

Single-Stage Adjustable Strabismus Surgery for Restrictive Strabismus

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Purpose: To evaluate the feasibility and stability of ocular alignment of single-stage adjustable strabismus surgery (SSASS) in restrictive strabismus. **Methods:** This was an observational case series comprising 12 patients with restrictive strabismus (mean age, 54.8 years) who were treated with SSASS using intravenous midazolam, fentanyl, and topical anesthesia. All were studied in a retrospective institutional manner. The refractive strabismus in 7 patients was caused by dysthyroid orbitopathy. Five patients had undergone previous ocular surgery, and 4 had undergone previous strabismus surgery. SSASS typically involved the vertical rectus muscles. Horizontal rectus muscles were adjusted when necessary. Silicon-treated polyester suture material (Ti-cron; United States Surgical, Norwalk, CT no longer available), 6-0, were used for inferior rectus recessions. Ocular alignment was set at ortho at the end of surgery and evaluated at 2 days, 6 weeks, and 3 months after surgery. The typical hang-back procedure was to lock the suture at the middle and edges of the tendon or muscle at the intended disinsertion point. The tendon was then disinserted and hung back from the original insertion with adjustments until the desired position (ortho) and single vision were attained. **Results:** All patients remained comfortable throughout surgery and had no significant postoperative discomfort. All patients except 2 (16.6%) maintained satisfactory vertical alignment (<2 prism diopters). These 2 patients with dysthyroid orbitopathy had progressive overcorrection after inferior rectus recession. **Conclusions:** SSASS, using intravenous midazolam, fentanyl, and topical anesthesia, is a safe and precise alternative treatment for patients with restrictive strabismus including those with dysthyroid orbitopathy. (J AAPOS 2003;7:358–362)

Precise ocular alignment is desirable in all strabismus surgery, especially in adults with diplopia. Although fusional reserves can overcome small overcorrections or undercorrections in the horizontal plane, cases involving vertical deviations are more demanding. Adjustable strabismus surgery has been useful in such cases, but is usually performed as a two-stage adjustment procedure.¹⁻⁶ This entails an extra visit or a prolonged stay in the hospital for the secondary phase of adjustment.⁷ It also requires the strabismologist to meet the following challenges: (1) perform ocular manipulations on an apprehensive, alert, and anxious patient (2) with risk of oculocardiac reflex and other vagal responses^{8,9} (3) without the supervision of an anesthesiologist (4) outside the operating room setting. Single-stage strabismus surgery, in which intraoperative adjustment is done, obviates these problems

and has been found to be useful.¹⁰⁻¹⁶ However, most reported cases, except for one study,¹⁵ involve horizontal strabismus.

We review the results of 12 cases of restrictive strabismus and discuss the feasibility and stability of ocular alignment after single-stage adjustable strabismus surgery (SSASS) using topical and dissociative anesthesia. The ease of the technique prompts the report.

DESIGN AND METHODS

This was an observational case series of 12 patients with restrictive strabismus. A retrospective review was done of all patients with restrictive strabismus who underwent SSASS while under the effect of dissociative anesthesia—using intravenous (IV) midazolam, fentanyl, and topical anesthesia—in the year 2000. All patients were followed-up for 3 months or longer. Twelve patients qualified for the review (Table 1). All patients were adults (mean age, 54.8 years; range, 30 to 73), 5 women and 7 men. Seven patients had dysthyroid orbitopathy, and 4 had undergone previous extraocular muscle surgery: 1 each for retinal detachment, strabismus (three procedures), orbital surgery for removal of optic nerve sheath meningioma, removal of conjunctival melanoma, and posttraumatic blow-out fracture. All patients had been noted to have stable ocular deviations for 3 consecutive monthly visits before surgery. The vertical deviations ranged from 5 to 75 prism diopters (PD), and horizontal deviations ranged

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TABLE 1. Diagnosis, surgery, and preoperative and postoperative deviations*

