TREATMENT OF THYROID OCULAR MYOPATHY WITH ADJUSTABLE AND NONADJUSTABLE SUTURE STRABISMUS SURGERY*

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INTRODUCTION

A SYMPTOMATIC RESTRICTIVE OCULAR MOTILITY DISORDER APPROXIMATELY 15% of patients with thyroid orbitopathy.[1] In a recent review of 557 patients, Kendler and associates[2] noted that affected individuals older than 50 years of age were more likely to present with limitation of ocular motility, most commonly impaired upgaze. Clinical signs and symptoms of thyroid ocular myopathy include asthenopia, diplopia, strabismus, restricted gaze with positive forced ductions, head turn and inflammation over the extraocular muscle insertions. Restriction of the inferior rectus muscle is most common, followed by restriction of the medial, superior, and lateral recti, and, very rarely, the oblique extraocular muscles. Muscle involvement, which is characteristically bilateral and asymmetric, progresses differently in every individual.

In thyroid ocular myopathy, the extraocular muscles can enlarge up to eight times their normal mass. This hypertrophy results from fibroblast-mediated mucopolysaccharide production (with attraction of water) and excess collagen production. Acutely, the inflammatory cells are present between muscle fibers, most notably mast cells, lymphocytes and plasma cells.[3] Gradual fibrosis ensues. Hypertrophy and fibrosis change muscle elasticity, length, lever arm, and opposing muscle forces.

Traditional strabismus surgery for thyroid ocular myopathy frequently leads to less than optimal results, primarily because of the alteration in each muscle's pathologic state. Different preoperative and intraoperative criteria have been implemented to determine the amount of muscle surgery required, with great variability in outcome.[1,4-6-8] To more predictably reinstate fusion in the primary and reading positions and increase ductions, several

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investigators, including Jampolsky, recommend the adjustable suture technique.[9-14] This procedure, first detailed by Bielschowsky in 1907,[15] recesses one or more extraocular muscles using a slipknot. The surgeon then "fine tunes" muscle position postoperatively, when alignment can be assessed, in hopes of avoiding large undercorrections and overcorrections. Whether there is a higher degree of success from one operation with adjustable surgery for patients with restrictive myopathies remains controversial.[13,16-24]

Few studies directly compare the traditional nonadjustable and adjustable suture techniques in patients with thyroid ocular myopathy.[1,4,10,21,25] We, therefore, conducted a retrospective study to evaluate the postoperative results of these two types of strabismus surgery for a particular subset of patients, ie, those with predominant unilateral inferior rectus muscle restriction. We calculated the success rates after one operation and the reoperation rates, for the two procedures, and then pooled our results with those of other comparable series to determine if the adjustable suture technique offered any statistically significant advantage over traditional strabismus surgery.

METHODS

We initially reviewed the course and outcome of 52 patients treated for thyroid ocular myopathy from 1981 to 1992. Orthoptic evaluations, which included cardinal field measurements, Lee screen, Hess screen, and binocular visual fields were studied in order to select individuals with predominant unilateral inferior rectus muscle restriction. Some patients included had medial rectus restriction, but none showed preoperative evidence of superior rectus or bilateral inferior rectus involvement.[4,26,27] Any patient who had had previous strabismus surgery, who did not have fusion potential or who did not return for 12-week postoperative measurements was eliminated from this study. All patients remained euthyroid and had maintained a stable orthoptic pattern for at least 6 months prior to strabismus surgery. Parameters recorded included sex; age at first muscle surgery; any prior orbital decompression; and, for each operation, preoperative vertical tropia in primary position at 6 m, the amount of inferior rectus recession in millimeters for nonadjustable surgery, and the 6-week and most recent postoperative deviation in the primary and reading positions with or without prisms.

All operative procedures were performed by one surgeon (JDB) who used surgical techniques well described by Jampolsky,[11,12] Metz,[14] and, more recently, Kraft and Jacobson.[9] For nonadjustable surgery, the muscle was recessed an amount determined by the preoperative deviation and

modified intraoperatively by forced duction testing. To adjust the recession postoperatively, the muscle was resutured to the original insertion and allowed to hang back loosely in the orbit. A slipknot with a loop in it was applied to the muscle suture. Overrecession was always confirmed by forced ductions to ensure easier adjustment in office the morning following surgery. At that time, ductions and alignment were measured and the muscle was repositioned until the patient became orthotropic. If infraduction was significantly limited, then the patient was left slightly undercorrected. After adjustment, preplaced conjunctival loop sutures were tied to allow closure of the wound over the muscle slipknot.[28]

