Original Article

Adjustable Strabismus Surgery: An Early Glance

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Purpose: To assess the short term success rate of adjustable suture technique on rectus muscle strabismus surgery in terms of postoperative alignment

Study Design: Prospective, interventional study

Place and Duration of Study: Eye Department, Fauji Foundation Hospital, Rawalpindi, from 25th June, 2016 to 25th December, 2017

Material and Methods: We carried out a study using the fornix approach for adjustable squint surgery, in mainly horizontal strabismus in adults and cooperative children, to finely tune the postoperative alignment. The preoperative deviation, strabismus type, patterns, were measured and analyzed. The early postoperative alignment was measured at 6 weeks postoperatively, to assess the success of the adjustable suture technique. A sliding noose knot was used to adjust the sutures, 1 hour postoperatively under topical proparacaine anesthesia, after the effects of general anesthesia had worn off.

Results: 31 patients were included in this study. The majority were female being 23 (74.5%). The age ranged from 9 to 37 years, with the mean age 16.87 ± 5.5 years. All consenting adults and teenagers, with strabismus were included in this study and operated via the adjustable suture technique. The mean preoperative deviation was 49.38 ± 16.29 $^{\Delta}$ prism diopters, and the mean postoperative deviation was 3.5 ± 5.42$^{\Delta}$ prism diopters. The difference between the two was statistically significant ($p < 0.05$), using the Wilcoxon Signed Ranks test ($p = 0.000$). Early surgical success defined as alignment within ± 10$^{\Delta}$ (prism diopters) of orthotropia at the end of 6 weeks after surgery, was found in 27 (87.1%) of our strabismus cases.

Conclusion: Adjustable strabismus surgery is associated with excellent short-term postoperative outcomes in terms of alignment and patient satisfaction. Adjustable sutures should be considered in all strabismus cases, whether adults or children.

Key Words: short term, success, adjustable, strabismus, fornix approach, alignment.

Adjustable strabismus surgery[1] is an art, dating back to 1907, with the ideation of Bielchowsky, O'Connor and Harms who first introduced this technique to refine postoperative alignment. Jampolsky[1] later re-introduced the adjustable suture technique to achieve stable motor alignment and sensory improvement. Although most strabismus surgeons who use adjustable sutures, including me, would prefer them for all their patients regardless of the cause of strabismus, or age of the patient; there are certain indications[2] where they are necessary for good cosmetic results: restrictive strabismus including thyroid myopathy, anesthetic myotoxicity, scleral buckles, paralytic strabismus, and diplopia to name a few. This art however, has failed to gain universal acceptance so far, and especially in

Pakistan[3]. Strabismus surgery can be tricky[3] in terms of its outcomes, despite accurate measurements and nomograms followed, and may yield different results in different patients, in spite of the same amount of alignment. Thus, the need arises, to adjust the eyes postoperatively, to maximize the chances of success. Adjustable sutures give the operating surgeon a 'second chance' at achieving a stable alignment[4].

In June 2016, we started doing adjustable strabismus surgery, and found it to achieve superior cosmesis, and improve binocular vision and diplopia[5]. Since we are relatively new at this technique, we decided to review and share our early postoperative alignment at six weeks[6] postoperatively, as this is the time, which reflects the chance of the patient achieving eventual long term stable alignment of eyes.

The *aim* of this study is to describe the adjustable suture technique and to assess its effectiveness and success in the early postoperative period, prospectively, in addition to highlight the importance and benefits of postoperative adjustment on postoperative outcomes. The importance of sharing our experiences with others is to benefit those who want to help their patients in achieving the best postoperative cosmetic results.

MATERIAL AND METHODS

All consenting adults and co-operative teenagers with strabismus were included in this ongoing study, reaching 31 patients. This study was carried out in the Department of Ophthalmology, Fauji Foundation Hospital, Rawalpindi, which is a tertiary care, teaching hospital affiliated with Foundation University Medical College; from 25th June 2016 to 25th December 2017. Approval from the ethical committee was taken. The strabismus cases included both horizontal and vertical strabismus, with only one horizontal muscle being used for adjustment. Patients with previous history of strabismus surgery were also included. The first author performed all surgeries. Restrictive strabismus, myasthenia gravis, and uncooperative children less than 9 years of age were excluded.

