Delayed adjustable sutures: a multicentred clinical review

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ABSTRACT

Purpose To characterise the results of the largest patient series to date undergoing closed conjunctival delayed adjustable suture techniques.

Methods A multicentre retrospective review of 440 operations (patients aged 10—91 years) by five surgeons at four centres were evaluated for surgical outcomes associated with the delayed adjustable suture technique.

Results 26% (116 of 440) of all patients required postoperative manipulation, with individual surgeon rates ranging from 13% to 56%. The majority of these patients did not complain of diplopia in target gaze and/or had satisfactory cosmetic improvement as evaluated at the 1—3 months follow-up visit (84%). Transient complications included dellen, poor conjunctival appearance, filamentary keratitis, infection, granuloma, exposed suture and corneal abrasion. Serious complications were rare.

Conclusions This large multicentred series characterises the closed conjunctival delayed adjustable suture technique for the correction of strabismus. It may present some significant advantages to more traditional adjustable suture techniques.

The modern adjustable suture technique was popularised by Jampolsky.[1] This approach has allowed the strabismus surgeon the ability to "fine tune" surgical outcomes postoperatively. The typical adjustable suture approach includes the patient being patched in the immediate postoperative period with some type of mandatory procedure performed within the first 24 h following surgery. These include trimming sutures, closing conjunctiva or a planned adjustment. The patient has had minimal time for binocular adaptation and may still be uncomfortable from anaesthesia, local ocular oedema and pain. Patients may be anxious about being "awake" and are at risk for a vasovagal response during the adjustment.[2] From the physician's perspective, one is obliged to spend time performing this adjustment and make educated guesses about where to place the patient's alignment. Even in patients not requiring adjustment for alignment purposes, a procedural manipulation is required to close the conjunctiva and trim or tie the suture.

Saunders and O'Neill[3] described a technique for adjustable sutures, which could be cut flush with the conjunctiva, and the pole suture never knotted, affording minimal manipulation if no adjustment was needed. Taking this a step further by closing the conjunctiva in a permanent fashion to allow a delayed adjustment was initially described by Burns[4 5] and then revisited by Granet and Banuelos[6] and Nguyen *et al*.[7] Stimulated by these reports, case series of adults[8 9] and children[10] have recently been published.

The delayed adjustable suture concept utilises many previously reported modifications to the original Jampolsky adjustable suture.[11] A temporary conjunctival closure through limbal incision was described by Eustis *et al* in 1987 and later by Kraft *et al* in 1990.[12 13] Most used viscoelastic materials to augment the ease of adjustability and decrease scarring, as described by Clorfeine *et al* in 1987 and Granet *et al* in 1994.[14 15] The conjunctival retraction suture near the original muscle insertion was popularised by Wright in 1991.[16] These advances along with the closure of conjunctiva are the main components of the delayed adjustable suture technique.

To characterise how the delayed adjustable approach is currently being implemented in clinical practice, we combined data from various centres. Only descriptive statistics are reported below for the assistance of the practicing ophthalmologist.

SUBJECTS AND METHODS

A multicentre retrospective chart review evaluated the surgical outcomes associated with the delayed adjustable suture technique (University of California, San Diego, Institutional Review Board #040764). Three hundred and ninety-five patients (of which 45 patients had repeat adjustable suture strabismus surgery) were included in this study. Four hundred and forty operations (patients aged 10—91 years, average 48.9 years) by five surgeons at four centres from 1992 to 2005 were reviewed. These patients represent a reverse chronology for each surgeon. This means that the charts were reviewed starting with the most recent and working backwards. Of these patients, there was a slight preponderance of women (218) over men (177). Our population included strabismus secondary to thyroid disease, cataract surgery, cranial nerve weaknesses, scleral buckling surgery, trauma, vascular events, childhood onset and unknown etiologies.