Success, defined as fusion in the primary and reading positions without prisms after one operation, was determined at the patient's most recent follow-up examination. The number of successes with and without prisms and the number of reoperations were recorded for the two groups. Statistical analysis with the chi-square test or Fisher's exact test was performed for success and reoperation rates using our results and those of others who published comparable data.[4,10,25]

RESULTS

From 1981 to 1992, a total of 52 patients with thyroid ocular myopathy underwent 95 muscle recessions: 63 (66%) on the inferior rectus, 22 (23%) on the medial rectus, 5 (5%) on the superior rectus, and 5 (5%) on the lateral rectus. Table I summarizes the number and type (vertical or horizontal) of muscle(s) recessed. No resections were performed. Overall, 15 patients (29%) required more than one operation.

A subset of 37 patients underwent solitary inferior rectus muscle recession as a primary procedure: 26 in a nonadjustable fashion and 11 in an adjustable fashion. Eight patients included in the nonadjustable group required unilateral medial rectus muscle recession as part of their primary procedure. Tables II and III list each patient's preoperative hypotropia, final postoperative vertical deviation, and result. Six-week measurements were not statistically different from the most recent deviation in either group. Surgical outcome is summarized as success (S), success with prism use in primary or reading position (P), or reoperation (R).

Table IV compares the nonadjustable and adjustable groups. Ages were similar in both groups. More females underwent nonadjustable and adjustable suture surgery. Both postoperative follow-up periods were long, averaging almost 1 year for the adjustable group and 2 years for the nonadjustable group. More patients in the nonadjustable category than in the adjustable category required transantral orbital decompression preoperatively

TABLE I: STRABISMUS SURGERY IN PATIENTS WITH THYROID OCULAR MYOPATHY: 11-YEAR EXPERIENCE

	PRIMARY SURGERY	FIRST REOPERATION	SUBSEQUENT REOPERATIONS
No. patients	52	15 (29%)*	3 (20%)†
Type of recession:			
1 V	30	11	2
2 V	2		
1 H	7		
1 V, 1 H	10	2	1
2 V, 1 H	1		
2 V, 2 H	2		

*Two patients had their second surgical procedure performed elsewhere.
†Two patients had a total of two reoperations. One patient required a total of five strabismus procedures, on three horizontal and four vertical muscles.
V, vertical; H, horizontal.

TABLE II: NONADJUSTABLE INFERIOR RECTUS (IR) RECESSION

PATIENT INITIALS	PREOPERATIVE HYPOTROPIA (PD)	POSTOPERATIVE HYPOTROPIA (PD)	IR RECESSION (mm)	RESULT: SUCCESS (S) PRISM USE (P) REOPERATION (R)
TK	18	−6*	4.0	P
RR	40	16	6.0	R
NH	6	0	9.0	P
HH	20	−15*	6.5	R
AL	18	0	2.5	S
RFo	12	1	3.5	S
RFu	30	18	5.0	R
BBc	8	0.5	4.0	P
EB	5	−5*	5.0	P
RS	14	0	2.5	S
CH	6	5	3.5	R
RD	12	−3*	5.0	P
KB	7	0	3.5	P
MW	40	10	9.0	S
DA	12	−12*	4.0	R
JL	20	−10	9.0	R
MK	15	0	4.0	S
MB	15	0	7.0	P
TM	24	0	4.5	S
PC	10	−5*	3.0	R
VG	32	−24*	6.5	R
BBo	18	2	3.0	S
RW	16	0	3.0	S
HR	10	0	2.5	S
JH	8	−12*	4.0	R
JW	4	−2*	3.5	S

*Negative value indicates hypertropia of operated eye.
PD, prism diopters.

TABLE III: ADJUSTABLE INFERIOR RECTUS RECESSION

PATIENT INITIALS	PREOPERATIVE HYPOTROPIA (PD)	POSTOPERATIVE HYPOTROPIA (PD)	RESULT: SUCCESS (S) PRISM USE (P) REOPERATION (R)
RB	15	−1	R
MM	32	0	S
CS	35	6	P
OS	18	0	S
CH	8	−4°	P
KR	38	0	S
GL	32	−5°	P
GD	36	0	S
JP	16	0	S
HV	14	0	S
JM	18	0	S

°Negative value indicates hypertropia of operated eye.
PD, prism diopters.

