Comparison of the Immediate With the 24-Hour Postoperative Prism and Cover Measurements in Adjustable Muscle Surgery: Is Immediate Postoperative Adjustment Reliable?

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Purpose: Immediate postoperative adjustment after adjustable-suture strabismus surgery has been suggested as a viable alternative to the classic adjustment that is performed, usually within 6 to 24 hours after surgery. The purpose of this study was to compare the immediate postoperative eye measurements with those taken 24 hours postoperatively and to determine whether there was any significant difference between the 2 measurements. ***Methods:*** This was a prospective study of strabismus patients who were candidates for muscle surgery using the adjustable-suture technique. All patients received a total intravenous general anesthesia, which allowed rapid recovery of consciousness. Measurements using the simultaneous prism cover test were obtained in the recovery room immediately after the patients regained consciousness and again 24 hours after surgery. Both measurements were taken before adjustment and were compared. ***Results:*** A total of 25 patients were studied. The postoperative alignment changed significantly during the first 24 hours in 84% of our patients. The mean drift in alignment during the first 24 hours measured 7.2 $\pm$ 4.3 prism diopters and was significantly different from 0 ($P < 0.001$). ***Conclusion:*** The immediate postoperative ocular alignment after adjustable strabismus surgery is significantly different from the 24 hours postoperative alignment. This difference was noticed despite using an anesthesia protocol that allowed rapid recovery and full regaining of consciousness shortly after the conclusion of surgery. This early drift should be taken into consideration if adjustment is to be made in the immediate postoperative period. (J AAPOS 2004;8:528-533)

Adjustable suture techniques for extraocular muscle surgery have become increasingly popular among strabismus surgeons. The rate of reoperation is said to have dropped to 9.7% with the adjustable suture technique as compared with 20% after traditional nonadjustable muscle surgery.[1] The single most important variable that determines the need for and the degree of adjustment after surgery is the postoperative (preadjustment) alignment as measured with the simultaneous prism cover test. The best timing to take these measurements and to perform the adjustment after surgery has been studied by several authors, and it has been shown that adjustment can be performed any time between 6 to 24 hours after surgery.[2,3] In an attempt to reach higher levels of patient comfort and convenience, some have suggested immediate postoperative adjustment in the operating room using special anesthetic techniques that allow rapid recovery.[4,5] This early timing for suture adjustment may be more convenient for the patient as well as for the surgeon. However, postoperative alignment may drift with time, and there is evidence that delayed adjustment may be desirable for better postoperative results.[6-13] The aim of this study was to determine whether there is a significant postoperative drift in alignment that occurs in the first 24 hours, which was accomplished by evaluating the eye alignment before adjustment at 2 different times, immediately postoperatively and after 24 hours by obtaining simultaneous prism cover test measurements. If the 2 measurements were similar, then one could safely assume that immediate postoperative adjustment is as reliable as the classic 6-24 hours postoperative adjustment in obtaining a satisfactory final alignment.

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TABLE 1. Recession procedures: measurements of alignment Immediately after surgery and 24 hours after surgery

Age and sex	Preoperative alignment	Surgical procedure	Duration of surgery in minutes	Minutes to full recovery	Immediate alignment in PD	24 hours alignment in PD	Difference in PD
22M*	LHT 20	R IR REC 5 mm ADJ L IO Myectomy	30	7	LHT 12	LHT 6	+6
22M	LXT 18	L LR REC 8 mm ADJ	13	7	Ortho	ET 10	+10
13F*	RXT 20	R LR REC 8 mm ADJ	14	8	XT 10	Ortho	+10
49M	RHT 8	L IR REC 5.5 mm ADJ	12	7	RHT 4	Ortho	+4
19F*	RET 22	R MR REC 8 mm ADJ	20	12	XT 12	XT 4	−8
31F*	X(T) 45	R LR REC 8 mm ADJ L LR REC 8 mm	25	17	Ortho	Ortho	0
29M*	RXT 25	R LR REC 9 mm ADJ	20	15	XT 20	XT 10	+10
28F	RXT 22	R LR REC 7 mm	13	12	XT 14	XT 4	+10
21M*	X(T) 30	R LR REC 7 mm ADJ L LR REC 6 mm	25	16	X(T) 15	X(T) 8	+7
43F	LET 20	LMR REC 8 ADJ	13	12	ET 15	Ortho	+15
20F*	RXT 20	L LR REC 9 ADJ	12	18	Ortho	Ortho	0
23F	LX(T) 18	L LR REC 7 ADJ	9	11	X(T) 4	Ortho	+4

