SURGEON'S CORNER

Short Tag Noose Technique for Optional and Late Suture Adjustment in Strabismus Surgery

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Objective: To present and evaluate a new technique that allows the second-stage suture adjustment in strabismus surgery to be skipped or delayed if the immediate postoperative alignment is satisfactory.

Methods: The "short tag noose" technique replaces long sutures with short tags that can be left under the conjunctiva after adjustment. Retrospectively, the medical records of all patients treated by a single surgeon with this approach between January 1, 2005, and December 31, 2008, were evaluated for success rate (≤10 prism diopters [PD] horizontal and ≤6 PD vertical), reoperation rate, and complications.

Results: Of 120 procedures reviewed, 27 (22.5%) were performed in children; 97 procedures (80.8%) were performed in patients with complex strabismus. Mean follow-up was 6 months. The success rate was 81.0% for horizontal strabismus and 70.7% for vertical strabismus at 2 months. The reoperation rate was 10.0% for horizontal strabismus and 19.0% for vertical strabismus. The noose slipped in 1 patient (0.8%) and was corrected by readjustment on day 4. Two patients (1.7%) required in-office excision of cysts or granulomas.

Conclusions: The short tag noose technique simplifies the logistics of suture adjustment and avoids the need for sedation in children who do not require adjustment. It provides the ability to defer adjustment for days after surgery.

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ADJUSTABLE SUTURES ALlow binocular alignment to be refined after strabismus surgery. They are particularly useful in patients in whom the standard strabismus surgical dosages may not apply.[1] The major advantage of adjustable-suture strabismus surgery is that it is believed to reduce the rate of reoperations. However, there are certain limitations of this surgery. The adjustment must be completed, and the sutures must be tied in a second stage, generally within 24 hours of the initial surgical procedure. Patient anxiety is increased, although the discomfort of adjustment is generally minimal. It is difficult to adjust sutures in children because of the challenge of obtaining the cooperation of a child for postsurgical manipulations.[1-5] Adjustable-suture strabismus surgery requires 2 stages of anesthesia in very young, less cooperative children.[6]

Granet et al[7] described a sliding noose technique that allowed for delayed suture adjustment. We evaluated a modification of this technique, which we term the "short tag noose" technique, that allows for delayed suture adjustment in adults and that provides an option of no adjustment in children and adults with satisfactory alignment in the postoperative recovery period. The dual purpose of this study is to describe the technique and to evaluate the outcomes of all patients treated using this technique.

METHODS

A retrospective review of billing records was performed to identify patients who underwent the short tag noose technique at Children's Hospital Boston by a single surgeon (D.G.H.) between January 1, 2005, and December 31, 2008. Institutional review board approval was obtained from Children's Hospital Boston for the study, which was conducted in compliance with the Health Insurance Portability and Accountability Act of the United States. The study population included patients with simple and complex strabismus (eg, reoperation, muscle restriction, nerve palsy, or

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trauma). Patients who did not return for a follow-up visit and patients who had adjustable-suture surgery using other methods were excluded from this study.

All of the patients underwent preoperative assessment to determine the type and amount of deviation. Surgery was performed through a single radial fornix incision through the conjunctiva and the Tenon capsule,[1] keeping the incision as small as possible. Use of a Guyton muscle hook (Katena Eye Instruments, Denville, New Jersey) allowed manipulation of the muscle through a conjunctival incision as small as 0.5 cm. The standard adjustable-suture sliding noose technique was performed using general anesthesia.[1] After the muscle was secured using double-armed 6-0 polyglactin 910 sutures (Vicryl; Ethicon Inc, Johnson & Johnson, Somerville, New Jersey) and was disinserted, the spatulated needles were passed in a "V" configuration through the original insertion. The muscle was drawn up to the original insertion, and the sutures (referred to as "pole sutures") were secured to each other using an overhand knot 10 to 15 cm from the exit site. The extra suture was cut just above the overhand knot. A 5-cm fragment of this extra suture was placed underneath the pole sutures and was wrapped around a second time to apply the adjustable noose. A square knot was tied as tight as possible to ensure a tight noose. The noose was adjusted to place the muscle at the desired location behind the original insertion. Both noose sutures were trimmed to 3 mm (short tag noose). The pole sutures were then clamped with an empty needle holder 2 to 3 mm away from the suture exit, tied on the clamp, and trimmed to allow for an additional 2- to 3-mm recession. All the sutures were buried under the conjunctiva (**Figure 1**). A 6-0 polyester (Mersilene; Ethicon Inc) traction suture was used in most adults for manipulating the globe and retracting the conjunctiva during suture adjustment. In some adult cases and most pediatric cases, no traction suture was used. This allowed for hospital discharge without any suture manipulation in patients with satisfactory alignment. For an adjustable recession, the standard hang-back approach and surgical dosages were used. For an adjustable resection, an extra 1 to 3 mm of muscle was resected, and the muscle was allowed to hang back by the same amount to allow for an increase or decrease in surgical dosage at adjustment.