TABLE IV: THYROID OCULAR MYOPATHY PATIENTS UNDERGOING INFERIOR RECTUS MUSCLE STRABISMUS SURGERY

	NONADJUSTABLE	ADJUSTABLE
No. of patients	26	11
Sex F:M	2.7:1	1.2:1
Mean age at surgery in years (range)	54 (31-72)	56 (28-77)
Preoperative transantral decompression rate	35% (9/26)	18% (2/11)
Mean postoperative follow-up in weeks (range)	95 (12-405)	47 (12-162)
Mean preoperative hypotropia in PD (range)	16.2 (4-40)	23.8 (8-38)
Mean postoperative hypotropia in PD (range)	−1.6° (−24-18)	−1.2° (−10-6)
Success rate without prisms (S)	38% (10/26)	64% (7/11)
Success rate with or without prisms (P)	65% (17/26)	91% (10/11)
Reoperation rate (R)	35% (9/26)	9% (1/11)

°Negative value indicates hypertropia of operated eye.
PD, prism diopters.

(35% versus 18%). Mean preoperative hypotropia was slightly greater in the adjustable group (16.2 prism diopters for nonadjustable, 23.8 prism diopters for adjustable), with similar ranges. The mean postoperative deviations for both groups, 1.6 prism diopters of hypertropia for the nonadjustable and 1.2 prism diopters of hypertropia for the adjustable, demonstrated more variation in individual results for the nonadjustable category. Success, as previously defined, occurred in 38% of patients who had nonadjustable surgery and 64% of patients who had adjustable surgery ($P = .279$). The reoperation rates were 35% for nonadjustable and 9% for adjustable ($P = .224$), since some patients fused with prisms after one operation (7 and 4 patients, respectively). No one in either group had an A-pattern exotropia postoperatively.[29] No correlation with outcome and concomitant medial rectus recession or prior orbital decompression surgery could be determined.

Twenty-seven percent of patients in both groups needed prisms postoperatively. Of the seven patients in the nonadjustable group who fused with prisms, three manifested a mild overcorrection and one a slight undercorrection. Three required prisms in their reading glasses for decreased infraduction of the operated eye. Two of the three patients in the adjustable group who needed prisms postoperatively demonstrated a mild overcorrection. The other person had 6 prism diopters of hypotropia present since 6 weeks after surgery. He was the only patient adjusted to a small (1 to 2 prism diopters) hypotropia. Two patients left hypophoric on adjustment remained stable and fused without prisms.

The nine failures in the nonadjustable group consisted of three immediate undercorrections, four immediate overcorrections, and two patients in whom large hypertropias developed about 2 months postoperatively. The undercorrected patients achieved fusion after a second recession on the same inferior rectus. The overcorrected patients each demonstrated poor infraduction of the operated eye and negative forced ductions for both eyes. They underwent a small recession of the opposite inferior rectus muscle. Three fused postoperatively, two without and one with prisms. The fourth patient had the same deviation postoperatively that manifested prior to any surgical intervention. Because of the subsequent development of poor vision in one eye, this fourth patient was not bothered by a significant vertical deviation. The last two failures in the nonadjustable group and the single failure in the adjustable group did well until 8 to 10 weeks postoperatively, at which time increased proptosis and inferior rectus muscle restriction developed in the unoperated eye. For their progressive myopathy, two required one more surgery and one required two more surgeries to attain fusion in primary position with prisms.

Possibly because of our limited sample size, outcomes for the two groups

were not statistically significant (Table IV). When our data are combined with those of Kushner,[10] Skov and Mazow,[25] and Trokel and associates[4] (Table V), the adjustable suture technique is statistically more successful (46% for nonadjustable versus 77% for adjustable, $P < .001$ by the chi-square test). A smaller but still highly significant difference is apparent in the reoperation rates for the pooled groups (29% for nonadjustable versus 11% for adjustable, $P = .021$ by the chi-square test).

DISCUSSION

This study demonstrates that both nonadjustable and adjustable inferior rectus muscle recession effectively improves alignment in patients with thyroid ocular myopathy. Our 38% success rate and 35% reoperation rate for nonadjustable surgery and 64% success rate and 9% reoperation rate for adjustable surgery are similar to previously reported outcomes.[1,4-8,10,16,18,21,22,25] In series with more than 10 subjects, success rates ranged from 43% to 82% and reoperation rates from 18% to 40% for nonadjustable surgery[1,4-8,25] and from 71% to 92% and 5% to 17%, respectively, for adjustable surgery.[16,18,21,22,25] Because of the diverse definitions of success, comparison of the many series does not offer solid conclusions as to the advantage of either technique.