Visual acuity was documented for every case with a refractive correction given to patients prior to consideration for surgery. The type of strabismus was noted for each patient. The preoperative angle of deviation was assessed by the prism cover test for both near and distance with the refractive correction in place. In certain cases of sensory strabismus with poor fixation, the Krimsky test was used for analysis of the angle or a pen torch used as a target for near and distance. The angle of deviation was measured for both near and distance as well as in up gaze, downgaze, right and left gaze. However, the distance angle with refractive correction in place was considered as the angle of deviation in all cases, and the surgical alignment was sought to correct this angle. At the time of suture adjustment, though, both near and distance alignment was corrected. Exception to this was accommodative refractive esotropia, for which the near deviation with distance spectacles in place was considered for correction of the alignment. A plus sign (+) was assigned to an exotropic angle and a negative sign (-) was assigned to an esotropic angle. The measurements were taken by the operating surgeon and a certified orthoptist, and repeated by the operating surgeon one day prior to surgery, to obtain maximum cosmesis. Binocular vision and stereopsis were assessed by the Titmus fly test and Worth four-dot test, routinely by the orthoptist preoperatively. A thorough eye examination was performed including fundus and intraocular pressures, and was documented.

All surgeries were performed under general anesthesia. A drop of phenylephrine 10% (Ethifrin®) were instilled into the conjunctival fornix at the beginning of surgery in each eye. The fornix approach for strabismus surgery was used in every case. Each muscle was hooked, and then secured with a double armed 6-0 vicryl (polyglactin 910) absorbable suture, which was passed through the sclera at its insertion, or transposed above or below the insertion in case of 'A' or 'V' patterns, in a 'hang-back'[7,8] fashion. The medial recti were transposed towards the apex, and the lateral recti were transposed away from the apex, in case of 'A' or 'V' patterns. The recessed muscles were mostly placed for adjustable purpose, with the required recession held in place by Guyton's[9] modification of the sliding noose knot, which was fashioned with a 6-0 Vicryl suture. The amount of 'hang-back' recession was calculated for each patient using standard tables[4,10,11]. The traction suture for holding the sclera for postoperative adjustment was created with ethibond 5-0 in every case. For the non-adjustable recessions, the muscle was tied and allowed to 'hang-back' from its insertion, with the required amount of recession calculated as required. Resections were also put up for adjustment in one case only, but avoided mostly, as they tend to cause more pain. For resections, the amount of resection is overcorrected by 2 mm, and allowed to 'hang-back' for this distance, to

be adjusted if required postoperatively. Only one muscle was kept on an adjustable sliding noose knot per case.

All patients were assessed for alignment and final adjustment at least 1 hour or more after surgery, in the recovery room, to allow time for the effects of general anesthesia to wear off[12]. The eyes were anesthetized topically with Alcaine® (proparacaine hydrochloride 0.5%) eye drops. The patients were assessed with the cover-uncover test at distance and near, with a torch light for distance if the vision was blurred (due to viscoelastic, antibiotic/steroid drops placed postoperatively or pupillary dilatation with phenylephrine or general anesthesia), or a distance readable target, and for near an accommodative target was used. If the alignment was satisfactory, with no movement on cover testing, the sutures were tied off in their existing position, held in place by the sliding noose, which was removable after tying the ends of the muscle sutures. Thereafter, the traction knot was cut, and the conjunctiva was sutured with at least one 6-0 vicryl suture. The final tying off point was orthotropia or maximum possible under-correction as required. In cases of exotropia, the goal was orthotropia or mild esotropia. In cases of esotropia, the goal was either orthotropia, if achieved, or slight under-correction.

The alignment was noted postoperatively the next day, at 2 weeks and 6 weeks after surgery. The patients were given postoperative topical steroid and antibiotic drops twice a day and ointment at night for a minimum of 2 weeks. The follow up is being continued to assess long term postoperative alignment as well.

Early surgical success was defined as alignment within ± 10^{Δ} (prism diopters) of orthotropia at the end of 6 weeks after surgery. This postoperative residual deviation was the average of the distance and near deviations noted on prism cover testing. Although both horizontal, vertical and complex strabismus were included in our study, the horizontal alignments preoperatively and postoperatively, were mainly assessed and analyzed for surgical success purpose.

The results were noted, tabulated and analyzed using the SPSS statistics version 20. Frequencies were calculated for age, gender, type and pattern of strabismus, surgical procedure performed, as well as the follow-up. Statistical analysis of success rate was done, and assessment of statistically significant differences between the preoperative and postoperative strabismus deviations was analyzed by the *Wilcoxon Signed Ranks test*. The success rate was compared and analyzed for the type of strabismus as well.