Patients were assessed in the recovery room 1 to 2 hours after surgery. Topical proparacaine hydrochloride drops were instilled at least 3 times at 2- to 3-minute intervals. Patients were asked to sit without back support on the edge of the bed with their legs dangling. Alignment was assessed with corrective lenses in place, if indicated. Ductions and versions were carefully assessed, and cover testing was performed at distance and near. The general goal of adjustment in patients with esotropia and hypertropia was to achieve orthotropia. One exception was to undercorrect superior oblique palsy in patients who had an inferior oblique weakening procedure combined with a vertical rectus muscle recession. The general goal of adjustment for exotropia was to overcorrect so that the patient was diplopic at distance (esotropia, 5-10 prism diopters [PD]) with no shift at 0.33 m. These target values were not always followed depending on the clinical scenario and surgeon assessment during adjustment.

During the adjustment procedure, to tighten or decrease the recession, the pole sutures were pulled up to draw the muscle to the original insertion while the patient was asked to look toward the muscle. The pole sutures were stabilized using a needle holder clamped in front of the noose, and the noose was slid toward the sclera using a second needle holder (**Figure 2**A). To loosen or increase the recession, the pole sutures were again pulled forward to the original insertion using a needle holder, this time stabilizing the pole sutures by clamping behind the noose. With the second needle holder, the noose was grasped and moved away from the muscle (Figure 2B). The patient was asked to look toward the muscle once the noose was adjusted to retract the muscle posteriorly and force the noose firmly against the sclera.

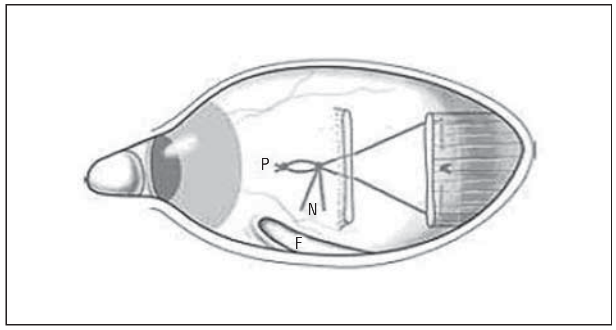

Figure 1. Short tag noose technique at the end of the initial surgical procedure showing the fornix incision (F). Trimmed pole sutures (P) and the trimmed noose (N) are buried under the conjunctiva. Reproduced with permission from Hunter et al.[1]

When the adjustment was performed more than 24 hours after surgery, additional topical anesthetic was applied. The conjunctival incision had typically self-sealed, but it was easily teased open using forceps. With this technique, we did not have any difficulty retrieving the sutures. If the muscle was firmly adherent to the sclera, a muscle hook was used to gently separate the muscle from the sclera. After adjustment, the sutures were again tucked under the conjunctiva.

The main outcome measure was surgical success rate. Horizontal success was defined as residual deviation of 10 PD or less; vertical success was defined as 6 PD or less on the prism and alternate cover test. Secondary outcome measures included reoperation rate and complication rate. The occurrence of potential complications, such as pyogenic granuloma and muscle slippage, was recorded. Patients were recorded as having diplopia if they reported double vision in the primary position at a distance or in the reading position at near. The outcomes were evaluated at the 2-month postoperative visit and at the last documented follow-up visit. We do not have 1- to 2-week follow-up data for most patients because they were not routinely examined. The Fisher exact test was used to compare groups in contingency tables. Differences were considered statistically significant at $P < .05$. Odds ratios (ORs) with corresponding 95% confidence intervals (CIs) were recorded.