Our results do suggest, however, that a select group of Graves' patients (ie, those with predominant unilateral vertical tropia) may benefit more from adjustable suture strabismus surgery. However, a statistically significant improvement in outcome with adjustable surgery is only gleaned when we combine our results with others who compared the two techniques.[4,10,25] Skov and Mazow[25] and Trokel and associates,[4] report their data such that we were able to use our definition of success to directly compare our data with theirs. In Kushner's series,[10] success is defined as a postoperative ocular deviation of less than 5 prism diopters. Reading position measurements and reoperation rates were not reported. His failures fit our criteria for reoperation because thyroid ocular myopathy patients with greater than 5 prism diopters of misalignment rarely achieve fusion in primary position.[10] Thus, we included his data in the pooled reoperation rates. Two other studies also implemented adjustable surgery in thyroid patients.[1,621] Keech and associates[21] reported the number of cases requiring adjustment (41%) and thus had an inherent control group of nonadjusted cases. We could not compare our data to theirs, or to Scott and Thalacker's,[1] because they did not specify outcome as a function of nonadjustment or adjustment.

Of the 27 patients in our series who underwent nonadjustable horizontal rectus muscle recession, 14 required unilateral medial rectus muscle weakening. Thirteen of these 14 patients fused postoperatively, 11 (79%) without

TABLE V: EXTRAOCULAR MUSCLE RECESSIONS FOR THYROID OCULAR MYOPATHY
COMPARISON OF OUTCOMES FROM OTHER SERIES

	PRESENT STUDY	SKOV ET AL[25]	KUSHNER[10]*	TROKEL ET AL[4]	TOTAL
Success rates without prisms:					
Nonadjustable surgery	38% (10/26)	100% (2/2)	75% (6/8)	43% (21/49)	46% (39/85)
Adjustable surgery	64% (7/11)	50% (1/2)	92% (24/26)	40% (2/5)	77% (34/44)
P value	.279†	1.000†	.483‡	1.000‡	< .001§
Reoperation rates:					
Nonadjustable surgery	35% (9/26)	0% (0/2)	25% (2/8)	29% (14/49)	29% (25/85)
Adjustable surgery	9% (1/11)	0% (0/2)	8% (2/26)	40% (2/5)	11% (5/44)
P value	.224†	1.000†	.483‡	.985‡	.021§

*Kushner defines "success" as ocular deviation of less than 5 prism diopters in primary position. Reoperation rate was unobtainable from his data.
†Fisher's exact test (two-tailed).
‡Chi-square test with Yates' correction for continuity.
§Chi-square test.

and 2 with prisms. In our study no comparable adjustable group exists, and thus no conclusion about nonadjustable versus adjustable surgery for horizontal restricted myopathy can be made. With such a high success rate after nonadjustable medial rectus surgery, an advantage will remain difficult to demonstrate.

Recently, we have begun to implement adjustable suture surgery for individuals with bilateral medial rectus and/or inferior rectus muscle restriction. Preliminary results indicate a better chance for fusion after one operation when multiple muscles are adjusted postoperatively in these severely afflicted patients. Others have also advocated adjustable surgery for these complicated cases.[16,18,19,23,30]

Our results show marked variability between the amount of recession and outcome among individuals. The effect of nonadjustable inferior muscle recession ranged from 0.29 to 8.62 prism diopters per millimeter of recession (mean, 3.9 prism diopters per millimeter). The range for unilateral medial rectus muscle recession was also great, varying from 0.67 to 5.60 prism diopters per millimeter (mean, 3.5 prism diopters per millimeter).

The cause of this variability in outcome for a particular amount of recession stems mainly from the unequal alteration of muscle elasticity, length, lever arm, and opposing muscle forces in thyroid patients. Since the ultimate clinical effect of all these forces cannot yet be thoroughly quantitated,[31] other means are used to gauge the amount of recession. Mourits and associates[8] employed the time-honored method of deriving the amount ?of recession according to the angle of deviation. Char[32] recommends recessing the inferior rectus muscle approximately 1 mm/2.5 prism diopters of deviation. Many investigators, including us, determine the extent of recession intraoperatively, by performing forced ductions and noting the muscle's appearance.[1,4,5,7,25,27] Dyer[33] recesses the inferior rectus muscle until the pupillary light reflex lies a little above center during general anesthesia.

