The Immediate Postoperative Adjustment of Sutures in Strabismus Surgery With Comaintenance of Anesthesia Using Propofol and Midazolam

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Purpose: Adjustable suture techniques are used to reduce the reoperation rate in strabismus surgery, but traditionally require that final adjustments be made between 1 to 24 hours after surgery. The purpose of this study was to evaluate a new anesthetic technique that would allow immediate postoperative adjustment of sutures in strabismus surgery, thereby improving patient convenience and comfort. ***Methods:*** This was a prospective study of strabismus patients who were judged to be appropriate candidates for adjustable sutures. Comaintenance of anesthesia was accomplished using a stepped-down infusion of propofol with midazolam. Final suture adjustments were performed in the operating room immediately upon completion of strabismus surgery. Patient satisfaction was assessed 24 hours later. Patients were followed for 6 weeks postoperatively. ***Results:*** A total of 16 patients were studied, with 8 patients having horizontal muscle surgery, 7 patients with vertical muscle surgery, and 1 patient undergoing both horizontal and vertical muscle surgery. The change in deviation after 6 weeks of follow-up was 8 PD or less horizontally in all patients and 4 PD or less vertically in 87% of patients when compared with the alignment in the operating room. Diplopia, if present, resolved in 85% of patients. One patient (6.7%) required a second surgery. The mean drift at 2 weeks horizontally was 1.87 PD esotropic (range, −6 PD exophoric to 18 PD esotropic) and vertically 0.94 PD (range, −4 PD hypotropic to 4 PD hypertropic). The mean drift at 6 weeks horizontally was −0.27 PD exotropic (range, −8 PD exophoric to 8 PD esotropic) and vertically 0.6 PD (range, −6 PD hypotropic to 10 PD hypertropic). ***Conclusion:*** The immediate postoperative adjustment of sutures in strabismus surgery may be accurately performed using this new anesthetic technique. (J AAPOS 2002;6:241-5)

Standard strabismus surgery has been reported to be associated with a 20% reoperation rate.[1] Adjustable sutures have been shown to lower the reoperation rate to approximately 9.7%.[1] This has led to increased use of adjustable sutures, particularly in complicated and adult strabismus cases.[2-5] As this technique has gained popularity, so has the desire to find a more efficient means of performing the postoperative adjustment. Currently, most postoperative adjustments are done from 1 to 24 hours after recovery from general anesthesia. This is frequently inconvenient for both the patient and surgeon. Further, the need for an alert patient prevents administration of narcotic analgesics and sedative antiemetics pending completion of the suture adjustment. This results in many patients finding the suture adjustment unpleasant.

The challenge was to devise a cost-effective general anesthetic technique that would allow rapid awakening and return of ocular motility to enable suture adjustment in the operating room immediately following strabismus surgery. Neither conventional inhalational anesthesia nor total intravenous anesthesia provides these conditions. Our study technique was based on the synergism between propofol and midazolam for hypnosis. Propofol provides quick emergence from anesthesia because of its short half-life (1-3 hours) and extremely high clearance (1.5-2.2 L/min). The effect of midazolam can quickly be reversed with flumazenil. All patients in the study breathed 65% nitrous oxide and received bispectral index (BIS) monitoring. BIS monitoring is a modified EEG designed to provide a continuous reading of hypnotic effect. Because this study involved using reduced doses of anesthetics, the BIS monitor was used to provide additional information regarding the adequacy of anesthesia. Immediate postoper-

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ative alignment was compared with alignment at 2 and 6 weeks after surgery.

METHODS

Patients presenting with strabismus and good vision in both eyes, who were judged to be appropriate surgical candidates for adjustable sutures, were invited to enroll in the study. Informed consent was obtained from all patients and the institutional review board of the hospital approved the study.

Anesthesia Protocol

All patients received a standardized induction of midazolam (2 mg), fentanyl (100 μg), and propofol (1.0-1.5 mg/kg). A laryngeal mask airway (LMA) was positioned and patients spontaneously breathed 65% nitrous oxide and 35% oxygen. Anesthesia was maintained with a stepped-down infusion (10-minute intervals) of propofol at 167, 133, 100, and finally 50 μg/kg/min. All patients in the study reached the lowest maintenance dose of propofol infusion (50 μg/kg/min). Patients also received a concurrent infusion of midazolam (1 μg/kg/min). Five minutes before the end of surgery, topical tetracaine 0.5% was placed on the operative eye. At the completion of surgery, all anesthetic agents were stopped, the LMA was removed, and patients were asked to open their eyes and to squeeze the examiners hand. Five minutes later, the patients received 0.5 mg of flumazenil and were again given verbal stimuli and requested to respond in a cognitive manner and to demonstrate orientation to place and person. Only when the patient was able to generate brisk, horizontal and vertical saccadic eye movements was it considered appropriate to begin the postoperative suture adjustment.