Patients undergoing horizontal and vertical surgery in a single procedure were included in both the horizontal and vertical groups and were analyzed independently. Patients adjusted on the day of surgery who were also adjusted 2 days or longer after surgery were included in both the early and late adjustment groups. Patients were contacted by telephone 1 to 2 days postoperatively. Those who reported diplopia or who had concerns about alignment were reexamined. The total amount of adjustment (immediate and delayed) was used for analysis. Surgical success or failure was not tabulated until the 2-month postoperative visit. The late adjustment was always considered a second adjustment because all the patients had an immediate postoperative assessment that could be considered the first adjustment. In the case of a reoperation, the final visit was the last visit before the reoperation. Patients who underwent reoperation were reentered into the study as a second procedure and were analyzed independently.

RESULTS

Of 127 procedures identified, 7 were excluded (3 were adjustable-suture procedures using other methods, 3

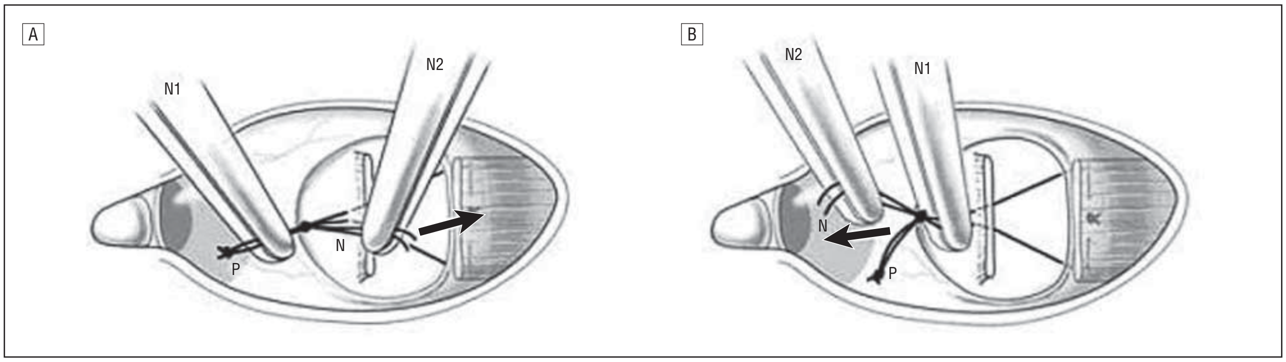

Figure 2. Suture-adjustment technique. A, To tighten or decrease the recession, the pole sutures (P) are used to pull the muscle forward using a needle holder (N1) clamped in front of the noose (N), and the noose is slid posteriorly toward the sclera (arrow) using a second needle holder (N2). B, To loosen or increase the recession, the muscle is pulled forward and then the pole sutures (P) are stabilized by clamping behind the noose (N) using a needle holder (N1). The noose is grasped with the second needle holder (N2) and is moved away from the muscle (arrow).

Table 1. Diagnoses in 97 Patients With Complex Strabismus for Which the Short Tag Noose Technique Was Performed

	Patients, No.			
Type of Strabismus	Horizontal Muscle Surgery Only	Vertical Muscle Surgery Only	Combined Horizontal and Vertical Muscle Surgery	Total[a]
Previous strabismus surgery	34	13	22	**69**
Ocular trauma	9	5	7	**21**
Cranial nerve IV palsy	0	6	4	**10**
Graves disease	1	4	2	**7**
Cranial nerve III palsy	4	0	0	**4**
Cranial nerve VI palsy	2	0	2	**4**
Duane syndrome	2	0	2	**4**
Brown syndrome	0	2	0	**2**

[a] The sum is greater than 97 because some patients had more than 1 diagnosis.

were performed on patients lost to follow-up, and 1 was performed on an adult with a psychiatric disorder who was believed to require adjustment but who was uncooperative for the adjustment procedure and had not adhered to the nothing-by-mouth requirement for sedation). The remaining 120 procedures were performed on 105 patients; 11 patients had 1 reoperation and 2 patients had 2 reoperations. Ninety-three surgical procedures (77.5%) were performed on adults (mean age, 41.3 years; median age, 41.5 years; age range, 14-83 years), and 27 procedures (22.5%) were performed on children 13 years and younger (7.4 years; 8.0 years; 2-13 years, respectively). Twenty-three surgical procedures (19.2%) were performed on patients with simple strabismus, and 97 (80.8%) were performed on patients with complex strabismus. Previous eye muscle surgery and ocular trauma were the most common causes of complex strabismus (**Table 1**). Horizontal strabismus was present in 100 procedures (83.3%), of which 43 (35.8%) were for esotropia and 56 (46.7%) were for exotropia (1 patient had horizontal nystagmus without strabismus). Vertical strabismus was present in 58 procedures (48.3%). The mean duration of follow-up was 6 months (range, 6-110 weeks).