Adjustable suture surgery allows one to change a muscle's position after all mechanical and innervational forces are assessed, thus obviating the need to measure these parameters. The problem now becomes where to leave the patient aligned in the immediate postoperative period to ensure a stable result. We and most other strabismus surgeons adjust to orthotropia, as long as ductions remain acceptable. This gives an individual the best chance of maintaining fusion without prisms.

Complications other than misalignment occurred. Even though all muscle suture knots were buried, patients who had adjustable strabismus surgery reported more irritation than those who underwent nonadjustable surgery. These particular patients did not subjectively demonstrate more

inflammation, lower lid retraction, proptosis or exposure keratopathy. The most probable explanation may be that they felt the exposed conjunctival suture knots. Two patients in the adjustable and six patients in the nonadjustable group (22% of the total patients) had postoperative lower lid retraction severe enough to require surgical correction. Kushner[34] demonstrated a statistically significant reduction in postoperative lower eyelid retraction when the capsulopalpebral head was advanced at the time of inferior rectus recession. Even though this supplemental procedure was not found to be as effective with large recessions, and was reportedly more difficult when used with adjustable sutures, Graves' patients would probably benefit from its use because they usually have exposure keratopathy for many other reasons. The only other notable complication in our series was the development of lower lid ectropion in a patient who underwent nonadjustable inferior rectus recession. Every one of our patients tolerated adjustment well: no suture breakage, muscle slippage, or vasovagal reactions[35] occurred. No one in either group had anterior segment ischemia or infection after surgery.

Our study has many limitations. As a retrospective, nonrandomized series, it naturally introduces bias. Since the preoperative decompression rate was higher for the nonadjustable group, these patients may represent a more difficult set of cases. Their preoperative hypotropia was not any more severe than that of others in the series. Mourits and associates[8] found no correlation between success of strabismus surgery and prior decompression. When we eliminate decompressed patients from both categories, the success rate for the nonadjustable technique changes from 38% to 35%, but the adjustable rate remains the same (60%). The pooled success rates still remain significantly different ($P = .001$ by chi-square). Thus, the higher decompression rate does not seem to account for the poorer outcomes in the nonadjustable group.

The fact that the follow-up time for the nonadjustable group was double that for the adjustable group may allow for over representation of poor results, especially reoperations. However, the 6-week measurements were excellent indicators of outcome in our study as well as in others.[21,27] Many investigators[13,21,22,27,36] have found little difference in postoperative alignment drift between nonadjustable and adjustable sutures.

Another limitation of our study is the fact that we did not quantify the amount of the adjusted recessions. Kushner and associates[37] have devised a simple method to determine the ultimate amount of recession using the adjustable sutures. Correlating the amount of adjusted recession with different preoperative measurements may help develop more definitive treatment plans for each patient with thyroid ocular myopathy. Recently, Hud-

son and Feldon[38] associated the preoperative degree of proptosis and superior rectus volume with risk of overcorrection of hypotropia by the adjustable suture method. Quantified adjustable suture strabismus surgery may be useful as a research tool.

Probably the most important problem with our study stems from our reliance on others' outcomes (and thus procedures) to determine a significant advantage of adjustable sutures over traditional surgery. Also, the pooled data include thyroid ocular myopathy patients with any pattern of muscle restriction. However, this is the best information presently obtainable.

Our study's main advantage is in its approach: to compare two groups that are as similar as possible. We thoroughly analyzed preoperative measurements performed by one observer. We made every effort to detect superior rectus restriction especially when inferior rectus restriction was substantial.[1,4,26,27] Follow-up times were quite long relative to other reported series.

SUMMARY

Our results pooled with those of others[4,10,25] demonstrate a statistically significant improvement in outcome when adjustable sutures are implemented in the treatment of thyroid ocular myopathy. To our knowledge, this degree of significance has not been reported previously. We believe the value of adjustable suture strabismus surgery lies mainly in the prevention of large undercorrections and overcorrections. However, one cannot guarantee fusion or long-term alignment stability, especially without prism use. A randomized, prospective, controlled study to compare the nonadjustable and adjustable techniques for the treatment of thyroid ocular myopathy has yet to be performed.

The success of any type of strabismus surgery relies on many factors. Future endeavors should implement the quantified adjustable suture technique to better define how preoperative conditions influence the response to strabismus surgery in Graves' patients.