RESULTS

31 patients were included in this study, with predominantly 23 (74.2%) females and 8 (25.8%) males. The mean age was 16.87 ± 5.5 years with a range from 9 years to 37 years. The early postoperative alignment was measured at 6 weeks follow up, and the average follow up was 52.7 ± 13.76 days, with an actual range from 38 to 94 days.

The patients were classified based on type of deviation and the majority of them were exotropic with 16 (51.6 %) cases [Table 1]. Table 1 categorizes the patients based on type of strabismus, with predominance of purely horizontal cases in 17 (54.8 %) cases; the rest being a combination of horizontal, vertical and/or complex strabismus. Associated patterns, A, V, X, Y were tabulated in Table 2, with predominance of V-pattern.

Table 1: Type of Strabismus.

Deviation Type	Frequency (Percent)
Exotropia	16 (51.6)
Esotropia	6 (19.4)
Exotropia & DVD$^{\phi}$	2 (6.5)
Esotropia & DVD$^{\phi}$	1 (3.2)
Exotropia & Hypertropia	5 (16.1)
Esotropia & Hypertropia	1 (3.2)
Horizontal	17 (54.8)
Horizontal and Vertical	7 (22.6)
Horizontal & Complex$^{\epsilon}$	4 (12.9)
Horizontal, Vertical & Complex$^{\epsilon}$	3 (9.7)

ϕ Dissociated vertical deviation

€ Sensory, paralytic strabismus or DVD

Table 2: Pattern of Strabismus if Present.

Pattern	Frequency (Percent)
V-pattern	20 (64.5)
A-pattern	4 (12.9)
None	7 (22.6)

Table 3: Surgical Procedure Performed.

Surgical Procedure	Frequency (Percent)
BLRc¶	12 (38.7)
BMRc§	5 (16.1)
BMRs¥	1 (3.2)
MRc¤ + LRs×	1(3.2)
MRsø + LRcꚪ	6 (19.4)
BLRc¶ + MRsø	4 (12.9)
BMRc§ + LRs×	1 (3.2)
MRc¤	1 (3.2)

¶ Bilateral recessions
§ Bimedial recessions
¥ Bimedial resections
¤ Unilateral medial rectus recession
× Unilateral lateral rectus resection
ø Unilateral medial rectus resection
ꚫ Unilateral lateral rectus recession

The various surgical procedures performed to correct horizontal component of strabismus are listed in Table 3. Associated vertical deviations were addressed with concurrent procedures on the vertical Recti or obliques, which are listed in Table 4. A summary of the data in accordance with the type of deviation is elaborated in Table 5.

The mean preoperative deviation was 49.38 ± 16.29$^{\Delta}$ (prism diopters), with a range from 23 to 85$^{\Delta}$. The mean postoperative deviation was 3.5 ± 5.42$^{\Delta}$ (prism diopters), with a range from zero to 20$^{\Delta}$. The difference between the preoperative and postoperative deviation was analyzed by the *Wilcoxon Signed Ranks test* and found to be statistically significant (p = 0.000) [Table 6]. Early surgical success defined as satisfactory alignment within ± 10$^{\Delta}$ (prism diopters) of orthotropia at the end of 6 weeks after surgery, was found in 27 (87.1%) of our strabismus cases, and were tabulated for each deviation type [Table 7], and under corrections were found in 3 (9.6%) cases of exotropia and 1 (3.2%) case of esotropia only. Figures 1-3 depict our post-operative success. Reoperation has not been required in any of these cases so far. No complication was encountered in any patient during suture adjustment and all proceeded smoothly with minimal patient discomfort.

Table 4: Surgery on Vertical Recti & Obliques.

Surgery on Vertical Recti & Obliques	Frequency (Percent)
Unilateral IOα myectomy	3 (9.7)
Bilateral IOα myectomies	6 (19.4)
IOα anteriorization	1 (3.2)
SRβ transposition	1 (3.2)
Bilateral IOα myectomies + SRcΣ	1 (3.2)
None	19 (61.3)

α Inferior oblique
β Superior rectus
Σ Superior rectus recession

Table 5: Data Analysis According to Deviation Type.