M: male; *F*: female; PD: prism diopters; ADJ: adjustable suture; ADV: advancement; R: right; L: left; HT: hypertropia; ET: esotropia; XT: exotropia; MR: medial rectus; LR: lateral rectus; IR; inferior rectus; IO: inferior oblique; REC: recession; RES: resection; +: shift in the direction of intended correction; −: shift in the opposite direction of the intended correction.
*Patients with previous muscle surgery.

METHODS

Preoperative Evaluation

Strabismus patients who were candidates for muscle surgery using the adjustable suture technique were enrolled in the study. Twenty-five consecutive patients who underwent adjustable suture surgery between January 2003 and December 2003 were included. All patients had a complete eye examination before surgery. The simultaneous prism cover test measurements for distance fixation with the patient wearing his/her eyeglasses and fixing on the 20/400 letter were obtained. The same conditions were used to obtain measurements immediately after surgery and 24 hours later. An informed consent was obtained from all patients.

Anesthesia Protocol

The anesthetic regimen was standardized. No premedication was given. Patients underwent an intravenous induction with midazolam 2 mg, propofol at a dose of 2 mg/kg, and remifentanil at a dose of 0.5 μg/kg given during the course of 2 minutes. A laryngeal mask airway was inserted, and patients were ventilated with a fresh gas flow of 35% oxygen in air 2 L/min. Anesthesia was maintained with an infusion of propofol at a dose of 2-4 mg/kg/h, and an infusion of remifentanil at a dose of 0.1–0.2 μg/kg/min as a form of total intravenous anesthesia. In the course of the operation, the infusions were adjusted to the decreasing need for anesthesia.

At the end of surgery, all anesthetics were stopped, and the laryngeal mask airway was removed. Recovery times were determined at 1-minute intervals by asking the patients to open his or her eyes, to respond to commands such as squeezing the anesthetist's hand, and to demonstrate orientation to person, date, and place. All patients were assessed in the recovery area at 5-minute intervals. The simultaneous prism cover test measurements were taken only when the patient was able to generate brisk, horizontal and vertical saccadic eye movements. Postoperative analgesia and antiemesis were administered on demand by the nursing staff in the recovery area.

Surgical Protocol

Eighteen of 25 adjustable sutures were placed on recessed muscles and 7 on a resected and/or advanced muscles. No topical, sub-Tenon, or subconjunctival anesthetic was used. All surgeries were performed by a single surgeon, and a limbal approach was used to isolate and expose the operated muscle. A double-armed 6-0 coated polyglactin suture was passed through the center of the tendon and then passed and locked through its upper and lower corners. The muscle was then disinserted. In case of a recession, the needles were passed through the sclera at the center of the original insertion. A sliding noose was used to secure the suture and place the muscle at the desired new insertion. A traction suture was placed at the muscle insertion. The 2 ends of the conjunctival incision were approximated with 2 7-0 coated polyglactin sutures that were left untied till the time of adjustment. The same technique was used for muscle resection except that the knot of the adjustable suture was placed in the muscle just behind the desired resection site, and the muscle stump was approximated to the original insertion. The anesthesiologist was alerted 5 minutes before the expected time of conclusion of the surgery.