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DISCUSSION

DR EUGENE M. HELVESTON. The authors have treated 52 patients with thyroid ocular myopathy between 1981 and 1991. They chose for study 37 patients who had unilateral surgery. These patients were further subdivided into 26 who had nonadjustable inferior rectus recession and 11 who had adjustable inferior rectus recession. The authors define successful treatment in these patients as fusion without the need for prism in the primary position and the ability to read without prism after just one operation.

The authors have in a very forthright manner actually done most of the discusser's work. They point out four limitations of this study, and I will add a fifth. First, the study is retrospective. All retrospective studies are subject to bias, even with sincere attempts at objectivity. However, recognition of this shortcoming is not intended to rule out the importance of retrospective studies. Second, the patients were not randomized and then placed in a case-control format. By this technique, the authors could have alternated treatment between adjustable and nonadjustable sutures using similar criteria for patient inclusion and thereby arriving at a more convincing result. The possibility of doing this type of procedure was severely hampered by the authors' apparent belief that adjustable sutures were more appropriately applied to this patient population. Third, the follow-up period in the adjustable suture group is slightly shorter than in the nonadjustable suture group. Since thyroid ocular myopathy is a condition that tends to be progressive, this does change the character of these two groups. One can only suspect that the longer the period of follow-up, the more likely a given patient would be to demonstrate a poor outcome, which in the case of thyroid ocular myopathy tends to be progressive overcorrection. Fourth, the authors point out that the adjustable sutures were not quantified. In the paper they did describe a technique for doing this and suggest that they will make an attempt to quantify the amount of adjustment in the future.

The authors' reliance on the data of others is a slightly more serious problem. They cite three papers and "borrow" data from each of them to bolster their numbers and arrive at statistical relevance. In the paper by Skov and Mazow, only four patients are described.

All were treated with adjustable suture, and one failed to meet the authors' criteria for success. These numbers alone are not significant. How do they add to the authors' "numbers" significantly?

In the paper by Trokel and associates, the authors treated only seven patients with

adjustable sutures, and they state that when adjustable suture procedures were examined separately, the results were very similar to the group as a whole (those with and without adjustable sutures). The third paper, by Kushner, provides the statistical "ammunition" the authors need to arrive at statistical significance for their paper. Kushner reports success in 24 of 26 patients with endocrine ophthalmopathy treated with adjustable suture. At the same time, he reports success in 6 of 8 patients treated with nonadjustable suture. This paper, also retrospective, while supporting the authors' contention that adjustable sutures are successful, also implies that nonadjustable sutures are successful too.

One of the most important features of this paper is not addressed specifically, and I will do so now. Ten of 26 patients with nonadjustable inferior rectus recession had overcorrections, and 3 of 11 patients treated with adjustable suture had overcorrections. In my experience, overcorrection in thyroid ocular myopathy after inferior rectus recession is a very difficult, long-term problem. These patients tend to progress with their overcorrection and often require multiple reoperations. The unique anatomy of the inferior rectus muscle in its relationship with the inferior oblique and Lockwood's ligament makes this muscle more likely to become disengaged from its scleral union and to become excessively weakened. Once this event has occurred, even full corrections at reoperation tend to revert to hyperdeviations.

Finally, thyroid ocular myopathy as pointed out by the authors is a disease of all six extraocular muscles. Surgery aimed at treating just one of these muscles has the chance of failing because there are 11 other muscles involved. Careful attention to passive duction testing in both eyes is an important guide to the design of appropriate surgery and should be emphasized.

The authors are to be congratulated for their efforts in further describing the clinically challenging problem of thyroid ocular myopathy. I also wish to thank them for providing me with their written paper well in advance of this meeting, thereby adequate time to allow preparation of this discussion.

DR SUZANNE VÉRONNEAU-TROUTMAN. Good morning. I would like to congratulate the authors on an interesting paper and I also enjoyed the discussion of Dr Helveston. Drs Kraus and Bullock seem to have used a similar technique for recession with and without adjustable sutures, that is a simple threading of the suture close to the insertion with a lock at each end of the muscle to include the ciliary arteries. When not using an adjustable suture one can reduce the possibility of a slipped muscle by passing each end of the suture from the episcleral bite again through the muscle cut edge in a "U" fashion before tying. However this technique cannot be used with an adjustable suture. Therefore for the latter I start the passage of the suture needle in the middle third of the insertion and place a security knot before threading each end of the suture in turn at the borders of the muscle to include the ciliary arteries.