Postoperative adjustment was required in 65 procedures (54.2%). The adjustment was performed on the same day in 56 procedures (46.7%). Adjustment was performed (or repeated) 2 days or longer after surgery in 18 procedures (15.0%).

SUCCESS RATES

At the 2-month postoperative follow-up visit, the success rate was 81.0% for horizontal strabismus and 70.7% for vertical strabismus (**Table 2**). The success rates in patients adjusted 2 days or longer after surgery were not significantly different from the overall rates (horizontal strabismus: OR, 1.9; 95% CI, 0.4-7.8; $P = .40$; vertical strabismus: OR, 0.6; 95% CI, 0.1-3.0; $P = .70$) (Table 2). The success rates at the last follow-up visit were similar to those at the 2-month postoperative visit (Table 2). Diplopia in the primary position was present in 67 patients (55.8%) at the initial examination. Diplopia persisted in 17% of the procedures; 6 of these cases were patients who had a subsequent successful reoperation but in whom the initial procedure did not successfully eliminate diplopia. Other cases of persistent diplopia included incomitant strabismus with improved head posture, recurrent strabismus secondary to Graves disease, and central fusion disruption in patients who had surgery in hopes of recovering stereopsis by improving alignment.[8]

No significant difference was noted in success rates between children and adults at the 2-month or final follow-up visit (horizontal strabismus: OR, 0.5; 95% CI, 0.2-1.4; $P = .20$; vertical strabismus: OR, 0.9; 95% CI, 0.2-3.4; $P > .99$) (**Table 3**). The success rates were also similar in simple and complex strabismus at the 2-month and final follow-up visits (horizontal strabismus: OR, 0.6; 95%

Table 2. Success and Reoperation Rates Based on Timing of Suture Adjustment[a]

Variable	Success Rates at 2-mo Postoperative Visit		Success Rates at Final Postoperative Visit		Reoperation Rates	
	Horizontal Strabismus	Vertical Strabismus	Horizontal Strabismus	Vertical Strabismus	Horizontal Strabismus	Vertical Strabismus
Not adjusted	49/58 (84.5)	23/30 (76.7)	48/58 (82.8)	23/30 (76.7)	3/58 (5.2)	5/30 (16.7)
Adjusted						
Early	25/32 (78.1)	10/18 (55.6)	23/32 (71.9)	11/18 (61.1)	6/32 (18.8)	4/18 (22.2)
Late[b]	7/10 (70.0)	8/10 (80.0)	5/10 (50.0)	7/10 (70.0)	1/10 (10.0)	2/10 (20.0)
Subtotal	**32/42** (76.2)	**18/28** (64.3)	**28/42** (66.7)	**18/28** (64.3)	**7/42** (16.7)	**6/28** (21.4)
Total	**81/100** (81.0)	**41/58** (70.7)	**76/100** (76.0)	**41/58** (70.7)	**10/100** (10.0)	**11/58** (19.0)

[a] Horizontal success was defined as residual deviation of 10 prism diopters (PD) or less, and vertical success was defined as 6 PD or less on the prism and alternate cover test. Data are given as number (percent).
[b] Late-adjusted patients were adjusted 2 days or more after surgery.

Table 3. Success and Reoperation Rates Based on Age, Complexity, and Type of Strabismus[a]

Variable	Success Rates at 2-mo Postoperative Visit		Success Rates at Final Postoperative Visit		Reoperation Rates	
	Horizontal Strabismus	Vertical Strabismus	Horizontal Strabismus	Vertical Strabismus	Horizontal Strabismus	Vertical Strabismus
Children	18/25 (72)	9/13 (69)	16/25 (64)	10/13 (77)	3/25 (12)	2/13 (15)
Adults	63/75 (84)	32/45 (71)	60/75 (80)	30/45 (67)	8/75 (11)	9/45 (20)
Simple strabismus	14/19 (74)	7/8 (88)	12/19 (63)	6/8 (75)	3/19 (16)	3/8 (37)
Complex strabismus	67/81 (83)	33/50 (66)	63/81 (78)	34/50 (68)	8/81 (10)	7/50 (14)
Esotropia	34/43 (79)	NA	33/43 (77)	NA	5/43 (12)	NA
Exotropia	45/56 (80)	NA	41/56 (73)	NA	5/56 (9)	NA

Abbreviation: NA, not applicable.
[a] Horizontal success was defined as residual deviation of 10 prism diopters (PD) or less, and vertical success was defined as 6 PD or less on the prism and alternate cover test. Data are given as number (percent).