Surgical and Adjustment Protocol

All the adjustable sutures in this study were placed on a recessed muscle. The technique used was the standard fornix approach with a sliding noose, which has been previously reported.[5] A traction suture was placed in the sclera of all the patients adjacent to the insertion of the muscle.[6] This was placed at the muscle pole farthest from the incision to retract the conjunctiva and stabilize the eye.

Prior to adjustment, another 2 to 5 drops of 0.5% tetracaine were placed on the operative eye. The patient was then seated upright on the operating room table with glasses on and looked at a 20/400 Snellen "E" on the far wall. The patient's alignment was checked with prism and alternate cover testing, and if needed, adjustments were made to the sutures holding the rectus muscle. When the desired eye alignment had been obtained, the sutures holding the rectus muscle were permanently tied over the sliding noose. The suture tags were cut short, and the conjunctiva was closed with 6-0 plain gut suture.

All patients were contacted the following day by the anesthesiologist and questioned regarding recall for the surgery and for the postoperative suture adjustment and asked to rate the experience as satisfactory or unsatisfactory.

Patients were examined by the strabismus surgeon 2 and 6 weeks following the procedure and the ocular alignment in primary gaze at distance fixation was recorded.

RESULTS

Sixteen patients ranging in age from 13 to 73 years participated in the study. The ocular alignment abnormalities consisted of pure horizontal (4), pure vertical (4), and combined vertical and horizontal (8) deviations. The ratio of male-to-female participants was 1:1. All patients received the same protocol and had the adjustment done immediately after surgery. One patient in the study was lost to follow-up before the 6-week alignment check but was included in the data for the 2-week alignment.

Measurements of alignment were recorded and compared at the time of adjustment, 2 weeks postoperatively, and 6 weeks postoperatively (Table). Changes in horizontal and vertical alignment were recorded. The mean convergent horizontal drift for all the patients grouped together was 1.87 PD (range, −6 PD exophoric to 18 PD esotropic) at 2 weeks. The mean divergent horizontal drift for all the patients grouped together at 6 weeks was −0.27 PD (range, −8 PD exophoric to 8 PD esotropic). The mean convergent horizontal drift for patients with only a horizontal deviation preoperatively (Figure 1) was 4.67 PD (range, 0-18 PD esotropic) at 2 weeks, and 1.1 PD (range, −4 PD exotropic to 8 PD esotropic) at 6 weeks. None of the patients with a pure vertical deviation preoperatively developed a horizontal drift postoperatively. In comparison to the immediate postoperative alignment, the 6-week alignment changed 8 PD or less horizontally in all patients. The 6-week alignment was also within 8 PD horizontally of orthophoria in all patients.

The mean vertical drift for all patients grouped together at 2 weeks was 0.94 PD (range, −4 PD hypotropic to 4 PD hypertropic). The mean vertical drift for all patients grouped together at 6 weeks was 0.6 PD (range, −6PD hypotropic to 10 PD hypertropic). The mean vertical drift for patients with only a vertical (hypertropic) deviation preoperatively (Figure 2) was 1.88 PD (range, 0-6 PD hypertropic) vertically at 2 weeks and 2.71 PD (range, 0-10 PD hypertropic) vertically at 6 weeks. The mean vertical drift for patients with only a horizontal deviation preoperatively was 0 PD (range, −4 PD hypotropic to 4 PD hypertropic) at 2 weeks, and −0.89 PD (range, −6 PD hypotropic to 4 PD hypertropic) at 6 weeks. Compared to the alignment following suture adjustment, the 6-week alignment changed 4 PD or less vertically in 87% (13/15) of the patients. The 6-week alignment was within 4 PD vertically of orthophoria in 80% (12/15) of the patients.