Patient No.	Age (yr)/Sex	Diagnosis	Preoperative Deviation	Surgery Performed	Postoperative Deviation		
					Two Days	Six Weeks	Three Months
1	73/F	Dysthyroid R with XT	15XT, 4RHT	RLRr 5 LIRr 1.5	H-O, V-O	3(X) V-)	4(X) V-O
2	50/M	Blow-out fracture R	5(X), 5RHT, 14RHT(DG)	LIRr 1.5	H-O V-O	H-O V-O	H-O V-O
3	73/M	Conjunctival melanoma excision L	6ET, 5LHT	LMRr 3.5 RIRr 1.5	H-O V-O	2(X) V-O	5(E) 2L(H)
4	57/F	Dysthyroid R	75RHT	LIRr 5 RSRr 6	8(X) 7LHT	H-O 12LHT	H-O 12LHT
5	55/M	Dysthyroid L	25LHT	LSRr 7	H-O V-O	H-O V-O	H-O V-O
6	43/F	Postorbitotomy for ON sheath meningioma R	20XT, 30RHT	RIRr 5, RSOt	H-O V-O	H-O V-O	H-O V-O
7	58/M	Post-RD surgery L	6XT, 9LHT	RIRr1	H-O V-O	H-O V-O	H-O V-O
8	51/M	Dysthyroid L	12ET, 44RHT	RSRr 8 LMRr 8 LIRr 9	H-O V-O	H-O V-O	H-O V-O
9	46/F	Dysthyroid L	9LHT, 16LHT(DG)	RIRr 5.5	3(X), V-O	2(X) 1R(H)	H-O 2R(H)
10	60/M	Dysthyroid XT	55XT	RLRr 7 LLRr 7	H-O V-O	H-O V-O	H-O V-O
11	62/M	Dysthyroid L	19LHT	RIRr 4.5	H-O V-O	H-O V-O	H-O 15RHT
12	30/F	Post-strabismus surgery ET	30ET A-pattern	RMRr 4s LMRr 5s	H-O V-O	H-O V-O	H-O V-O

DG, downgaze; (E), esophoria; ET, esotropia; F, female; (H), hyperphoria; H-O, horizontal orthophoria; HT, hypertropia; IR, inferior rectus; L, left; LR, lateral rectus; M, male; MR, medial rectus; ON, optic nerve; R, right; r, recession; RD, retinal detachment; s, vertical offset 8 mm; SO, superior oblique; SR, superior rectus; t, tenotomy; V-O, vertical orthophoria; (X), exophoria; XT, exotropia. *Numbers indicate deviation in prism diopters and millimeters of recession (r) performed during surgery.

from 5 to 55 PD. One surgeon (RDR) performed all of the surgeries. The study was approved by the Wills Eye Hospital Institutional Review Board.

Anesthesia Procedure

Povidone-iodide and 2% lidocaine gel were instilled in the eyes before surgery. The eyes were prepared and draped per standard hospital protocol such that both eyes were exposed. All patients received nasal oxygen and cardiac monitoring, including pulse oximetry, throughout surgery. Intravenous midazolam was injected (1- to 2-mg boluses at approximately 15 µg/kg) at the initiation of surgery and intermittently, as required, to keep the patient comfortable and conscious. Initially, fentanyl citrate, 1 to 2 µg/kg, was administered and repeated, if required, to maintain adequate analgesia. Glycopyrrholate or atropine, 0.4 mg, was given to prevent oculocardiac or vagal responses. Ondansetron, metoclopramide, and ranitidine were administered when indicated for nausea or vomiting. Before the conjunctival incision was made, 0.1 mL of 50:50 carbocaine and bupivacaine was injected subconjunctivally at the incision site close to the limbus. One 7-0 silk traction suture with rubber band was passed in the limbus as ap-

propriate for best exposure. The rubber band acted as a shock absorber when used for traction and helped the surgeon to avoid making sudden tugs, which are often painful for the patient. Incision was limbal with radial extensions.

Adjustment Procedure

An accommodative target, ie, a cross with readable letters, was projected directly onto the ceiling approximately 7 feet from the eyes. When fixation was desired, the overhead light was directed toward the ceiling target. During the operative procedure a sterile, soft plastic shield covered the cornea of the operated eye, and the eyelid covered the other eye. A surgeon's headlight alone was used for illumination during surgery to prevent bleaching of the macular pigment. No mydriatic drops were used. The anesthetic drops without preservatives were used on the conjunctiva sparingly but avoided on the cornea to minimize keratopathy.

In a separate unpublished study of six patients with strabismus, we measured the ocular deviations in supine patients in the operating room before and 3 minutes after administering midazolam and fentanyl (bolus dose) intra-

venously. We found no difference in the horizontal or vertical deviations in any of the patients. In two patients, transient downbeat nystagmus (probably midazolam-induced) developed within the first 2 minutes and lasted for another 2 minutes, but the patients did not experience oscillopsia. We concluded that midazolam or fentanyl, in the doses used by us, did not induce changes in ocular deviations.