CI, 0.2-1.9; $P = .30$; vertical strabismus: OR, 3.5; 95% CI, 0.4-30.8; $P = .40$) (Table 3). There was no significant difference in success rates for esotropia vs exotropia (OR, 1.0; 95% CI, 0.3-2.5; $P > .99$) (Table 3).

REOPERATION RATES

The overall reoperation rate was 15.0% (18 of 120 procedures). The reoperation rate was 10.0% for horizontal strabismus and 19.0% for vertical strabismus (Table 2). There were no significant differences in reoperation rates for children vs adults (horizontal strabismus: OR, 1.2; 95% CI, 0.3-4.8; $P > .99$; vertical strabismus: OR, 0.8; 95% CI, 0.1-4.0; $P > .99$), simple vs complex strabismus (horizontal strabismus: OR, 1.7; 95% CI, 0.4-7.3; $P = .40$; vertical strabismus: OR, 3.8; 95% CI, 0.7-19.4; $P = .10$), or esotropia vs exotropia (OR, 1.3; 95% CI, 0.3-4.8; $P = .80$) (Table 3). Some patients with complex strabismus technically met the criteria for success but still required reoperation. Some of these patients had symptomatic strabismus away from the primary position, whereas in others, a small remaining vertical misalignment was readdressed at the time of horizontal surgery.

POSTOPERATIVE DRIFT

Postoperative drift was similar in patients with esotropia and exotropia (**Table 4**). Patients with esotropia were more likely to have esotropic drift (20 of 43 patients [46.5%]) than exotropic drift (15 of 43 patients [34.9%]), whereas patients with exotropia were more likely to have exotropic drift (37 of 55 patients [67.3%]) than esotropic drift (10 of 55 patients [18.2%]) (OR, 0.2; 95% CI, 0.1-0.5; $P < .001$). Mean vertical drift was less than mean horizontal drift (Table 4). Of 55 patients with vertical strabismus, 27 (49.1%) had a decreasing effect and 18 (32.7%) had an increasing effect of surgery during follow-up.

COMPLICATIONS

Although patient discomfort during adjustment was not routinely recorded, our impression was that patients seemed to be more uncomfortable if adjustment was performed more than 24 hours after surgery. At the 2-month postoperative visit, mild hyperemia and conjunctival thickening were typically still visible over the sutures. Although it was not quantified in this study, it was slightly more prominent than observed in patients who underwent sliding noose adjustment who had not had the additional suture material left behind. This redness and thickening disappeared within 3 to 6 months after surgery. A cyst or pyogenic granuloma required excision in 2 patients (1.7%). A slipped muscle was noted in 1 patient (0.8%) owing to slippage of the sliding noose. The patient noted recurrence of diplopia on

Table 4. Postoperative Drift in Patients With Horizontal and Vertical Strabismus

Variable	Patients, No.	2-mo Postoperative Visit		Final Postoperative Visit	
		Mean (SD) Drift, PD	Median Drift, PD	Mean (SD) Drift, PD	Median Drift, PD
Horizontal strabismus: ET[a]					
No drift	8	NA	NA	NA	NA
Increasing effect (XT)	15	−11.5 (18.4)	−5.0	−11.6 (19.5)	−3.0
Decreasing effect (ET)	20	8.4 (8.0)	5.5	9.3 (7.5)	7.0
Horizontal strabismus: XT[a]					
No drift	8	NA	NA	NA	NA
Increasing effect (ET)	10	11.5 (13.8)	4.5	13.3 (16.1)	5.5
Decreasing effect (XT)	37	−11.7 (11.4)	−7.0	−12.2 (13.9)	−7.0
Vertical strabismus[b]					
No change	10				
Increasing effect	18	5.4 (4.4)	4.0	7.7 (7.6)	5.5
Decreasing effect	27	6.2 (5.0)	4.0	6.7 (6.2)	5.0

Abbreviations: ET, esotropia; NA, not applicable; PD, prism diopter; XT, exotropia.
[a] The immediate postoperative deviation was not recorded in 1 patient with XT; hence, mean and median drift were calculated for 43 patients with ET and 55 with XT.
[b] The immediate postoperative deviation was not recorded in 3 patients; hence, mean and median drift were calculated for only 55 patients.

day 3; this was corrected with adjustment in the office on day 4.

