Drift of ocular alignment following strabismus surgery. Part 2: using adjustable sutures

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ABSTRACT

Aim: To measure the drift of ocular alignment following strabismus surgery utilising adjustable sutures.

Methods: 106 patients, aged 12 to 84 years, underwent adjustable suture strabismus surgery with a follow-up of 0.5–4 years (mean 24.3 months).

Results: For all subjects measured on distant fixation, there was a mean undercorrection drift of 8.3 (SD 2.3) prism dioptres (PD) from week 1 to 48 months postoperatively ($p = 0.005$). Patients with exotropia demonstrated an undercorrection drift on distant fixation from week 1 to 2 years (mean 10.1 (3.5) PD, $p = 0.023$). Patients who underwent recession surgery developed a mean 9.1 (3.3) PD undercorrection drift from week 1 to 3 years ($p = 0.031$). Patients who had unilateral recession and resection surgery showed a mean 6.8 (2.9) PD undercorrection drift from week 1 to 18 months ($p = 0.049$). Patients with constant or intermittent postoperative stereopsis had a statistically significant undercorrection drift ($\leqslant 5.1$ PD) at certain postoperative periods ($p < 0.042$), while those without stereopsis had no significant drift.

Conclusion: Most patients developed a general drift toward undercorrection, especially following recession or recession with resection surgery and those with exotropia. Surgeons should consider creating a mild overcorrection at the time of suture adjustment, while avoiding long-term diplopia.

Adjustable sutures are now widely used for strabismus surgery.[1 2] However, there is still a level of uncertainty as to whether this technique provides a better outcome. A recent Cochrane systemic review found that no reliable conclusions could be reached as to whether adjustable or non-adjustable suture surgery produced a more accurate long-term ocular alignment.[3] Only a few studies have addressed the long-term results of this surgery.

The long-term changes following adjustable suture surgery could potentially differ from fixed suture surgery. A muscle suspended by a suture from the insertion could recess further than intended with continued tension supplied by the muscle in the awake state. Alternatively, the muscle could creep forward in the course of healing due to fibrosis. Indeed, in an animal model of the "hang-back" technique, Repka and colleagues found an anterior displacement of the muscle of 0.4 to 1.1 mm depending on the amount of recession.[4] Wysenbeek and associates found in "hang-back" techniques that the greater the amount of recession, the greater the tendency to displace anteriorly.[5] Even after the healing phase may be completed, forces beside that exerted by the muscle could affect ocular alignment.

To ascertain the long-term results following adjustable suture strabismus surgery, we chose to study ocular drift postoperatively. We analysed the drift patterns for patients with esotropia (ET), exotropia (XT) and vertical strabismus (HT) with follow-up from 6 months to as long as 4 years. This analysis may help suggest the proper ocular alignment of patients with ET, XT or HT at the time of adjustment.

MATERIALS AND METHODS

This protocol and HIPPA issues were approved by the Institution Review Board of the Office for Protection of Research Subjects of UCLA. We performed a retrospective chart review of 106 patients who had undergone strabismus surgery utilising adjustable sutures between August 1992 and January 2005. All surgeries were performed by one surgeon (SJI). We included patients with at least 6 months' follow-up who were at least 12 years of age at time of surgery. Patients who had recession, resection or recession and resection surgery were included. Patients who had undergone surgery for esotropia, exotropia, hyper- or hypotropia either for the first time or as a reoperation were included. We excluded patients who had horizontal and vertical surgery performed simultaneously. Patients undergoing another type of ophthalmic surgery in addition to one of the previously stated surgeries were excluded from the study.

All patients underwent a similar operative procedure. All adjustable suture operations were done with 6-0 Vicryl (Ethicon, Somerville, New Jersey) as a "hang-back" procedure utilising a slip-knot.[6] The "suture noose" technique was not employed. For recession-resection surgery, only the recessed muscle was placed on an adjustable suture. Subconjunctival corticosteroids were injected for reoperated muscles only.[7] At adjustment, most cases were aligned from "straight" to a small overcorrection. Postoperatively, an antibiotic-steroid eye-drop was used for 2 weeks.

Patients were divided into three groups based on (1) type of strabismus: esotropia, exotropia and hypertropia; (2) alignment at the first postoperative week: overcorrection, orthophoria (± 2 PD) and undercorrection and (3) type of surgery: recession alone, resection alone and recession with resection.