TABLE 2. Combined recess resect procedures: measurements of alignment immediately after surgery and 24 hours after surgery

Age and sex	Preoperative alignment	Surgical procedure	Duration of surgery in minutes	Minutes to full recovery	Immediate alignment in PD	24 hours alignment in PD	Difference in PD
31F*	RET 45	R LR RES 8 mm ADJ R MR REC 8 mm	20	7	ET 15	ET 4	+11
40M	RXT 40	R LR REC 8 mm ADJ R MR RES 6 mm	24	15	XT 12	Ortho	+12
38F	RET 45	R MR REC 8 mm ADJ R LR RES 9 mm	25	15	Ortho	ET 6	−6
29M	RXT 55	R LR REC 10 mm ADJ R MR RES 8 mm	30	22	XT 25	XT 15	+10
64M	RET 45	R MR REC 8 mm ADJ R LR RES 9 mm	26	20	Ortho	Ortho	0
23F	LXT 40	L LR REC 8 mm ADJ L MR RES 5	25	15	Ortho	ET 10	+10
26F	LET 25	L MR REC 5 ADJ L LR RES 5	14	12	XT 4	XT 12	+8

M: male; *F*: female; PD: prism diopters; ADJ: adjustable suture; ADV: advancement; R: right; L: left; HT: hypertropia; ET: esotropia; XT: exotropia; MR: medial rectus; LR: lateral rectus; IR; inferior rectus; IO: inferior oblique; REC: recession; RES: resection; +: shift in the direction of intended correction; −: shift in the opposite direction of the intended correction.
*Patients with previous muscle surgery.

Postoperative Measurements

Measurements of ocular alignment were taken immediately when the patient regained consciousness and at 24 hours. Both measurements were taken before the adjustment of the sutures. The measurements were taken with the simultaneous prism cover test while the patient was in the sitting position, wearing his or her correction and fixing at a 20/400 E fixation target 4 meters away. The immediate postoperative measurements were taken in the recovery room only after it was judged by the anesthesiologist that the patient had fully recovered and after the ophthalmologist made sure that the patient was able to generate saccadic eye movements, an indicator of frontal lobe recovery. This usually took place 7-22 minutes after the completion of surgery. The eye was then covered with a cotton pad. The 24-hour postoperative measurements were taken the next morning in the clinic. Adjustment of the sutures was then performed, if needed, and the sutures tied to obtain the desired postoperative alignment. All patients were seen by the ophthalmologist 6 weeks postoperatively and a complete ophthalmic and motility evaluation was performed.

Statistical Analysis

The mean and standard deviation of the absolute differences between the 2 postoperative measurements were obtained and studied against the 0 value using one sample *t*-test. We also compared the means and standard deviations of the immediate and the 24-hour measurements for each group of patients based on the direction of their drift using paired sample *t*-test. A *P* value less than 0.05 was considered statistically significant.

RESULTS

Twenty-five patients were included in the study. Eleven were males and 14 females. The age ranged from 13 years to 64 years with a mean age of 29.8 ± 12.5 years. Sixteen patients had exotropia, 6 had esotropia, 2 had a hypertropia, and 1 patient had a combined exotropia with hypertropia. The mean preoperative deviation for all 25 patients was 28.5 ± 11.8 prism diopters. Twelve patients underwent recession of 1 or more rectus muscles (Table 1), 7 underwent combined recess/resect procedures (Table 2), and 6 underwent rectus muscle resections and/or advancements (Table 3). The adjustable suture was placed on a recessed muscle in 18 patients, and on a resected and/or advanced muscle in 7 patients. The duration of surgery ranged from 9 to 30 minutes, with an average of 18.6 ± 6.4 minutes. The postoperative interval between the end of surgery and full recovery ranged from 7 to 22 minutes, with a mean of 12.1 ± 4.3 minutes. This was the time when the immediate postoperative measurements were recorded. The 24-hour postoperative measurements were taken the next morning, and the difference between the 2 measurements, if any, was calculated. The difference between the immediate and the 24-hour measurements ranged between 0 and 15 prism diopters, with a mean of 7.2 ± 4.3 prism diopters and was significantly different from the 0 value ($P < 0.001$). A difference (other than 0) between the 2 measurements was found in 21 of the 25 patients (84%).