Surgical technique included fornix (SLR, DBG, HSE) and limbal-based (CB, RSF usually) conjunctival incisions. The intact or resected recti muscles were reattached to sclera using a double-armed 6.0 absorbable suture in the "cross-swords" Parks style. The sutures were grasped approximately 2 cm from the scleral exit site and secured distally. A cinch knot (SLR, DBG, CB) or bow knot (HSE, RSF) was placed. Finally, an absorbable traction suture of similar size (5.0 or 6.0) was placed (by four of our five surgeons) adjacent to the original insertion site through partial thickness sclera with the ends secured to allow several millimetres of suture; this

suture could be easily distinguished from the cinch knot suture due to its differing length.[16] All sutures were tucked underneath the conjunctiva, which was re-approximated with 6.0, 7.0 or 8.0 absorbable suture, either vicryl (Ethicon, Somerville, New Jersey, USA) or chromic, as in figure 1. Some surgeons placed viscoelastic material overlying the adjustable sutures, new muscle insertion and muscle belly (SLR, DBG). Some surgeons used subconjunctival antibiotics, steroids and analgesia (SLR, DBG). All patients used topical antibiotics and steroids in the postoperative period. One surgeon used steroids in a bimodal fashion to account for initial inflammation and secondary inflammation due to suture resorption.

Adjustments were performed typically in the first week after surgery but ranged widely. Unsatisfactory outcomes were defined post hoc for this review as either >10 prism diopters (PD) of tropic horizontal deviation, patient or doctor dissatisfaction with cosmesis and/or sensory discomfort (defined as asthenopia or diplopia). Preadjustment anaesthetic consisted of topical proparacaine ± lidocaine liquid or gel with a few patients requiring subconjunctival injections to control pain during the adjustment procedure. The adjustment was performed by removing or stretching conjunctival sutures and positioning the globe with the traction suture to enable exposure of the cinch or bow knot. The knots were adjusted until the muscle was in its desired position, confirmed by motility testing before conjunctival closure with 6.0 or 8.0 absorbable suture. Evaluation of diplopia was by patient report in the chief complaint. Diplopia impeding normal daily life activities was deemed significant.

RESULTS

Study population and procedures

The strabismus distribution in our study was 31% isolated esotropia (137 of 440), 23% isolated exotropia (103 of 440), 19% isolated vertical (83 of 440) and 27% combined deviation (117 of 440). The operations consisted of 145 horizontal, 198 vertical and 97 combined procedures. The mean follow-up of these patients was 10.8 months (range 1 week–10 years).

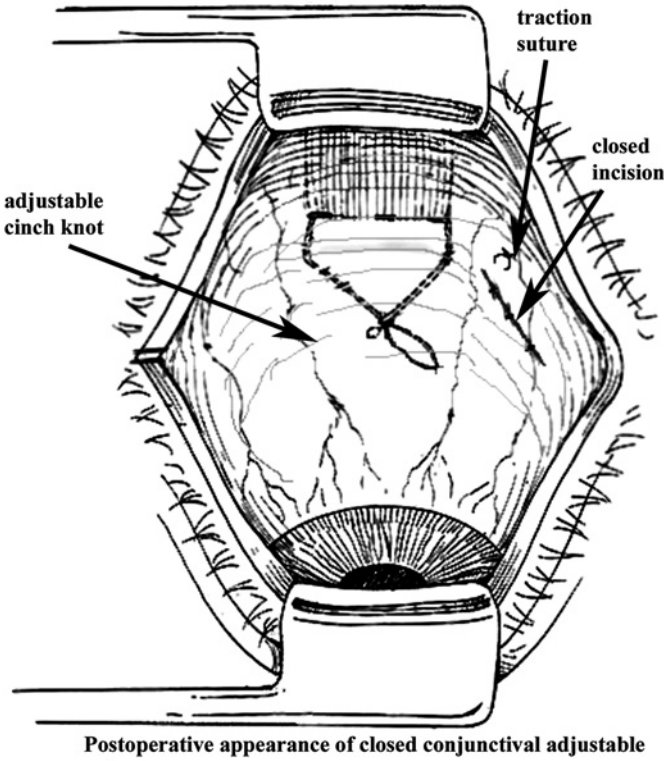

Figure 1 Postoperative appearance of closed conjunctival adjustable suture.