COMMENT

We describe a modification of the existing techniques of adjustable-suture strabismus surgery,[2-6,9-16] which we call the short tag noose adjustable technique. Saunders and O'Neil[11] devised a technique in which postoperative knot tying was required only in patients who underwent adjustment. The main disadvantage of their technique was that the suture ends had to be trimmed and buried under the conjunctiva even in patients who did not require adjustment. Engel and Rousta[4] described a technique in which the second stage of manipulation was entirely avoided if adjustment was not needed. Only children who needed adjustment required exploration of the incision. Eustis et al[17] described a technique in which the ends of absorbable pole sutures were tied with a knot that consisted of a double throw followed by a bow. The sutures were left in the subconjunctival space to dissolve spontaneously if adjustment was not required. Kipioti et al[9] and Nguyen et al[18] also described variations in the bow-tie technique to eliminate a second procedure if adjustment was deemed unnecessary. Coats[19] described a technique in which he passed a "ripcord" suture around the muscle suture, pulling the muscle forward approximately 2 mm. The ripcord suture was cut in those who were undercorrected, allowing for an additional 2 mm of recession. Hakim et al[5] described a modification of this technique using a releasable suture, which was removed to allow for additional recession. Both of these techniques allowed extra recession but no advancement. Granet et al[7] described a sliding noose technique similar to ours that allowed for delayed adjustment, but they did not use this technique in children.

The short tag noose technique is a further extension of many of these methods specifically devised to allow the option of no adjustment or delayed adjustment. It uses the standard cinch or sliding noose technique of muscle reattachment. It allows for additional recession and advancement in horizontal and vertical muscles. A notable advantage of this technique in children is that the second stage of sedation may be skipped if no adjustment is required. In adults, it gives the eye muscles a longer time to recover from surgical manipulation and provides the binocular visual system more time to adjust to the new eye position; that is, the extra time allows the alignment and binocular vision to settle before adjustment. This allows patients with, for example, diplopia from anomalous retinal correspondence, to have time to adjust to their new binocular status before the alignment is finalized and for readjustment in patients with fat adherence syndrome in whom the alignment may shift days after surgery. For logistic convenience, we found it satisfactory to determine who should return for readjustment via a 1- to 2-day postoperative telephone call in most cases; however, surgeons who adopt this technique may want to schedule a routine postoperative visit 5 to 7 days after surgery. There are certain disadvantages of this technique. There is a potential for slippage of the noose due to lack of a permanent knot. There is increased suture material with the potential for increased postoperative inflammation or discomfort. We also found that patients reported greater discomfort when suture adjustment was performed more than 1 day after surgery, but we subsequently found that subconjunctival infusion of 1 mL of lidocaine hydrochloride, 2% (Xylocaine; AstraZeneca, Wilmington, Delaware) at adjustment reduces or eliminates this discomfort.

Many factors contribute to binocular alignment in the long term. After surgery, there is a period of adjustment and healing that lasts for approximately 2 months. The ideal adjustable-suture method would allow for modifications to alignment throughout this period. Even with techniques such as ours that provide the ability to delay suture adjustment for days after surgery, many patients demonstrate continued postoperative drift in subsequent weeks. Surgeon experience with this drift informs the decisions that are made at the time of adjustment. Changes that occur beyond 2 months probably do not reflect the surgery itself but rather the course of the underlying condition. We, therefore, believe that the best time to assess the effect of surgery is 2 months postoperatively.

Studies of strabismus surgery have chosen various success criteria that vary depending on the reason for surgery; for example, a patient with diplopia might have success only if the residual angle is 0 PD, whereas a patient with an angle kappa might have a successful outcome despite a 20-PD measurement. The ideal criteria would incorporate patient satisfaction, reoperation rate, and postoperative angle in the context of the reason for pursuing surgery. In this retrospective study, patient satisfaction was not documented consistently, so we used only reoperation rate and postoperative angle. For the horizontal angle, we selected 10 PD or less in the primary position, as used by several other investigators, including Dawson et al,[3] Engel and Rousta,[4] Hakim et al,[5] and Eustis et al.[17] Note that in 12 of 100 of the present horizontal procedures, the final deviation was 10 PD at 2 months. Of these, only 1 required reoperation for an angle greater than 10 PD at the final visit. For the vertical angle, we could find no predecessor in the literature but chose 6 PD or less because it would generally give a satisfactory appearance and allow for fusion with a small compensatory head posture in patients with incomitant strabismus.