On the basis of the direction of the drift during the first 24 hours, the patients were divided into 3 groups (Table 4). Group 1 patients had similar measurements at each of the 2 time periods, that is, no drift (0 difference); group 2

TABLE 3 Resection and/or advancement procedures: measurements of alignment after surgery and 24 hours after surgery

Age and sex	Preoperative alignment	Surgical procedure	Duration of surgery in minutes	Minutes to full recovery	Immediate alignment in PD	24 hours alignment in PD	Difference in PD
58M*	LXT 20 RHT 24	L MR RES 8 mm ADJ R IOM	25	10	XT 6 RHT 8	XT12 RHT 8	−6
21M*	RXT 30	R MR RES/ADV ADJ	15	10	XT 8	XT 16	−8
27F*	LXT 30	L MR RES 7 mm ADJ	15	7	XT 4	XT 8	−4
30F*	LXT 15	L MR RES 6 mm ADJ	11	7	ET 15	ET 15	0
20F*	RXT 25	R MR RES/ADV ADJ	15	10	XT 12	ET 2	+14
20M*	LXT 30	L MR RES/ADV ADJ	14	11	XT 6	XT 12	−6

M: male; *F*: female; PD: prism diopters; ADJ: adjustable suture; ADV: advancement; R: right; L: left; HT: hypertropia; ET: esotropia; XT: exotropia; MR: medial rectus; LR: lateral rectus; IR; inferior rectus; IO: inferior oblique; REC: recession; RES: resection; +: shift in the direction of intended correction; −: shift in the opposite direction of the intended correction.
*Patients with previous muscle surgery.

TABLE 4. Means and standard deviations of immediate and 24 hours measurements in prism dioptres based on direction of drift

	Number of patients	Immediate measurements	24-hour measurements	*P* value
Group 1 (zero difference)	4	3.75 ± 7.5	3.75 ± 7.5	–
Group 2 (plus difference)	15	10.8 ± 7.2	5.4 ± 5.1	0.023
Group 3 (minus difference)	6	6.0 ± 4.0	9.6 ± 4.4	0.18

patients showed more correction of the original deviation after 24 hours, that is, a shift in the direction of the intended correction (plus difference); and group 3 patients showed less correction of the original deviation after 24 hours, that is, a shift in the opposite direction of the intended correction (minus difference). Four patients belonged to group 1 (16%), 15 patients to group 2 (60%), and 6 patients to group 3 (24%). The mean and standard deviations of the immediate postoperative measurements and the 24 hours postoperative measurements for each group were studied. The difference between the means of the 2 measurements was statistically significant ($P = 0.023$) for patients in group 2 but not for patients in group 3 ($P = 0.18$).

DISCUSSION

The best timing for muscle adjustment after adjustable muscle surgery is still a controversial issue and has been the subject of many studies. Whether adjustment is made 6 or 24 hours postoperatively does not seem to make much difference.[2,3] Some authors have shown that immediate postoperative adjustment is as reliable as later adjustment in obtaining a satisfactory outcome.[4,5] An anesthetic technique that allowed immediate postoperative suture adjustment was first reported by Ward et al in 1995.[4] More recently, another such technique was also described.[5] All of these techniques aim at improving patient convenience and comfort by performing the adjustment under controlled conditions in the operating room. There is evidence, on the other hand, that final alignment is improved when suture adjustment is delayed.[6-15] A postoperative drift in ocular alignment is well known to occur, but most studies compare alignment at 6 weeks with the first postoperative day.[6-8]

