61.3% respectively in childhood strabismus at 7 day to 12 weeks follow-up examination. We did not compare the results of primary procedure to reoperations's like Mireskandri and Zhang and our success rates were similar to their series [11,12]. Although our follow-up period was significantly longer than other authors's series, our adjustable surgery group success rates were comparable to their series.

Our success rate of XT patient was 78.9% in TSG and 78.78% ASG while it was 78.75% in TSG and 75.51% in ASG in ET patients. Although patient in our ASG had more complex deviation in which expected success rates were lower than non-complex squint, the long-term success rates were not different in both groups. According to our results the success rates of one-stage intraoperative adjustable suture technique in patients with complex deviation were as high as in patients with non-complicated deviation.

The aim of correction in patient with the risk of postoperative diplopia were as small amount residual deviation as possible without postoperative diplopia. Excluding these patients who had purposely received hypocorrection in ASG, the long term success rate would be 86.6% which was higer than TSG's success rate of 78.78% in XT patient. The corrected success rate of 77.35% in ASG which has complex strabismus, was similar to TSG's success rate in ET patients. Excluding only one reoperation case, no one had complex strabismus in TSG.

In ASG the rate of complex strabismus, such as 6th nerve palsies, reoperations, and restrictive strabismus were higher in ET cases than XT cases, so the success rate in XT group was higher than ET patients in this group.

We preferred recessing the muscle as optimal position as possible according to preoperative evaluation and later pulling or releasing to muscle by the adjustable sutures up to the required position to achieve the desired postoperative long-term stability. By following this procedure 50 of 115 (43.4%) patients needed adjustment during the surgery in our series.

Weston *et al*[1] recommended to place the muscle in a desired position during the surgery in two stage adjustable suture technique without overrecession and reported 40% of adjustment rate. Other authors who follow the similar procedure as Weston reported the adjustment rate in their series have ranged from 30% to 50% [1-3]. According to multicentre clinical review, 26% of all patients required postoperative suture manuplation, with individual surgeon rates ranging from 13% to 56% in the same study[10].

To achieve long-term ideal postoperative position, the most likely drift pattern must be considered. Wygnanski-Jaffe *et al*[2] observed that patients with ET had a tendency to drift towards ET while patients with XT tended to drift towards XT postoperatively, the meaning that both groups had a tendency to drift towards their original postoperative deviation in 24 months follow up. Due to postoperative changes they recommended mild overcorrection during adjustment to justify to minimize postoperative misalingment. Weston *et al* [1] had also reported that XT patient drifted towards their original direction of deviation but ET patients have an approximately equal risk of drifting towards or away from their original misalignment. On the other hand Metz and Rosenbaum *et al* [9] observed exo-drifts in their seires, which has complex squint such as mechanical and innervational anomalies were included similar to our series[13]. To overcome long term recurrences in XT cases, we performed minimal overcorrection as recommended by all other authors. As far as we know fusional potential is one of the important factor for ocular alignment, we prefered exact alignment in ET patients with normal fusional potential. Patients mainly with low fusional potential have tendency to drift outward in long term as it is observed by different series we performed minimal hypocorreciton in ET patients with low visual acuity and lack of fusion[9,13-15].

One of the major advantages of adjustable suture technique is to reduce the reoperation rate.

Wisnicki and coworkers [15] observed 20% of reoperation rate in nonadjustable strabismus surgery while only 9.7% in adjustable suture technique. Tripathi *et al* [16] reported higher reoperation rate (27%) in conventional strabismus surgery comparing to adjustable suture techique's reoperation rate (8.5%). Although patients with complex squint which have high risk of unpredictable surgical outcome were included only in ASG in our series, the reoperation rate (13.5%) in TSG was higher than that of ASG's rate (10.45%) during the mean follow up of longer than 24 months.

One stage intraoperative adjustable suture technique has some advantages comparing to two stage procedure. Ocular manipulations are performed inside of the operating room with the supervision of an anesthesiologist that gives chance to control oculocardiac reflex and vasovagal reflexes if it needs. Rhiu *et al* [17] reported that, intravenous ketorolac was administered preoperatively in one-stage adjustable strabismus surgery for patient who underwent operation with topical anaesthesia. We performed surgeries with anterior subtenon anaesthesia rather than under only topical anaesthesia, and we did not needed additional sedation or pain medication for any patient.

In our one-stage intraoperative adjustable suture technique adjustment procedure was performed in sterile condition as a part of surgery so the risk of infection due to environmental condition is eliminated. Because of being one stage manipulation, free suture endings are not left overnight on the conjunctiva which may cause irritation, foreign body sensation and corneal erosion. Robbins *et al* [10] observed

transient complications such as delen, filamentary keratitis, granuloma in patients who underwent operations with two stage adjustable suture. Sherma and Reinecke recommended adjustable suture surgery in 12 patients with restrictive strabismus while Rauz and Goven used this technique in 8 patients with vertical strabismus[6,18].

According to our knowledge ours is both the largest series of one-stage intraoperative adjustable suture surgery and has the longest follow-up period. We observed that strabismus surgery with one-stage intraoperative adjustable suture technique for patient even had complex strabismus has as high success rastes as non complex strabismus. This technique is also safe and effective method both in short and long term for patients with good cooperation during adjustment.

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