Rate and timing of adjustment

Just over 73% (324 of 440) of patients required no procedure at their 0–14 days postoperative visit. About one-quarter (26%, 116 of 440) of all patients received adjustment with individual surgeon rates ranging from 13% to 57% (table 1). Of the patients requiring adjustment, 55 were men and 49 were women. The median time to adjustment was 1 day post operation (range from 2 h to 14 days). The mean time to adjustment ranged by site from 0.96, 1.5, 1.6 to 5.8 days with an overall mean of 2.5 days. No surgeon reported extensive clinical early scleral adhesion during the adjustment process. Two of our surgeons performed a second adjustable procedure (9 of 116) at the 6- or 7-day mark. One patient was adjusted on 3 separate days. Of note, only one patient underwent adjustment at postoperative day 14. The largest proportion of patients required adjustment of horizontal (49%) or a horizontal and vertical muscle simultaneously (24%). Adjustable sutures of the vertical muscles had the lowest rate of adjustment (11%). Adjustment rate among patients with thyroid-induced strabismus was, as might be expected, higher at 30.23% (13 of 43).

Adjustment

The majority of patients requiring adjustment had initial preoperative horizontal deviations >20 PD or initial vertical deviations >10 PD (average 75%, ranging from 68% to 86%). There was no clear trend of required adjustment associated with larger amount of surgery performed. Of the adjusted patients with specific amounts of surgery reported, 63% underwent horizontal muscle surgery >3 mm and 51% underwent vertical muscle surgery >2 mm. The largest proportion of vertical adjustments compared to total patients submitted was performed at the centre where there was a greater proportion of strabismus induced by thyroid disease. The range of PD change accomplished by the adjustment procedure was 0–30 PD. Isolated adjustment averaged a change of 6.7 PD in the horizontal plane and 4.8 PD in the vertical plane. Combined horizontal and vertical muscle surgeries averaged an adjustment change of 6.8 PD in the horizontal plane and 5.7 PD in the vertical plane.

Overall satisfaction

In the total sample, all strabismus subgroups had high levels of patient satisfaction, defined as no report of diplopia in the chief complaint in target gaze and/or had cosmetic improvement at the short-term (1–3 month) and long-term (greater than 3 months) follow-up as documented in the chart review. The short-term satisfaction rates were highest in horizontal surgery (table 2).

Satisfaction of adjusted versus non-adjusted patients

The majority of the adjusted patients did not complain of diplopia in target gaze and/or had cosmetic improvement during the 1–3 months follow-up visit (84%, 93 of 111 patients with short term follow-up; table 3). This percentage slightly

Table 1 Rate of adjustment required

	Total	RSF patients	CB patients	SLR/DBG patients	HSE patients
Total patients	440	240	98	51	51
Adjusted patients	116	33	47	7	29
Percentage (%)	26.36	13.75	47.96	13.25	56.86

Table 2 Patient satisfaction and initial strabismus type

Preoperative strabismus type	No	Per cent of total sample	Short-term satisfaction (%)	Long-term satisfaction (%)
Esotropia isolated	137	31.14	92.59 (125/135)	87.60 (113/129)
Exotropia isolated	103	23.41	88.57 (93/105)	85.66 (86/97)
Hypertropia or hypotropia isolated	83	18.86	82.19 (60/73)	75.36 (52/69)
Combined horizontal and vertical	117	26.59	86.36 (95/110)	79.24 (84/106)
Total	440	100		

Satisfaction is defined as no troublesome diplopia in target gaze and/or had satisfactory cosmetic improvement. Short term is 1–3 months post operation and long term is >3 months post operation.

decreased at the >3 months follow-up. Of the patients who were measured after 3 months post operation, the rate of "unhappiness" (ie, diplopia in target gaze and/or no cosmetic improvement) in the adjusted patients changed from 16% at 1 to 3 months versus 24% at >3 months. Non-adjusted unsatisfied patients at 1–3 months follow-up numbered 10%, and at >3 months follow-up numbered 13.3%. There was no difference in long-term satisfaction based on the muscle adjusted (horizontal, vertical or combined).