It is not the purpose of this study to address the efficacy of adjustable muscle surgery. The study aims at comparing the eye alignment after surgery at 2 different postoperative times, immediately after surgery and after 24 hours. The 2 measurements were taken before adjustment and the final tying of the sutures. The aim of this comparison is to study the postoperative drift that occurs over the first 24 hours. We think that it is acceptable to assume that if the 2 measurements proved to be similar (0 difference), then adjustment in the immediate postoperative period can be as reliable as the next-morning adjustment. In 21 patients (84%), there was a difference between the 2 measurements that ranged between 4 and 15 prism diopters. The mean of the drift for all patients measured 7.2 ± 4.3 prism diopters and was significantly different from 0 ($P < 0.001$). In addition, group 2 patients who had more correction of their original deviation after 24 hours showed a significant difference between the immediate versus the 24-hour measurements ($P = 0.023$). All patients in group 3 showed less correction of their deviation after 24 hours, although the difference between the two measurements was not significant, probably because of the small sample size (Table 4). It is also worth noting that the mean preoperative deviation for all patients was 28.5 ± 11.8 prism diopters. This denotes that the mean drift over the first 24 hours of 7.2 ± 4.3 prism diopters represents a 25% change in the original deviation.

The anesthesia technique was chosen to allow rapid recovery and return of ocular motility in order to enable postoperative eye measurements immediately following strabismus surgery. Propofol has a short half-life (1-3 hours) and extremely high clearance (1.5–2.2 L/min). Its recovery is rapid and clear-headed. Also, it is known to

have antiemetic properties.[16] Remifentanil is a mu-opioid receptor with a half-life of 3 min and an elimination half-time of less or equal to 10 min.[17] With the use of total intravenous anesthesia remifentanil-propofol and co-induction with midazolam, it is possible to achieve hemodynamic stability of patients during surgery. This technique allows fast, early, and high-quality arousal while reducing the high incidence of nausea and vomiting associated with strabismus surgery.[18,19]

The mechanical effect of muscle recession as a weakening procedure is said to be caused through several mechanisms.[8] One is attributed to the loss of rotational force or torque following a recession. Others believe that the primary weakening effect is caused by slackening of the muscle and by the severing of many of the supporting structures. Resection, on the other hand, strengthens the muscle by shortening it and by increasing the resting muscle tension.[8] It seems that such mechanical factors, alone or in combination, do not produce their weakening or strengthening effect instantly at the conclusion of surgery. In addition, the postoperative tissue reaction, photophobia, and ocular discomfort have a known effect on the position of the eye and are most pronounced immediately after surgery but fade away gradually over the next hours and days.

It appears from the results of our study that there is a gradual drift in the postoperative alignment that starts to take place immediately after surgery. This is shown by the difference in alignment between the immediate postoperative period and 24 hours postoperatively that was noticed in 21 of the 25 patients included in the study. All 21 patients demonstrated a difference of 4 prism diopters or more. We think that in adjustable suture strabismus surgery, such a change in the alignment during the first 24 hours may influence the decision-making regarding the need for and degree of adjustment. The immediate postoperative measurements were taken 12.1 minutes on the average after the conclusion of surgery, when it was judged that the patient was fully awake. We think that the mechanical effects of recession and/or resection procedures are not fully pronounced in this immediate postoperative period even though the patient is fully awake. We also agree with Ward et al that residual anesthetic effects may compromise the measurement reliability in the immediate postoperative period, despite the recovery of brisk saccades.[4]