Patients were divided into another set of three groups based on the pattern of stereopsis during their follow-up: constant stereopsis (stereopsis found on every postoperative visit), intermittent

stereopsis (stereopsis found on some postoperative visits) and no stereopsis found on any visit. Stereopsis was measured using the Titmus test (Stereo Optical Co., Chicago) with optical correction. Our technique of stereopsis measurement has been previously described.[8 9]

We measured the change in ocular alignment from the first postoperative week to 6, 12, 18, 24, 27, 30, 36, 42 and 48 months. For statistical analysis, the change in drift within each group was assessed using the Wilcoxon signed rank test. A p value of $\leqslant 0.05$ was considered to be statistically significant.

RESULTS

One hundred and six patients were included in the study. Forty-five of the subjects were female. The mean age was 38 years (range 12 to 84 years). The mean follow-up was 24.3 months (range 6 to 142 months). Table 1 indicates the number of subjects examined over the follow-up period. Twenty-five of the subjects were not examined at the 6 (SD 1) month visit, but were examined at subsequent time periods. The sum of patients in each subgroup may be less than the total number of patients included in the study because patients with insufficient data for a particular group were not included.

For all subjects measured on distant fixation, the drift towards undercorrection was significant whether considered at 1, 2, 3 or 4 postoperative years ($p \leqslant 0.032$) (table 2A). The drift pattern on near fixation was not statistically significant for any time period studied.

Thirty-four (32%) patients had esotropia, 36 (34%) had exotropia, and 16 (15%) had hyper- or hypotropia (fig 1). When measuring the drift of exotropic patients from week 1 to 24 months postoperatively, a statistically significant drift towards undercorrection was noted (table 2B). When exotropic patients were measured on near fixation, there was a mean of 2.5 (1.3) prism dioptres (PD) undercorrection drift at 6 postoperative weeks ($p = 0.033$), but all subsequent drift at near was not statistically significant. All other patients (esotropia and hypertropia) showed no significant drift pattern over a maximal period of 48 months' follow-up.

Fifty (47%) patients underwent recession surgery, 40 (38%) unilateral recession and resection surgery, eight (8%) resection surgery and eight (8%) other types of strabismus surgery. Patients who underwent recession surgery developed a statistically significant undercorrection drift from week 1 through 36 months on distant fixation (table 2C). However, when measured on near fixation, patients who underwent recession surgery developed a statistically significant mean undercorrection drift of 1.3 (0.6) PD from week 1 to week 6 ($p = 0.028$) but not thereafter. Patients who underwent unilateral recession and resection surgery demonstrated an undercorrection drift for all periods when measured on distant fixation, but only the change from week 1 to 18 months was significant (mean 6.8 (2.9) PD, $p = 0.049$) (table 2D). At distant fixation, patients who underwent resection surgery developed no significant drift. For near fixation, the drift was not statistically significant for patients who underwent resection or unilateral recession and resection surgery (fig 2).

Table 1 No of subjects examined over time

Months (SD 1) (postop)	No of subjects
0	106
6	81
12	71
18	34
24	30
30	11
36	17
48	13

The near and distant fixation drift patterns showed no statistically significant difference between those patients undergoing primary surgery and those undergoing reoperation ($p = 0.054$ to 1.00 at different follow-up periods).

When measured at distance during the first postoperative week, 39 (40.6%) cases demonstrated orthophoria (SD 2 PD), 18 (18.8%) cases undercorrection and 49 (51.0%) cases overcorrection. There was no significant subsequent drift in patients who measured overcorrection, undercorrection or orthophoria (SD 2 PD) at distance fixation during the first postoperative week. When measured at near during the first postoperative week, 65 (61.3%) cases had orthophoria (SD 2 PD), 15 (14.2%) cases undercorrection and 26 (24.5%) cases overcorrection. Patients overcorrected for near fixation at 1 week postoperative demonstrated a mean undercorrection drift of 2.8 (2.5) PD at 12 months ($p = 0.002$), 7.3 (4.9) PD at 18 months ($p = 0.053$) and 14.0 (12.0) PD at 42 months ($p = 0.053$). There was no significant drift in patients who measured undercorrection or orthophoria (SD 2 PD) at near during the first postoperative week.