Type of Deviation	Age in Years (mean ± SD)	Gender		Preoperative Angle (PD) (Mean ± SD) Ω	Postoperative Angle (PD) (Mean ± SD)	Pattern	
		Male	Female			V-Pattern	A-Pattern
Exotropia	19.06 ± 6.18	4	12	48.1 ± 16.7	4.46 ± 6.77	9	2
Esotropia	14.17 ± 4.4	2	4	60.1 ± 13.3	2.58 ± 4.34	4	2
Exotropia & DVDϕ	13.5 ± 4.9	1	1	34 ± 8.4	1.00 ± 1.41	2	0
Esotropia & DVDϕ	15.0	1	0	70	0	1	0
Exotropia & Hypertropia	15.0 ± 3.53	0	5	47.8 ± 10.7	2.30 ± 2.58	4	0
Esotropia & Hypertropia	16.0	0	1	23	8 ± 3.50	0	0

PD Prism diopters
SD Standard deviation
Ω distance deviation in all cases except accommodative esotropia in which near deviation with distance correction was taken

Table 6: Preoperative and Postoperative Deviations.

Descriptive Statistics	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
Preoperative Deviation (PD)	49.3871	16.29249	23.00	85.00	40.0000	45.0000	65.0000
Postoperative Deviation (PD) at 6 weeks	3.5000	5.42525	.00	20.00	.0000	1.0000	6.0000

PD Prism diopters

Test Statistics[a]

	Postoperative Deviation at 6 weeks - Preoperative Deviation (prism diopters)
Z	-4.862[b]
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test
b. Based on positive ranks.

Table 7: Surgical Success.

		Surgical Success with Postoperative Deviation within 10 Prism Diopters	
		Yes	No
Total	31	27 (87.1)	4 (12.9)
Deviation Type	Exotropia	13 (41.9)	3(9.6)
	Esotropia	5 (16.1)	1 (3.2)
	Exotropia & DVD$^{\phi}$	2 (6.4)	0
	Esotropia & DVD$^{\phi}$	1 (3.2)	0
	Exotropia & Hypertropia	5 (16.1)	0
	Esotropia & Hypertropia	1 (3.2)	0

ϕ Dissociated vertical deviation

Fig. 1 (A): 20 year old girl with congenital alternate esotropia of 70Δ, a left hypertropia of 8Δ, and a V-pattern of 15Δ. Bimedial recessions of 7mm OD and 8 mm OS after adjustment and a left inferior oblique myectomy was done.

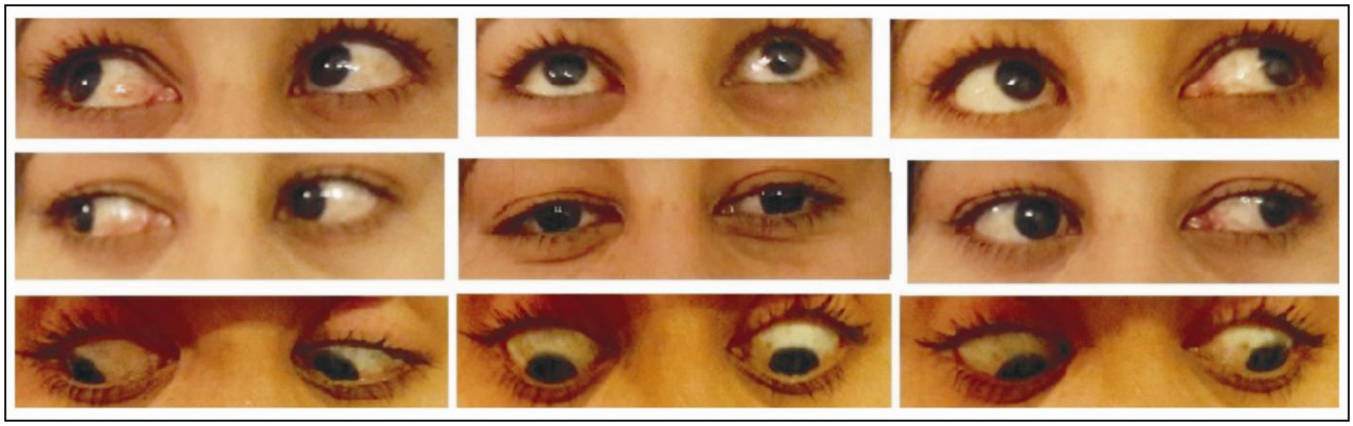

Fig. 1 (B): Postoperatively, she is well aligned.