Absorbable 6-0 polyglactin suture material (Vicryl; Ethicon, Somerville, NJ) was used for the muscles except in cases of inferior rectus recession, for which 6-0 nonabsorbable silicone-treated polyester (Ti-cron) sutures were used. The suture ends were left long with needles attached to facilitate adjustment after tying the bowknot. In cases involving surgery on more than one muscle (ie, one horizontal in one eye and one vertical in the other eye), both eyes' muscles were kept adjustable until the final adjustment was completed. Several adjustments were often required until the patient saw one single image in both of the dimensions and the alignment was confirmed with cover test and alternate cover test. Patients with A-V patterns or incomitance in lateral versions or upgaze and downgaze were tested in the respective positions with the head suitably turned. Each time after adjustment, the patient was asked to look to either side to correct any slack of the muscle or sutures. Because patient comfort is related to effective surgical technique, an appropriate drug was injected intravenously when the patient felt any discomfort or nausea. Pulling on the muscle is painful. In this technique we used gentle traction on adjacent tissues to expose the muscles and their insertions, paying particular attention to avoid any sudden traction. Good exposure is essential, and a head light with loupes is helpful. Gas-sterilized spectacle fronts were placed and removed, without disrupting the sterile field, for patients who required prescription glasses to see the target. (Temples were removed before sterilization, and the sterile fronts were placed appropriately. The fronts remained in place for measurements because the patient was lying down throughout the procedure.) Part of the preoperative workup was to measure the amount of strabismus with the patient in the sitting and supine positions. No differences were found. All cases were followed up initially on the second to fifth day, again after 3 weeks, and last after 3 months.

RESULTS

All patients remained cooperative and comfortable throughout the procedure. All except two were phoric or within 5 PD and fused well for both vertical and horizontal deviation on repeated follow-up examinations (Table 1). The two patients (nos. 4 and 11) who showed progressive overcorrection after inferior rectus recession (POAIRR) underwent surgery for treatment of dysthyroid orbitopathy. In patient no. 4, overcorrection was evident on the second postoperative day; in the other patient, overcorrection was seen at the 3-month visit. Two other patients had

recurrence of vertical deviation of approximately 2 PD, but they were comfortable without any aid. All other patients had vertical and horizontal orthotropia/orthophoria until the last follow-up visit, which was at least 3 months after surgery for all patients; however, in some patients residual orthophoria/orthotropia continued for longer than 1 year.

DISCUSSION

Jampolsky's¹⁷ statement—"Not all procedures are entirely new . . . rekindling and modification of older techniques, wedded to newer knowledge and techniques, allow the surgical goal of balanced alignment and balanced rotation with a minimal number of surgical procedures"—is apt. The surgical goal should be attainable either during or soon after surgery by a single-stage or two-stage adjustable procedure. Adjustable surgery has decreased the reoperation rate^{3,4} and increased the accuracy of success rate from 70% to 80% to 90% to 94%.^{18,19} It has also led to earlier rehabilitation of patients with diplopia and increased the confidence of strabismologists as well as patients, especially those whose troublesome diplopia remains despite undergoing several procedures.

Two-stage adjustable surgery is done more often after either general anesthesia or peribulbar injection has been administered for the first procedure.^{1-6,17} The timing of postoperative adjustment has been studied, and no significant difference has been found between adjustment done postsurgically at 5 to 6 hours or after 14 hours.^{20,21} However, in a rabbit model a significant relationship was seen between the time of adjustment and the peak force required for adjustment.²² The peak force required to advance the muscle 3 mm at 48 hours was greater (103 g \pm 5 g) than at 24 hours (60 g \pm 4 g, $P = .04$); less at 6 hours (37 g \pm 10 g, $P = .003$); and least at 15 minutes (14 g \pm 5 g, $P = .0002$). This indicates a definite difference between single-stage and two-stage adjustment procedures. Attempts have been made to modify the healing response to allow for delayed adjustments.²³ A two-stage procedure entails the problems of (1) operating on an apprehensive and anxious patient with (2) risk of vagal responses and oculocardiac reflexes and (3) without the availability of the anesthesia facility and staff. If adjustment is made on the same day, it may prolong the patient's hospital stay; if it is done on a subsequent day, it will mandate a second visit by the patient. Adjustment is known to lead to unintended overnight hospital stays in 7.9% cases, especially as a result of nausea and bilateral patching.⁷ The irritation caused by long suture ends, which remain in place until adjustment is made, is also a nuisance for the patient. There is also a risk of the suture cutting through or slipping out of the muscle during adjustment, which may be difficult to manage in the office setting.