Only 1 patient in the study required another operation, resulting in a reoperation rate of 6.7%. Diplopia (if present) resolved in 85% (11/13) of patients, and no pa-

TABLE. Measurements of alignment compared at 3 times

Patient information	Preoperative deviation in primary gaze	Procedure	Muscle adjustment	OR alignment	2 wk Postoperative alignment	6-8 wk Postoperative alignment	Vision
Number 1 Age 45 Female	LXT = 25 (A pattern)	Recess right lateral rectus 6.0 mm & lower $\frac{1}{2}$ tendon Resect right medial rectus 5.0 mm & raise $\frac{1}{2}$ tendon	Right lateral rectus	LET = 2	LET = 20	LET = 4 L-hypo = 4	20/20 20/40-2
Number 2 Age 39 Male	X(T) = 45 L-hypo = 4 (V pattern)	Recess left lateral rectus 8.5 mm & elevate $\frac{1}{2}$ tendon resect left medial rectus 6.0 mm	Left lateral rectus	L-hypo = 2	L-hypo = 2	X = 4 L-hypo = 2	20/20 20/20
Number 3 Age 29 Female	RET = 40 (V pattern)	Recess left medial rectus 6.0 mm & lower $\frac{1}{2}$ tendon Recess right medial rectus 5.0 mm & lower $\frac{1}{2}$ tendon	Right medial rectus	Ortho	RET = 2	ortho	20/20 20/20
Number 4 Age 29 Female	E = 25	Recess left medial rectus 5.5 mm	Left medial rectus	Ortho	E = 10	E = 8	20/20 20/20
Number 5 Age 39 Male	LET = 16	Recess left medial rectus 6.0 mm	Left medial rectus	Ortho	L-hypo = 4	L-hypo = 2	20/25 20/25
Number 6 Age 55 Male	XT = 10 RHT = 14	Tuck right sup. oblique 8.0 mm Recess right sup. rectus 4.0 mm	Right superior rectus	Ortho	X = 6	X = 6	20/20 20/20
Number 7 Age 31 Female	LXT = 12 (A pattern) L-hypo = 6	Recess right lateral rectus 9.0 mm & lower $\frac{1}{2}$ tendon	Right lateral	Ortho	Ortho	LET = 2 L-hypo = 6	20/20 20/20-2
Number 8 Age 45 Female	LHT = 10 X(T) = 12	Recess left lateral rectus 7.0 mm Recess left sup. rectus 6.0 mm	Left superior rectus	Ortho	LET = 10	LET = 2 L-hyperphoria = 2	20/20 20/20
Number 9 Age 53 Female	LET = 30 L-hypo = 4	Recess left medial rectus 2.0 mm & elevate $\frac{1}{2}$ tendon Resect left lateral rectus 9.0 mm	Left medial	Ortho	Ortho	L-hypo = 2	20/25 20/25
Number 10 Age 46 Male	RHT = 16 X = 14	Tuck right sup. oblique 10 mm Recess right sup. rectus 4 mm	Right superior rectus	Ortho	X = 6	X = 8	20/20 20/20
Number 11 Age 13 Female	LHT = 30	Tuck left sup. oblique 16.0 mm Recess left sup. rectus 3.5 mm	Left sup. rectus	Ortho	LH = 4	Lost to follow-up	20/20 20/20
Number 12 Age 47 Male	RHT = 25	Tuck right sup. oblique 14.0 mm Recess right sup. rectus 2.0 mm	Right sup. rectus	Ortho	RH = 4	RH = 4	20/25 20/25
Number 13 Age 54 Female	RET = 45 RHT = 8	Recess right medial rectus 6.0 mm & lower $\frac{1}{2}$ tendon Resect right lateral rectus 8.0 mm	Right medial rectus	RHT = 2	RET = 2 RHT = 6	RHT = 6	20/20 20/20
Number 14 Age 61 Male	RHT = 25	Tuck right sup. oblique 8.0 mm Recess right sup. rectus 5.0 mm	Right sup. rectus	Ortho	Ortho	Ortho	20/20 20/25
Number 15 Age 73 Male	RHT = 25	Tuck right sup. oblique 6.0 mm Recess right Sup. rectus 9.0 mm	Right sup. rectus	RHT = 2	RHT = 6	RHT = 12 **Required 2nd operation	20/25 20/25
Number 16 Age 37 Male	RHT = 20 X = 6	Tuck right sup. oblique 10 mm Recess right sup. rectus 4 mm	Right sup. rectus	Ortho	RH = 3	RH=3	20/20 20/20

E, Esophoria; *X*, exophoria; *ET*, esotropia; *XT*, exotropia; *H*, hyperphoria; *HT*, hypertropia; *R*, right; *L*, left.

tients without preoperative diplopia developed postoperative diplopia.