I would like to know if the authors have any idea why the adjustable suture technique, popular at the time of Bielshowsky, fell into disfavor and regained popularity only in the 1970s when reintroduced by Jampolsky. Is it because we are using different and smaller sutures that create less tissue reaction?

My third "question-remark" is related to the wide range of the effect of a

nonadjustable inferior rectus recession as noted by authors (0.3 to 8.6 prism diopters per millimeter). As the surgical success rate was greater when an adjustable technique was used it would be interesting to know the correction achieved in that group. However, this is not possible unless a marker on the suture is used as described by Dr Flynn some years ago. Thank you.

DR MALCOLM MAZOW. I would like to make a couple of comments on this excellent paper.

There is a condition that I call "masked bilateral thyroid eye disease." Masked thyroid eye disease occurs either as a result of the contralateral inferior rectus being involved or ipsilateral superior rectus involvement after the inferior rectus is weakened. Often the involvement is asymmetrical. I have found that if you do not evaluate for both conditions, an overcorrection with diplopia may occur in downgaze. If fusion is present, then both inferior rectus muscles must be operated on at the same time. The binocular field is an extremely important test that must be done on every patient with thyroid disease or any restrictive strabismus with fusion so as to not to destroy binocularity in downgaze.

In thyroid eye muscle disorders, there is muscle involvement in certain patients and there is connective tissue involvement without muscle change in others. If an adjustable procedure is done when the muscle placement is altered, then even though you adjust and allow it to hang back a given number of millimeters, the muscle will not fall back appropriately. Attachment may occur at the old insertion site, where raw surface attaches to raw surface. The decision for adjustment is based on intraoperative findings as related to forced ductions after the muscle has been removed. When the muscle is freely movable and not stiff then an adjustable technique can be performed. Otherwise the muscle needs to be recessed without adjustment.

DR ALBERT BIGLAN. The authors have presented a well thought-out study on the use of adjustable sutures in the management of patients with thyroid eye disease. Once stability of the ocular alignment has occurred, this certainly seems to be the preferred technique for treatment of the related strabismus problems.

I would encourage the authors to consider performing adjustment of the muscle position in the operating room. Patients can be prepared for this by having the anesthesiologist use a combination of intravenous sedation and analgesic medications. Drugs such as midazolam HCl (Versed), diprivan (Propofol), and fentanyl citrate (Sublimaze) combined with a topical proparacaine HCl and a perimuscular injection of mepivacaine (Carbocaine) will provide sufficient anesthesia for strabismus surgery in cooperative adults. Just prior to performing an adjustment of the muscle position, I ask the anesthesiologist to stop the diprivan intravenous sedation. The patient will then become alert and responsive, and he or she can be placed in a seated position while remaining on the operating room table. Prism and cover testing can then be performed on a fixation target. To adjust the muscle position, the patient is again placed into the recumbent position and adjustment is made on the position of the muscle. This may be repeated as frequently as needed.

I have found that patients with thyroid eye disease have marked chemosis and soft tissue reaction following strabismus procedures. To reduce this, I routinely treat patients with perimuscular injections of 40 mg/cc of dexamethasone (Decadron). I infiltrate about 0.2 to 0.3 cc of this drug into Tenon's capsule and perimuscular tissue in proximity to the extraocular muscle. I have found these measures to be very helpful in the management of patients with strabismus related to thyroid eye disease.

DR THOMAS FRANCE. I would like to echo the other comments regarding the good job these authors did in presenting this information to us and to also echo the concerns expressed by Drs Helveston and Mazow regarding the variability in thyroid patients and their eye muscles. Dr Bullock, I would like to know a little bit about what Dr Troutman has already suggested. How many millimeters of adjustment were repaired on average with these muscles based on your suggested 3 prism diopters per millimeter initial placement. In my experience the muscles are quite variable as to how tight they are. Sometimes you can pull the muscle up very nicely while other times they are quite tight. Obviously the tighter the muscle the more response you are going to get. For that reason I think formulas have generally not proven to be very useful in patients with thyroid myopathy.

Did you find that the 3 prism diopters per millimeter was accurate? How often and how did you have to change it? And could you relate this to the amount of restriction that you found at the time of surgery?