To provide a realistic assessment of the performance of the procedure in a referral practice, we included adults and children of all ages and patients with complex strabismus that includes reoperations, nerve palsy, and trauma. Surgical outcomes were evaluated at the 2-month postoperative visit and at the last documented follow-up visit. The success rates of the short tag noose technique were comparable with those reported using other methods.[2-4,6,9,17,18] Most of these studies excluded vertical muscle surgery. Dawson et al[3] had 5 of 45 patients who underwent surgery for vertical strabismus, but they did not report the results of vertical muscle surgery separately. The results of delayed suture adjustment seem to be comparable with the surgical outcomes in other studies.

To minimize the amount of remaining suture material while allowing for a reasonable amount of adjustment, suture ends were trimmed to permit a 2- to 3-mm recession. In cases of high uncertainty, the sutures were left long and were converted to the short tag noose configuration only after the immediate postoperative adjustment. Eustis et al[17] observed postoperative complications such as more tissue response, suture granuloma, and subconjunctival infection owing to the greater amount of suture material left behind at the end of surgery. In the present study, although we observed more tissue response transiently (especially in first operations), only 1% of patients required removal of a conjunctival cyst after surgery, and we did not observe any conjunctival infections.

Bleik and Karam[20] found mean (SD) horizontal postoperative drift of 7.2 (4.3) PD during the first 24 hours after surgery, but this was compared with the alignment immediately on emergence from anesthesia, when patients would not have been fully alert. They suggested that this postoperative drift should be considered if the adjustment is to be made in the immediate postoperative period. Our patients were not assessed until they were fully alert, at least 1 hour after they emerged from anesthesia, and it is likely that the alignment would have stabilized by that time. Eino and Kraft[21] found postoperative drift to be higher in exotropia compared with esotropia. We observed a similar trend in our patients, even in those adjusted 2 days or longer after surgery. This is the first study, to our knowledge, to evaluate vertical drift after adjustable-suture eye muscle surgery.

This study is a retrospective review. A prospective randomized controlled trial comparing standard strabismus surgery, adjustable suture surgery, and the short tag noose technique would have been ideal. A larger sample size with longer follow-up would have been desirable. Another drawback is the lack of prospective assessment of pain in patients undergoing early and late adjustment.

In conclusion, the short tag noose technique simplifies the logistics of suture adjustment in patients who have satisfactory alignment after strabismus surgery and avoids the second stage in children who do not require adjustment. The ability to delay the adjustment for days after surgery provides an option of additional intervention in patients who develop unexpected shifts in alignment in the days after surgery.

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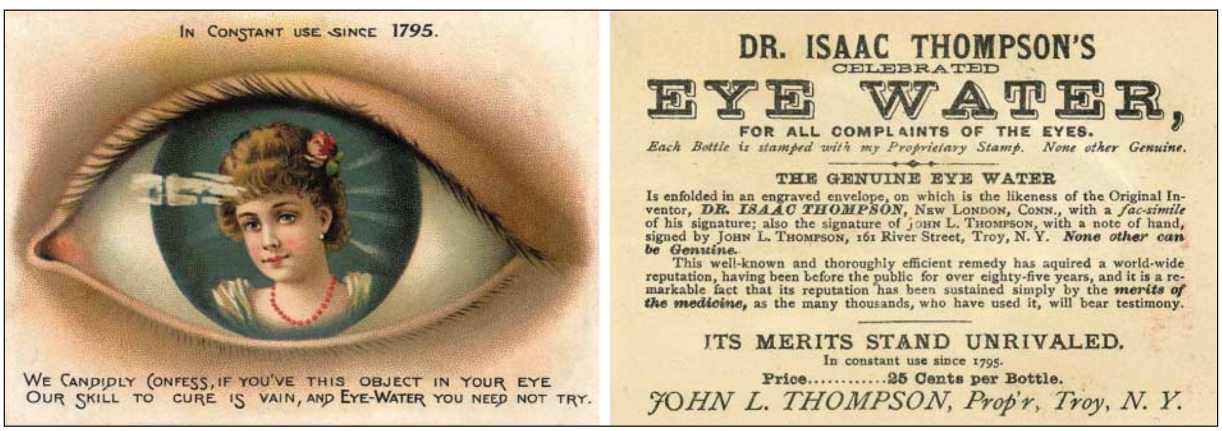
REFERENCES