Patients in the study group recovered consciousness sufficient to generate saccadic eye movements, an indicator of frontal lobe recovery, within 10 minutes following removal of the LMA 87.5% of the time and within 15 minutes 100% of the time. None of the study participants recalled the strabismus surgery, nor had any more than the

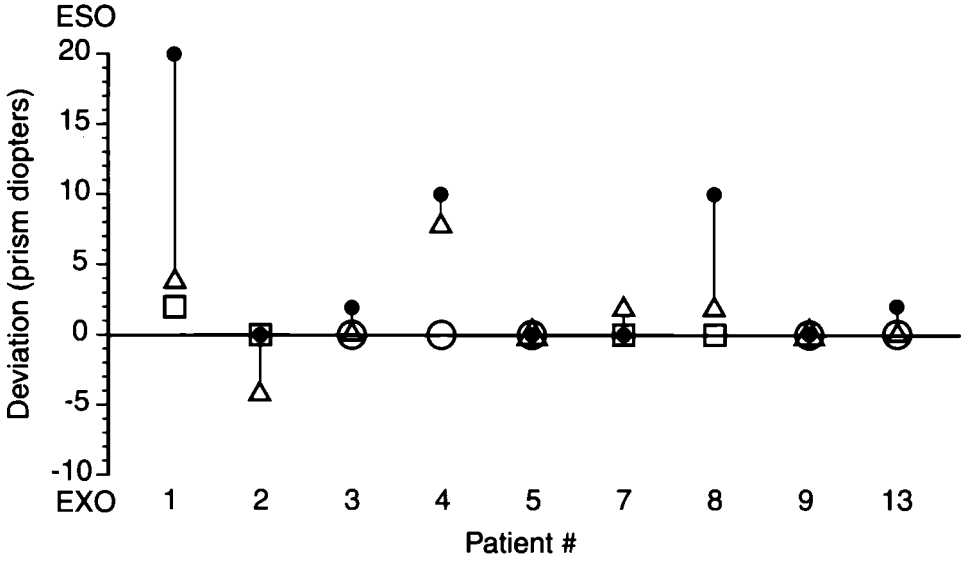

FIG 1. Patients undergoing horizontal strabismus surgery. *Open squares* represent preoperative exotropia; *open circles*, preoperative esotropia (eye position after suture adjustment); *closed circles*, 2-week postoperative alignment; *open triangles*, 6-week postoperative alignment.

vaguest recall of the adjustment procedure. Satisfactory responses regarding the procedure were obtained from 100% of the participants.

DISCUSSION

In 1995, Ward et al[7] reported the successful use of propofol and mivacurium anesthetic technique for the immediate postoperative adjustment of sutures in strabismus surgery. Our study was performed in an attempt to discover a new and improved anesthetic technique that would build on the concepts of previous work.[1-8] Our method is based on the binary synergism between propofol and midazolam for hypnosis. It has been demonstrated that the hypnotic potency of propofol could be enhanced by concurrent administration of a small dose of the benzodiazepine, midazolam.[8] This approach was successfully applied as coinduction of anesthesia and the concept was then logically extended to provide comaintenance of general anesthesia. Individually, the doses of propofol and midazolam are subhypnotic; however, in combination the synergistic interaction provides adequate hypnosis for surgery. Upon conclusion of surgery, the synergy is terminated by administration of flumazenil, a benzodiazepine antagonist. With a short half-life, the propofol rapidly