Through the entire follow-up period, 14 (14%) patients demonstrated no stereopsis, 60 (58%) displayed constant stereopsis, and 29 (28%) were found to have stereopsis intermittently. Patients who maintained stereopsis continually demonstrated a statistically significant undercorrection drift at certain time periods when measured on distant fixation (table 2E). When measured on near fixation, undercorrection drifts of 1.3 (0.7) ($p = 0.050$) and 1.9 (0.9) ($p = 0.033$) PD were present 12 and 18 months postoperatively. When patients with intermittent stereopsis were measured on distant fixation, a mean undercorrection drift was noted (table 2F). Regardless of stereopsis group, the statistically significant drifts were never more than about 5 PD, which would permit monofixation or another form of fusion. Patients who lacked stereopsis throughout their follow-up period developed no significant drift.

DISCUSSION

In this era of adjustable suture strabismus surgery, when the patient's eye position can be aligned at or shortly following surgery, it would be beneficial to obtain the best long-term result. In order to achieve this, we would need to know the natural history of ocular alignment changes after surgery and adjustment. We, therefore, investigated the pattern of alignment changes following this surgery.

Other studies have considered the alignment changes following adjustable suture strabismus surgery. With a mean follow-up of 7.5 months, Wisnicki and associates reported a reoperation rate of 9.7% but did not distinguish between over- and undercorrections.[10] With a mean follow-up of 13 months, Keech and colleagues reported an undercorrection drift pattern (11 PD) for their exotropic patients but an overcorrection drift for their patients with esotropia (6 PD).[11] Since no statistical evaluation was performed in that study, it is hard to compare their data with ours. There was also no statistical evaluation in the study by Eino and Kraft, who reported drift patterns 6–8 months after adjustable suture surgery.[12] Their esotropic patients were about equally over- and undercorrected. Most of their exotropic patients had an undercorrection drift of 3–7 PD, which agrees with our findings. On the other hand, Weston and coworkers statistically evaluated the drift following adjustable suture

Table 2 Mean (SD) drift on distant fixation compared with week 1 postoperative

Months (postop)	No of subjects	Drift (undercorrection, prism dioptres)	p Value
A. All subjects			
12	72	3.2 (1.0)	0.002
24	30	5.1 (1.5)	0.001
36	18	5.7 (2.5)	0.032
48	13	8.3 (2.3)	0.005
B. Exotropic patients			
12	21	6.9 (1.9)	0.003
18	13	7.2 (2.5)	0.021
24	9	10.1 (3.5)	0.023
36	6	6.8 (5.8)	0.438
48	5	9.6 (3.7)	0.125
C. Patients undergoing recession surgery			
12	35	3.0 (1.4)	0.019
24	15	5.6 (2.1)	0.023
36	8	9.1 (3.3)	0.031
48	5	8.0 (4.2)	0.188
D. Patients undergoing recession with resection surgery			
12	27	3.4 (2.0)	0.152
18	12	6.8 (2.9)	0.049
24	10	5.1 (3.3)	0.172
36	6	7.2 (4.2)	0.313
48	5	12.4 (3.3)	0.125
E. Patients who maintained constant stereopsis			
12	39	4.4 (1.0)	<0.001
18	20	4.2 (1.1)	<0.001
24	19	5.1 (1.6)	0.003
36	10	3.8 (3.0)	0.191
48	7	10.0 (3.7)	0.078
F. Patients with intermittent stereopsis			
1.5	28	3.3 (1.2)	0.014
3	24	4.2 (1.9)	0.035
6	21	4.6 (2.0)	0.042
12	24	3.4 (2.2)	0.192
24	10	5.7 (3.4)	0.172
36	5	7.8 (4.6)	0.250
48	4	5.0 (2.6)	0.250

surgery but only up a maximum of 6 months following surgery.[13] They found a statistically significant undercorrection drift for their exotropic patients (about 5 PD) but no significant drift for their esotropic patients.

Tripathi and associates compared results from adjustable and fixed suture techniques.[14] They reported a follow-up of 12–50 months with no mean or median values indicated. Reoperations were performed in 8.5% of their adjustable suture patients and 27.1% of their fixed suture patients. The criteria for reoperation were not given. All reoperations for the adjustable group were done for undercorrections, which is consistent with our findings.

Reviewing only patients with strabismus induced by thyroid ophthalmopathy, Lueder and coworkers reported results an average of 41 months following adjustable suture surgery.[15] A fair or poor outcome was found in 28% due to diplopia, but it is not clear if these were under- or overcorrections.