The subset of patients that had an adjustable suture placed on the inferior rectus muscle had high levels of short-term satisfaction (1–3 months) at individual centres: 69% (9 of 13 patients), 80% (16 of 20 patients) and 94 % (43 of 46 patients) with a combined rate of 81%. The lowest long-term satisfaction group had the highest rate of thyroid-associated ophthalmopathy-induced strabismus.

Complications

The transient complications reported were dellen, poor conjunctival appearance, filamentary keratitis, infection, granuloma, cyst, exposed suture and corneal abrasion. There was a solitary case of corneal microperforation treated with glue and contact lens in a patient with severe-trauma-induced dry eye (long-term upper and lower lid retraction, lagophthalmos and exposure keratopathy) requiring previous tarsorraphy. There was one case of scleral perforation in a patient with previous retinal detachment and high myopia treated with retinal laser and repeat detachment surgery. The total untoward event rate, including all events, was 6% (29 of 440) with individual surgeon rates varying from 0.8% to 26%. Only patients who underwent adjustment presented with exposed suture, filamentary keratitis, infection and poor conjunctival cosmetic appearance. Issues in adjusted patient ranged from 0% to 8% at the four centres. Sutures were removed secondary to conjunctival irritation from 35 of 440 patients (8%).

DISCUSSION

The Cochrane Review of adjustable sutures did not show any prospective reports of that technique.[17] Strabismus surgery, in general, does not lend itself easily to controlled prospective studies across multiple centres. The current report was conceived to provide a clinical "snapshot" of a conceptual change to traditional adjustable sutures.

Multiple theoretic arguments have been advanced in favor of a delayed time before adjustment evaluation, including healing of the muscle and conjunctiva, reduced oedema of conjunctiva and tenon's capsule, improved accommodation on fixation target, avoidance of vasovagal episodes and waiting for changes in the length-tension curve of the operated muscle.[18] Later adjustments at 24 h compared to 6 h post operation have been noted to decrease nausea and vomiting with similar subjective pain in early and later adjustments.[19]

Perhaps the most appealing theoretical aspect of the delayed approach is the opportunity for binocular sensory motor adaptation and thus the ability to include the sensory system in the adjustment decision. Without a patch and given enough time in the postoperative period, the delayed adjustable suture patient has the chance to let fusion or other sensory motor adaptations (depending on the cause and timing of their strabismus) to be taken into account.

Previous reports have quantified the effect of delayed adjustment on alignment measurements.[20] Postoperative alignment measurements were significantly different in immediate and 24 h postoperative measurements in adjustable suture patients in 84% of patients with a mean drift of 7.2±4.3 PD. Postoperative deviation decreased in recession procedures and increased in resection or advancement procedures probably secondary to onset of splinting. These authors suggested that delayed adjustment may be optimal to achieve better long-term results given this early drift.

The current report describes the clinical implementation of delayed adjustable sutures. It includes surgeons from varying locations utilising techniques that were not standardised between centres, in "all-comer" strabismus populations. As such, the data reported should be useful to the practicing surgeon.

There are several findings in the present report that deserve highlighting. The delayed approach provides benefits to the patient and surgeon. Approximately 75% of our patients did not undergo the anxiety or discomfort associated with the additional adjustment procedure, yet they still benefited from the opportunity for adjustment if needed. This conserves surgeon time compared to the usual 100% manipulation (adjustment or otherwise trimming sutures, etc) rate required with traditional adjustable sutures. Approximately 25% of our sample required adjustment (vertical muscles had the lowest rate of adjustment at 11.1%), with a large range of surgeon variance. This may reflect a variability in postoperative alignment goals.