1. Hunter DG, Dingeman RS, Nihalani BR. Adjustable sutures in strabismus surgery. In: Wilson ME, Saunders RA, Trivedi RH, eds. *Pediatric Ophthalmology: Current Thought and a Practical Guide.* Heidelberg, Germany: Springer; 2008:213-226.
2. Chan TK, Rosenbaum AL, Hall L. The results of adjustable suture technique in paediatric strabismus surgery. *Eye.* 1999;13(pt 4):567-570.
3. Dawson E, Bentley C, Lee J. Adjustable squint surgery in children. *Strabismus.* 2001;9(4):221-224.

4. Engel JM, Rousta ST. Adjustable sutures in children using a modified technique. *J AAPOS*. 2004;8(3):243-248.
5. Hakim OM, El-Hag YG, Haikal MA. Releasable adjustable suture technique for children. *J AAPOS*. 2005;9(4):386-390.
6. Awadein A, Sharma M, Bazemore MG, Saeed H, Guyton D. Adjustable suture strabismus surgery in infants and children. *J AAPOS*. 2008;12(6):585-590.
7. Granet DA, Banuelos LR, Wang G, et al Adjustable sutures for delayed adjustment or no procedure. Paper presented at: American Association for Pediatric Ophthalmology and Strabismus Annual Meeting; March 22, 2001; Orlando, FL.
8. Reddy SK, Salgado CM, Hunter DG. Central fusion disruption following irradiation of neoplasms in the pineal region. *Arch Ophthalmol*. 2009;127(3):337-338.
9. Kipioti A, George ND, Taylor RH. Tied and tidy: closing the conjunctiva over adjustable sutures. *J Pediatr Ophthalmol Strabismus*. 2004;41(4):226-229.
10. Ogüt MS, Onal S, Demirtas S. Adjustable suture surgery for correction of various types of strabismus. *Ophthalmic Surg Lasers Imaging*. 2007;38(3):196-202.
11. Saunders RA, O'Neil JW. Tying the knot: is it always necessary? *Arch Ophthalmol*. 1992;110(9):1318-1321.
12. Spierer A. Adjustment of sutures 8 hours vs 24 hours after strabismus surgery. *Am J Ophthalmol*. 2000;129(4):521-524.
13. Strominger MB, Richards R. Adjustable sutures in pediatric ophthalmology and strabismus. *J Pediatr Ophthalmol Strabismus*. 1999;36(3):112-117, quiz 134-135.
14. Thacker NM, Velez FG, Rosenbaum AL. Combined adjustable rectus muscle resection–recession for incomitant strabismus. *J AAPOS*. 2005;9(2):137-140.
15. Tripathi A, Haslett R, Marsh IB. Strabismus surgery: adjustable sutures: good for all? *Eye*. 2003;17(6):739-742.
16. Velez FG, Chan TK, Vives T, et al. Timing of postoperative adjustment in adjustable suture strabismus surgery. *J AAPOS*. 2001;5(3):178-183.
17. Eustis HS, Elmer TR Jr, Ellis G Jr. Postoperative results of absorbable, subconjunctival adjustable sutures. *J AAPOS*. 2004;8(3):240-242.
18. Nguyen DQ, Hale J, Von Lany H, Harrad RA. Releasable conjunctival suture for adjustable suture surgery. *J Pediatr Ophthalmol Strabismus*. 2007;44(1):35-38.
19. Coats DK. Ripcord adjustable suture technique for use in strabismus surgery. *Arch Ophthalmol*. 2001;119(9):1364-1367.
20. Bleik JH, Karam VY. Comparison of the immediate with the 24-hour postoperative prism and cover measurements in adjustable muscle surgery: is immediate postoperative adjustment reliable? *J AAPOS*. 2004;8(6):528-533.
21. Eino D, Kraft SP. Postoperative drifts after adjustable-suture strabismus surgery. *Can J Ophthalmol*. 1997;32(3):163-169.

Ophthalmological Ephemera

In 1795, Dr Isaac Thompson concocted an eye water of zinc sulfate, saffron, camphor, and rose water. It was sold as late as 1939. This is 1 of a series of 32 medical trade cards advertising the product from 1875 through 1895.



Courtesy of: Daniel M. Albert, MD, MS