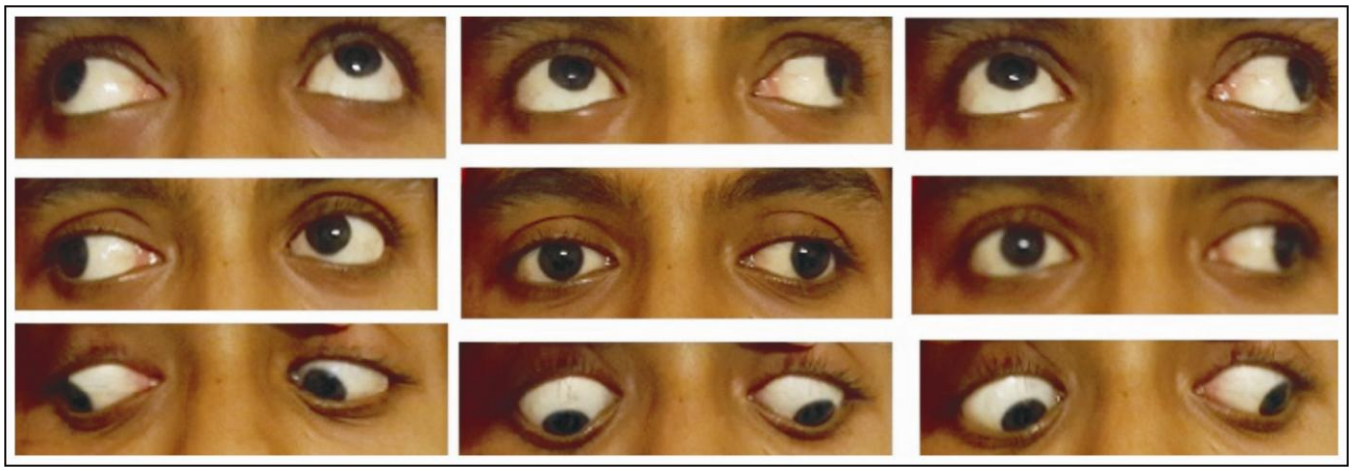

Fig. 2 (A): A 15-year-old girl with an alternate exotropia of 70Δ and a V-pattern of 32Δ was managed by bilateral lateral rectus recessions of 7mm and a right medial rectus resection of 6 mm, and bilateral inferior oblique myectomies. No adjustment was needed postoperatively and the sutures were tied off.

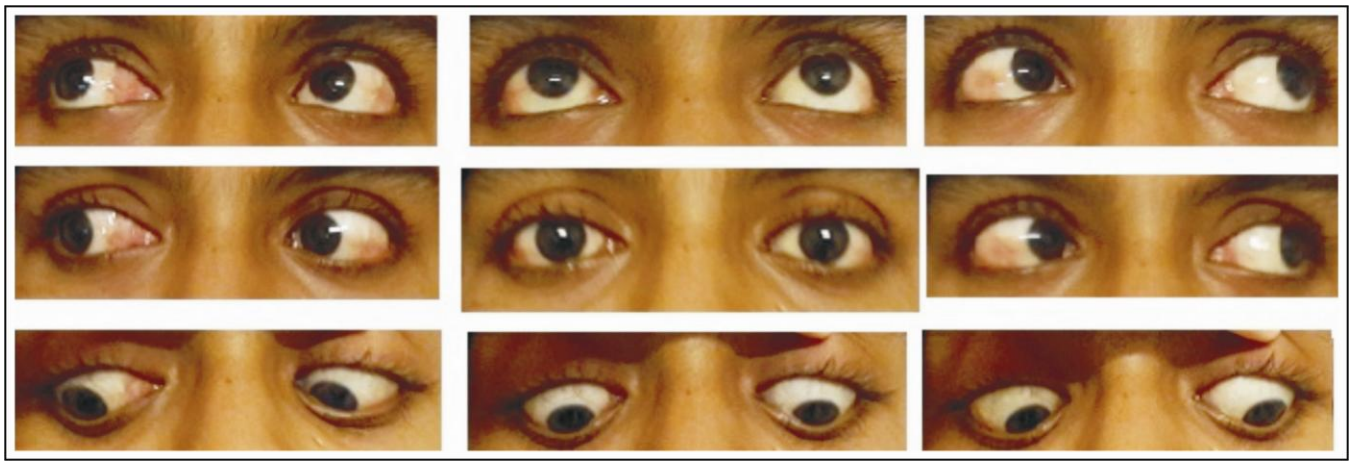

Fig. 2 (B): Postoperatively she is orthotropic.