An SSASS procedure is advantageous, but the presence of restrictive strabismus, in general, and conditions such as dysthyroid orbitopathy, specifically, have been considered

to be relative contraindications.¹ Although most of the single-stage procedures reported have involved horizontal muscles,^{10-14,16} this approach has also been found effective for vertical strabismus.¹⁵ In our experience, with the use of midazolam and fentanyl and with minimal use of local anesthetic agents, it is feasible to perform single-stage adjustments in all adult patients irrespective of the muscles involved. Certain considerations must be noted, however. The adjustment is done with the patient in the supine posture and with a fixation target projected onto the ceiling. It is important that the target control accommodation and be at least 7 feet from the eyes (limitation due to ceiling; the accommodation requirement for a target at 7 feet is < 0.5 D). The room illumination should be similar to that of an office because too much or too little illumination could alter horizontal deviations. The pupil should not be dilated during the procedure, thus restricting the use of phenylephrine or epinephrine to avoid glare. Corneal shields should be used to protect the cornea and prevent the macula from bleaching. If the patient requires prescription glasses for best vision, the glasses should be available after they are sterilized. Between each adjustment, the patient should be asked to look in different directions to offset any slack introduced during adjustment. Because sedation can alter the tonic position, the patient should be fully conscious during adjustments. The use of local anesthetic agents can paralyze the muscles, so no local anesthetic should be injected close to the muscle; even topical anesthetic use should be minimized after the conjunctival incision is made. We injected 0.1 mL anesthetic subconjunctivally close to the limbus at the incision site, and doing so did not affect deviation.

The stability of ocular alignment for two-stage or single-stage adjustable procedures is well documented.^{1-6,10-16} It has generally been observed that the variation is 3.0 to 8.8 PD in horizontal deviations and 1.2 to 5.5 PD in vertical deviations.¹⁵ In special reference to vertical deviations, POAIRR has been a serious concern when inferior rectus recession is performed.²⁴ In a series of 67 patients, 21% developed POAIRR; these included 9 of the 18 patients (50%) with dysthyroid orbitopathy.²⁴ In our series, the 2 patients who developed POAIRR also had dysthyroid orbitopathy, but our incidence was 28.5% (2 of 7). This difference may be related to the use of nonabsorbable suture material (6-0 silicone-treated polyester) instead of the 6-0 polyglactin used in the previous study. Sprunger and Helveston²⁴ suggested using tandem double-armed 5-0 polyglactin to solve this problem. In another study in which undercorrection of approximately 4 to 6 PD was planned, 2 patients with dysthyroid orbitopathy developed a drift of 6 PD and 8 PD, respectively, by the 3-month follow-up visit.²⁵ This late overcorrection is not caused just by progressive thyroid disease because it has also been seen in patients without thyroid disease.²⁶ Various causal factors have been suggested. A tight superior rectus muscle on the same side as POAIRR would cause the inferior

rectus to work against resistance, and it may slip in the initial phase of healing. These investigators therefore suggested that if the superior rectus muscle is tight, it should also be recessed.²⁷ A tight inferior rectus muscle in the other eye has also been implicated because the superior rectus muscle of the nonoperated eye would work against resistance, and the superior rectus muscle of the operated eye would receive extra innervation based on Hering's law, thus causing chronic tightness and preventing proper healing of the inferior rectus muscle. These investigators also suggested recessing the other inferior rectus muscle in cases of bilateral asymmetry.²⁴ In our patients, any vertical rectus that was tight and causing diplopia in any gaze was adjusted. This flexibility is one great advantage of single-stage adjustable surgery. However, the development POAIRR may simply be caused by Bell's phenomenon and may be better controlled using coated, nonabsorbable suture material.

Recently, propofol has been described as safe to use for single-stage adjustable surgery.²⁸ However, of the seven cases described only one patient underwent inferior rectus recession, and another underwent inferior oblique recession. The rest of the surgeries involved horizontal rectus muscles. In a study comparing propofol with midazolam for sub-Tenon's injection in strabismus surgery, it was found that the degree of discomfort felt by the patient was less when midazolam was used.²⁹ Propofol is also known to be painful when it is injected intravenously. Moreover, some studies show no difference between propofol and thiopental with regard to postoperative nausea and vomiting.³⁰ Midazolam has the least effect on oculocardiac rate compared with propofol, halothane, or sevoflurane,³¹ and its amnesic properties are also better for the patient. The effect of the midazolam is brief and ends within 15 to 20 minutes of injection, and—if necessary—it can be reversed even faster by administering an appropriate dose of its antagonist, flumazenil.

Single-stage adjustable surgery avoids the problems of both local and general anesthesia. The procedure, as well as the medications used, offers the patient the advantages of decreased stress, lack of discomfort from intubation, ability to remain alert, lack of respiratory depression, shorter recovery time, and better pain control after surgery compared with general anesthesia. This procedure is also without the possible risks of retrobulbar hemorrhage, globe perforation, endophthalmitis, and injury to optic nerve or inferior rectus often seen after peribulbar or retrobulbar surgery.

To conclude, SSASS with the use of midazolam and fentanyl is well tolerated in patients with restrictive strabismus, including those with dysthyroid orbitopathy. The stability of ocular alignment may be better than that achieved by multiple-stage surgery,²⁴ and the incidence of postoperative advancement of the inferior rectus muscle is also possibly less with the use of nonabsorbable suture material for inferior rectus recessions.

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