Similar to the findings of some of the studies cited above, we found exotropic patients to demonstrate a postoperative undercorrection drift at most time periods. Thus, it may be especially important to consider overcorrecting exotropic patients at the time of adjustment while being concerned to not produce long-term diplopia.

Unlike other authors, we have presented drift patterns for patients stratified by the type of surgery and their level of stereopsis. Patients who underwent recession and resection surgery or just recession surgery presented a general drift towards undercorrection. Therefore, an overcorrection may also be preferred when aligning patients undergoing recession and resection or just recession surgery.

The presence of stereopsis, either constantly or intermittently, led to an undercorrection drift during some time periods. The statistically significant undercorrection drifts were not greater than a mean of about 5 PD, which would still permit monofixation or another form of fusion. Those subjects who never demonstrated stereopsis had no consistent drift pattern. While informative, since the surgeon has no idea of the future pattern of stereopsis at the time of adjustment, they cannot consider this issue at that time.

Some limitations of this study should be noted. This study was retrospective. As such, there was an attenuation of patients over the maximum follow-up period of 4 years. While 71 were examined at 1 year, by 4 years the number decreased to 13. Yet, that number was sufficient to provide statistical significance for a number of the clinical situations that we studied. We included both primary surgeries and reoperations in this investigation. After the first postoperative week, the drift should not differ if the patient had undergone a primary surgery or a reoperation.[16] For the analysis, 1 week postoperative was used as time zero. This was done in order to fashion a direct comparison with Part 1

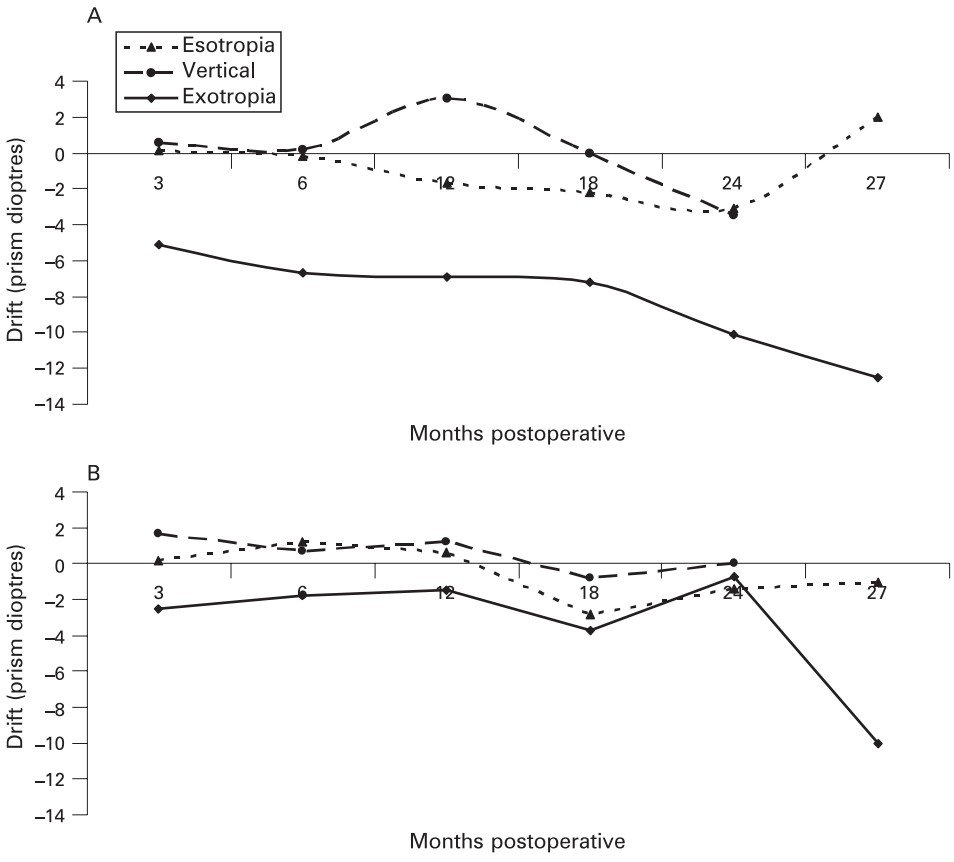

Figure 1 Type of strabismus: comparing mean postoperative drift for patients who had esotropia, exotropia and vertical strabismus at distant (top) and near (bottom) fixation. Comparisons were made over a duration of 3–48 months. A positive drift indicates an overcorrection postoperatively, and a negative drift indicates an undercorrection postoperatively. Each data point represents at least three subjects who may be different.