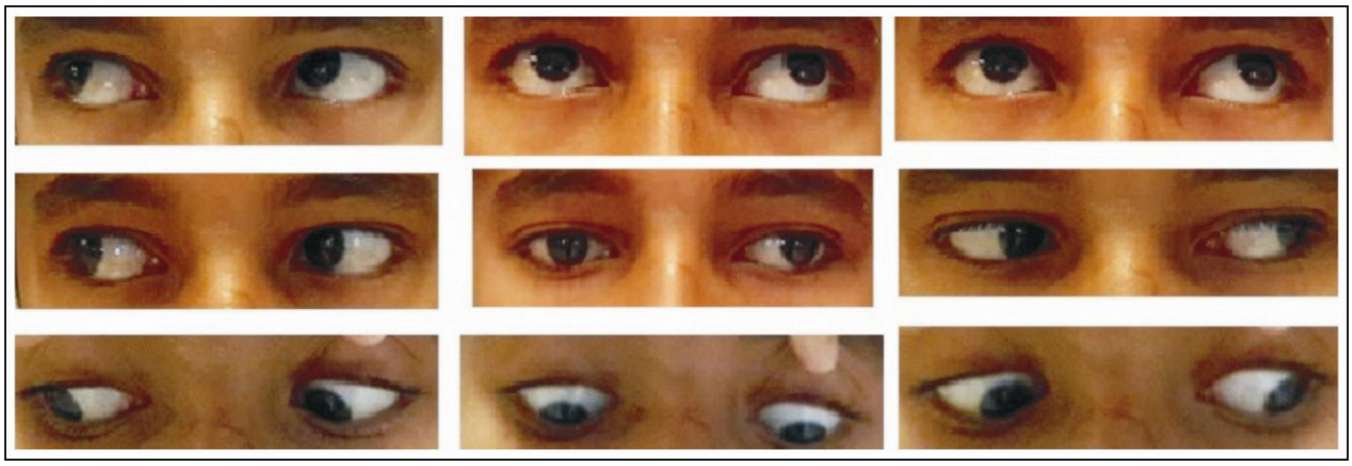

Fig. 3 (A): A 12 year old boy with an alternate exotropia of 40Δ and a V-pattern of 20Δ was managed with bilateral lateral rectus recessions 6mm OD and 8 mm OS after adjustment, along with a half tendon width upward transposition of both muscles was done.

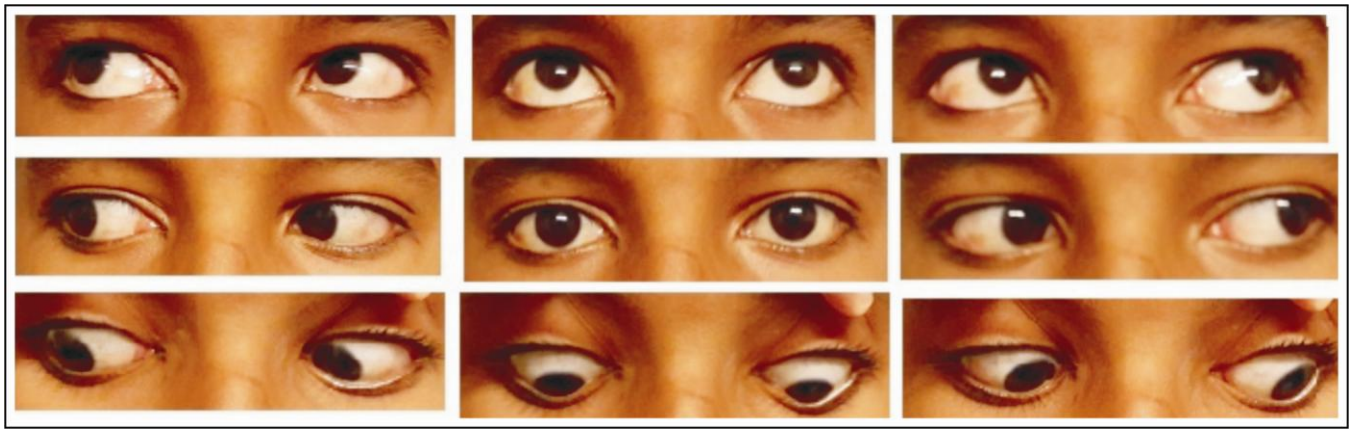

Fig. 3 (B): Postoperatively, he is orthotropic, with resolution of the V-pattern.