DR EDWARD L. RAAB. I too enjoyed this paper. We tend to assume that thyroid ocular myopathy is entirely a restrictive problem. However, there are observations, including my own that I have described in other discussions here, indicating that there is an additional condition of varying muscle force since these muscles are infiltrated and act as though they are myopathic. If Dr Bullock extends his study, I would recommend that he investigate muscle force either directly with a strain gauge type of device, or indirectly such as by saccadic velocity recordings. Otherwise there could be some confounding of his observations when alignment is used as an outcome, since alignment can be fortuitously good, as well as bad, in the presence of multiple weak muscles. Such information would add to this valuable contribution.

DR JOHN T. FLYNN. I would like to add my congratulations to Dr Bullock and co-workers on an elegant study. Thyroid eye disease is a very tricky muscle disease to treat. I would like to underscore a couple of points that the discussants and authors have made. It is very important to me to know at the outset, has this patient had an orbital decompression? Because thyroid eye muscle disease in the presence of orbital decompression is a very, very different animal than thyroid eye disease in the absence of the same.

The second point I would like to make is that extraocular muscle surgery for thyroid eye disease has moved, at this point in time, to the point where I do not believe we will ever go back to the nonadjustable suture era. I, therefore, don't think we will ever get the randomized, prospective trial of fixed versus adjustable sutures

in this entity. Surgeons have, in my experience, moved in the direction of the adjustable suture for the treatment of this disorder.

The final point I would like to make is that the measurement that is most important is where you have left the muscle after you have adjusted it. There are several simple ways to do this and one that we like is to add a third suture, which is a measured 5 cm suture, attached to the cut end of the muscle. After you have finished the adjustment, you simply pull that suture taut and cut it at the limbus. By subtracting the difference between the cut end of the suture and 5 cm you know exactly where you have left the muscle, give or take a millimeter perhaps. It helps you to build a learning curve as to what each millimeter of adjustable suture recession means in your hands.

DR RONALD BURDE. I would like to echo what everyone has said. I think this is a provocative paper. I would like to add to what Dr Flynn said that not only is the patient who has had orbital decompression different, but those who have been radiated are also. If one were going to classify patients with orbitopathy, then one would have to classify them into a group which had not been treated medically with corticosteroids or immunosuppressants, a group treated with radiation therapy, and a group undergoing orbital decompression, so that we can get a clear view of what is going on.

Secondly, Dr Scott has recorded and Dr Roper-Hall and I reported as well, 77 cases that developed an A-pattern postoperatively on the inferior rectus. I wonder if the authors are doing anything to try to avoid the development of such an A pattern which to us has been a very troublesome problem, especially in the reading position.

I would also like to mention, and I think Dr Kearns would agree, that among those patients who have thyroid ocular myopathy, which is an autoimmune disease, some will act differently from what you might expect. In those instances, Tensilon testing is in order. You will find that there is a very significant incidence of myasthenia gravis in these patients which has been well reported in the literature. Myasthenia gravis and thyroid ocular myopathy often appear concurrently. These patients have both positive forced ductions and myasthenic weakness. Their malposition or ptosis will be Tensilon responsive.

DR JOHN D. BULLOCK. Dr Helveston's comment about the evolution of thyroid ocular myopathy is certainly true. Many Graves' patients do change over time; different muscles can deelop inflammation and fibrosis after extraocular muscle surgery on the opposite eye. Dr Flynn mentioned the effect of decompression on thyroid ocular myopathy. When we evaluated that we did not find a difference between our two groups. He also commented on intraoperative suture placement. Ours was a retrospective study; if we were going to do the study in the future, we would certainly follow his suggestion. That is an excellent idea.

Dr Véronneau-Troutmen mentioned a "security not. Fortunately we have not had slippage. Hers is an excellent suggestion, but we have not yet tried it. She also talked about the amount of intraoperative adjustment. That was also not quantitated. Dr

Raab mentioned muscle force studies. This is an excellent idea that we will incorporate into future studies.

Dr Burde mentioned the association between myasthenia gravis and thyroid eye disease. He raises an excellent point. As far as we know, none of our patients had myasthenia gravis.

Dr Mazow mentioned intraoperative adjustments. We were not too concerned about the exact placement because we knew that we could correct either an overcorrection or an undercorrection during the adjustment portion of the operation the following day. We do not feel that the initial positioning was that critical. Dr Biglan also mentioned intraoperative measurements. I have addressed that in comments above. Dr Frace commented on muscle placement. Our initial muscle placement was merely a rough guide, based on the amount of preoperative tropia and on intraoperative forced ductions.

I wish to thank all of the discussants, especially Dr Helveston, for their insightful and helpful comments.