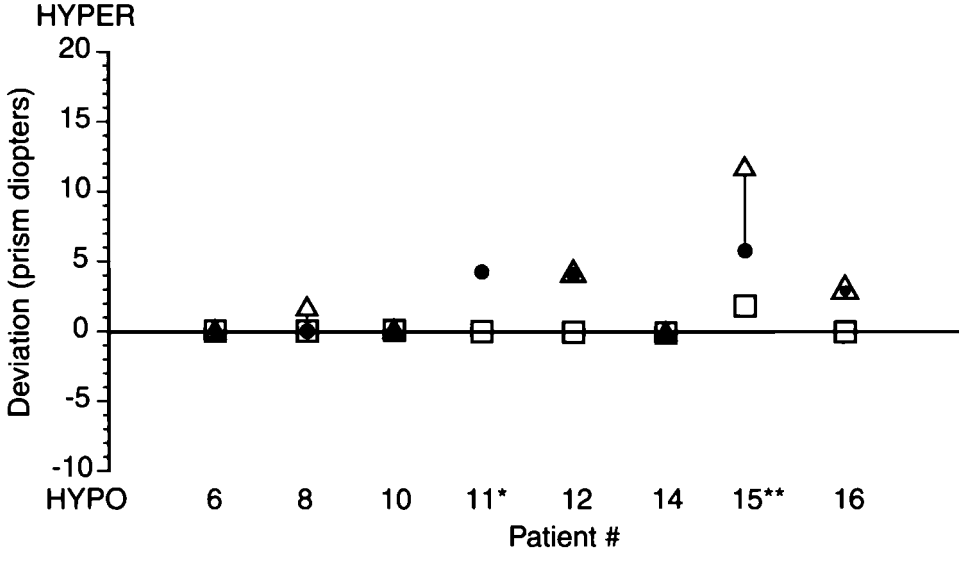

FIG 2. Patients undergoing vertical strabismus surgery. *Open squares* represent preoperative hypertropia (eye position after suture adjustment); *closed circles*, 2-week postoperative alignment; *open triangles*, 6-week postoperative alignment. *Asterisk (*)* shows patient unavailable after 2-week measurement. *Double asterisk (**)* indicates patient who required another procedure.

distributes, allowing the patient to regain consciousness in less than 5 minutes.

Comaintenance of anesthesia has an advantage over the technique described by Ward et al[7] in that the entire surgical procedure is completed under general anesthesia. In the technique described by Ward et al,[7] the infusions of alfentanil, propofol, and mivacurium were stopped prior to the completion of surgery. In our view this defeats the purpose of general anesthesia, which is to provide unconsciousness for the duration of the surgery. Our technique was completely successful in this regard, reflected by the complete lack of patient recall for surgery. Additionally, the amnesia persisted into the adjustment period and this likely improves patient satisfaction with the procedure.

The BIS monitor was used in this study because the subhypnotic doses of both propofol and midazolam were being administered. This provided reassurance against unwanted consciousness occurring during the procedure. However, the BIS monitor is not essential to perform this anesthetic technique because the nonparalyzed patient can indicate inadequate anesthesia by movement.

This study showed an average divergent shift of −0.27 PD at 6 weeks. Ward et al[7] reported an average convergent shift of 4 PD. There could be several reasons for the small difference. Our results could be unique to this particular anesthetic protocol. However, the study by Ward et al[7] terminated at 1 day postoperatively. It is possible that the patients in that study would have shown a different alignment at 6 weeks. Without such data, a truly meaningful comparison is impossible. Nevertheless, our data suggest that an early postoperative convergent shift might be offset by a late divergent drift and that final alignment is actually predicted by the immediate alignment following suture adjustment. Ideally, a larger sample size with even longer follow-up would allow statistical analysis of drift, and the inability to definitively address this question is a shortcoming of our study.

Our reoperation rate of 6.7% compares favorably to the standard reoperation rate with adjustable sutures of 9.7%. In our study only 1 patient required another strabismus surgery. This patient had previously undergone retinal detachment repair with a vitrectomy and scleral buckle procedure and could not be adjusted to orthophoria despite maximal loosening of the adjustable suture holding the superior rectus muscle.

Nausea occurred in 12% of the patients in this study, while Ward et al[7] reported a nausea rate of 14% when performing their technique for immediate postoperative suture adjustment.

This procedure offers many practical benefits to both the surgeon and patient. While still in the operating room, sterile conditions are easier to maintain, theoretically reducing the chance of postoperative infection. Also, all ancillary personnel and instruments are available if needed. There is no need for temporary pressure patching, and the nuisance of long suture ends abrading the conjunctiva and cornea are avoided. In addition, extended time for patients and staff in the recovery room is eliminated. With a high rate of success, patient comfort is enhanced and convenience for both patient and surgeon are greatly improved by performing the adjustment before the patient leaves the operating room.

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