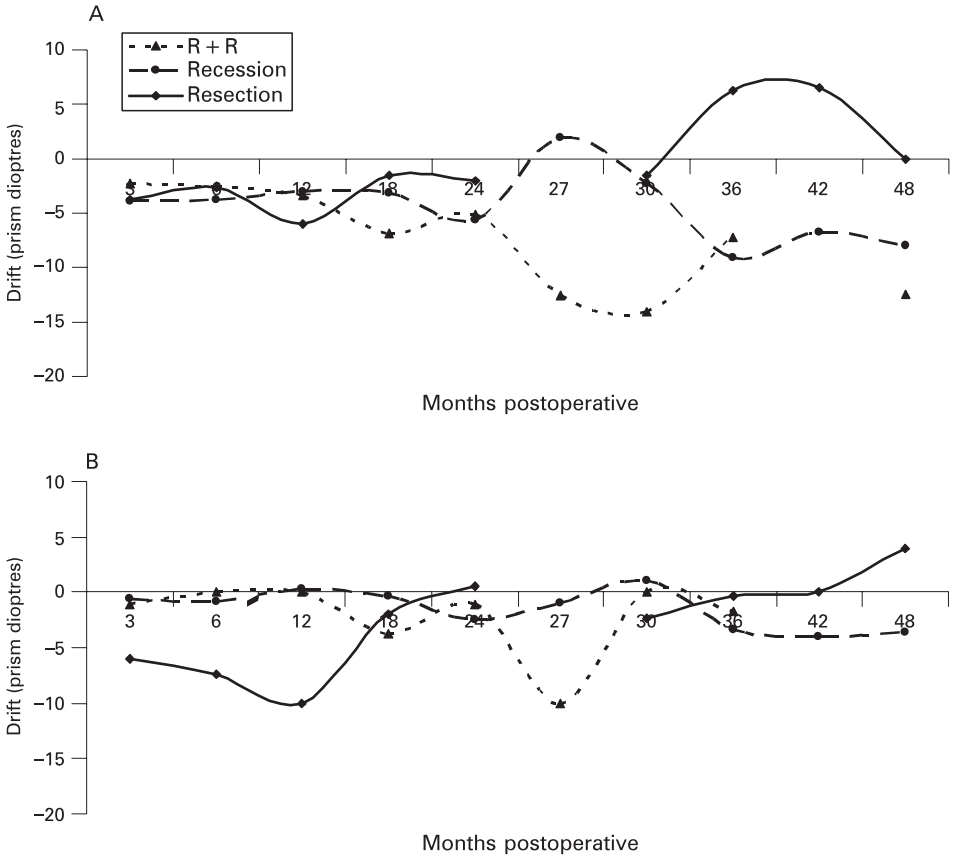

Figure 2 Type of surgery: comparing mean postoperative drift for patients who underwent recession, recession and resection (R+R) surgery at distant (top) and near (bottom) fixation. Comparisons were made over a duration of 3–48 months. A positive drift indicates an overcorrection postoperatively, and a negative drift indicates an undercorrection postoperatively. Each data point represents at least three subjects who may be different.

of this study.[16] Secondarily, creating this baseline would eliminate as much as possible the immediate consequences and complications of surgery. Such hindrances might include oedema, infection, bleeding, reactions to anaesthetic drugs and other complicating factors. By a week after surgery, these issues would have likely resolved.

When compared with Part 1 of this study, similarities and differences can be evaluated between patients with fixed and adjustable sutures. Similarities for distant fixation include statistically significant mean undercorrection drift for all patients, exotropic patients, patients undergoing recession surgery and overcorrected patients at 1 week postoperative. On the other hand, the fixed suture group demonstrated a more significant drift over a longer duration. This may imply that adjustable sutures provide less drift in the long run. Additionally, more statistically significant drift occurred with near fixation in the fixed suture group. Since fixed suture fixation patients were younger, their greater amplitudes for convergence and divergence may account for the drift patterns found with fixed sutures at near fixation.

In conclusion, these results can help provide clinical guidelines for strabismus surgery with adjustable sutures. At the time of adjustment, anticipating future undercorrection, especially for exotropic patients and those undergoing recessions alone or recessions with resections, the surgeon should consider a mild overcorrection while being mindful of cosmetic concerns and wary of long-term diplopia.

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