The postoperative drift in alignment during the first 24 hours seemed to be more dependent on the type of surgery than on the type of the original deviation. When the surgical procedure involved recession of a muscle or a combined recession and resection, there was a general tendency in our study towards a "false" undercorrection effect in the immediate postoperative period as compared with 24 hours later. In 14 of 19 patients who had a recession or a recess resect procedure, more of the original deviation was corrected after 24 hours as compared with the immediate postoperative period (Tables 1 and 2). In these 14 patients, the shift in alignment during the first 24 hours was in the direction of the intended correction, and we think that this shift should be taken into consideration if adjustment of the suture is to be performed in the immediate postoperative period. Otherwise, later overcorrectrions are to be anticipated. In resections and/or advancements, on the other hand, the opposite effect was noticed. Less of the original deviation was corrected after 24 hours as compared with the immediate postoperative period in 4 of the 6 patients who had isolated resections and/or advancement (Table 3). This drift in the opposite direction of the intended correction may be explained by the immediate splinting effect that is produced by the resected muscle and that may lead to more initial correction as compared with 24 hours later. Again this immediate "false" overcorrection effect should be taken into account if adjustment of the sutures is to be made in the immediate postoperative period.

The 2 patients in our study that had a preoperative pure vertical deviation showed a shift in alignment in the direction of the intended correction. This was consistent with the type of surgery that they received, which was a recession of the inferior rectus muscle in both cases.

Fourteen patients had previous strabismus surgery. Eleven of the 14 patients demonstrated a drift in alignment during the first 24 hours. The direction of the drift was similar to the general trend described above, and was mostly dependent upon the type of surgery performed.

Seventeen patients in the study were operated for exotropia. Fourteen showed a postoperative shift in alignment of 4 prism diopters or more in the first 24 hours. Most of the patients (10 of 14) showed further correction of the original deviation after 24 hours, that is, a shift in the direction of the intended correction. Five of the 6 patients who underwent surgery for esotropia demonstrated a shift of alignment during the first 24 hours. The direction of the shift was in the direction of the intended correction in 3 patients and in the opposite direction of the intended correction in 2.

In conclusion, this study demonstrates that a change in alignment after adjustable strabismus surgery during the first 24 hours occurs in most patients. This early drift suggests that later or delayed adjustment may be a better option for the strabismus surgeon to obtain satisfactory long-term alignment.

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An Eye on the Arts – The Arts on the Eye

Gung Mahal. It was a lofty building carved of stone. Far from other dwellings, it seemed quite new, as if the masons had just struck the final blow. Bihzad had felt curious listening to the story of the strange experiment being conducted there. The ruler had imprisoned a dozen newborn babies, orphans, in the building. Right from birth they were reared without ever hearing a human voice. The women who attended to them were prohibited from speaking, either among themselves or to the children. Not even a word. The ruler, Bihzad had learnt, wished to prove a point—if the children remained dumb as a result of growing up in silence, it would prove that the power of speech was simply a trick learned young, not a gift of divine inspiration.

Bihzad entered the Gung Mahal, managing to arrive and enter the building unnoticed. It was dusk; the children were about to rise from their afternoon nap, their attendants still dozing in their own quarters. He stepped into the room where all the children were sleeping, and opened the windows. As they woke, they observed him in silence. Bihzad watched them too—a whole room full of children, silent as a graveyard. It couldn't be true, he told himself. Perhaps there was a trick . . . Something must make them talk, squeal aloud or cry. He started to imitate birds, cooing and whistling as if they were returning to their nests at the end of the day. He cried the shrill cry of a peacock, feigned the soft moaning of a dove. The children listened in silence, following him with their eyes as he darted from one end of the room to the other as if playing hide and seek with himself. He clapped his hands loudly, laughed out loud, raising his voice to a crescendo, rising higher and higher. Bringing his face close to each one of the children, he called them by various names, speaking in many tongues—Farsi, Turki, Chagtai, Uzbeki.

The children remained silent. Dumb. Their eyes widened with each new trick.

Bihzad sat on his mule-cart and thought about the Hall of Silence. Silence has robbed the children of the power of speech. He frowned, attempting to solve the riddle. Could blindness then. . .? What would make the artist forget? What would kill his urge, destroy the magic of his fingers? He played with the edge of his turban, taking it off, still lost in thought. Then he tore off a piece of the white cloth and tied it firmly over his eyes.

—Kunal Basu (from *The Miniaturist*)