DISCUSSION

In our study, we found adjustable strabismus surgery to be highly effective for postoperative satisfactory alignment with a high success rate of 87.1%. The patients experienced no adverse effects or complications during the adjustable procedure, and did not report much discomfort during suture tying. We minimized patient discomfort by putting only one muscle on an adjustable noose knot per procedure, and this too has borne fruitful results. Suture adjustment was needed in the majority of patients postoperatively, amounting to 26 (83.8%) cases, and no adjustment was required for 5 (16.1%) cases, thus indicating the need to fine tune the postoperative alignment to achieve orthotropia and better surgical outcomes, because the nomograms and tables may not be appropriate for each individual case.

Thus, our study findings indicating positive and encouraging outcomes with the adjustable suture technique are consistent with numerous studies worldwide, which report high success rates with the likes of Wisnicki, Repka and Guyton[13], who reported a huge success rate of this adjustable procedure in a massive 290 patients, and rate of reoperation in just 9.7%. Eino et al[14], reported a success rate of 91.7% in 109 patients, and Tripathi et al[15], observed a higher success rate with adjustable versus non-adjustable surgery in 443 total cases. Engel et al[16] reported a high short-term success rate of 88% in their adjustable suture technique in 61 children, and so did Awadein and Guyton[12], with their study on children and infants using propofol anesthesia, who noted a success rate of 79%. Nihalani and Hunter[16] also noted a high success rate for both vertical and horizontal muscle surgery

using a short tag noose technique. Budning et al[17] developed a short adjustable suture with high success in 304 patients. Locally, a study done by Shakir et al[18] at LRBT Free Base Eye Hospital in Karachi, reported a success rate of 88% in 18 exotropic subjects with adjustable technique.

Several other authors Park et al[19] and Bishop et al[20], have contrasting evidence in their reported studies, where they did not find any difference in surgical success, when comparing adjustable versus non-adjustable techniques.

The strengths of our study are its success in terms of surgical results. There are both vertical and horizontal strabismus patients included along with complex cases like consecutive strabismus, DVD, patterns, and one case of a sixth nerve palsy. Transpositions were also performed during surgery on these patients. The surgeries were carried out in a single step to restore ocular alignment, rather than splitting the large alignments at a second stage.

A few limitations of our study are a relatively small sample size, because we wanted to share our early postoperative results, and we do intend to add more patients to this study with time. Strabismus patients are not that frequent in our set up and using this technique on more patients is our priority, for the interest of the patients. Four of our patients did not have a successful postoperative alignment, and we could attribute it to measurement errors[21,22], or muscle abnormalities, hypoplasia or pulley anomalies, which can be assessed preoperatively with neuroimaging[23]. Also early alignment may vary from subsequent long-term alignment, which is more important to the patient especially, and to the operating surgeon, although we have observed them to be quite similar in many of the cases. In addition, we used only one muscle per patient for the adjustable suture technique both to avoid excessive discomfort, and to save time. Others[2] recommend using adjustable sutures on all muscles, except on the inferior oblique, in order to adjust the muscles symmetrically and achieve a balanced alignment between the two eyes. We intend to broaden our experience on adjustable strabismus, to include all cases including children, to offer our patients a better chance of success. Some patients have not returned for a follow up, which we had to exclude from the study, decreasing our eventual total number of cases.

Future work required is a large-scale study with more subjects, which we are recruiting, and assessment of long-term outcomes at one year postoperatively and beyond. Using the adjustable suture on multiple or all muscles may further enhance the success rate of this procedure. Infants and children[12] also need to be given a chance at better postoperative success with the use of propofol anesthesia. Superior oblique adjustment can also be done with this technique, if the need arises to operate on this muscle.

The need arises to encourage strabismus surgeons, to use this adjustable technique to maximize the chances of their surgical success, and to reduce the number of reoperations needed to satisfy the patients.

CONCLUSION

Adjustable strabismus surgery has been found to yield excellent short-term postoperative outcomes in terms of alignment and patient satisfaction. The adjustable suture technique should be considered in all strabismus cases, whether horizontal, vertical or cyclovertical; simple or complex strabismus, and irrespective of the subjects being adults or children.

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