Table 3 Patient satisfaction in adjusted and non-adjusted patients

	No	Short-term satisfied	Long-term satisfied	Short-term unsatisfied	Long-term unsatisfied	Short-term unknown	Long-term unknown
Adjusted patients	116	93 (83.78%)	78 (76.47%)	18 (16.22%)	24 (23.53%)	5	14
Non-adjusted patients	324	280 (90.32%)	261 (86.71%)	30 (9.68%)	40 (13.29%)	14	23

Satisfaction is defined as no troublesome diplopia in target gaze and/or had cosmetic improvement. Short term is 1–3 months post operation and long term is >3 months post operation. Unknown means no follow-up by patient. Unknown follow-up was disregarded in percentage calculations of satisfaction.

One concern of the longer tucked adjustable sutures is creating an increased conjunctival reaction. Eustis[21] compared the conjunctival reaction to bow and cinch knots in 1993. This review, which included both tying techniques, did not find a clinical difference in conjunctival reaction. There was a greater satisfaction rate among the non-adjusted patients at short and long terms. This may be representative of the fact that more complex strabismus patients may often have less predictable outcomes.

The optimal timing of adjustment based on peak force required to advance a muscle on adjustable sutures was studied by Holmes *et al* in 1995.[22] These findings may not be clinically relevant when using materials such as viscoelastics and steroids. Searl *et al*[23] quantified histologic muscle changes "using a biologic sleeve" of viscoelastic in a rabbit model in 1987. This technique was later analysed in a larger case series by Granet *et al*[15] in humans. The materials hydroxypropylmethylcellulose and sodium hyalorunate significantly decreased the force needed to adjust muscle position in a rabbit model.[24] However, the use of 3% sodium hyaluronate and 4% chondroitin sulphate, Viscoat (Alcon, Fort Worth, Texas, USA) and mitomycin C were not as effective in reducing post-operative adhesions in a later study by Cengiz *et al*.[25] Other materials such as polyglycan ester in a gelatin matrix (ADCON-L) have shown promising results in animal adjustable suture models, enabling successful adjustments in 100% of the subjects up to 7 days post operation compared with 46% of the control subjects.[26] Even longer effects have been noted with slow release transilast in polytetrafluoroethylene/polylactide-co-glycolide laminate, where adjustments were possible in 80% of rabbit eye muscles at 3 and 5 weeks after surgery.[27] Additional studies are needed to ensure proper and stable muscle sclera adhesion in the long-term post-operative period. In the current review, surgeons chose to adjust based on many factors, including (1) age of the patient, (2) type of surgery, (3) convenience and (4) stability of the postoperative deviation.

The choice to use adjustable sutures is still not always agreed upon.[28] The Cochrane Review noted only one large controlled but not randomised clinical trial. This was the prospective Tripathi study, which looked at 443 patients with either adjustable or non-adjustable strabismus surgery.[29] A better result in the adjustable group was found in all outcome measures: re-operation rate (9%, 27%), patient satisfaction cosmetically (96%, 63%) or with diplopia relief (92%, 62%), and average change in angle of deviation (87.5%, 67%).

There were many confounding factors and limitations in our study, including multiple surgical techniques by various surgeons with no prospective threshold for success, its retrospective nature, lack of a randomised control group, and reverse chronology patient selection for each surgeon. This method of patient selection—looking at only the most recent patients—may discount the initial surgeon learning curve but was chosen to represent the current state of clinical practice. Moreover, the sensory status of the patient, whether their strabismus occurred before or after visual maturation, was not collected. Data could not be collected for the easiness of the adjustment, patient comfort or pain since this was retrospective in nature. The present report is intended to be a snapshot of current clinical practice only and should not be interpreted as a prospective clinical trial. For example, comparison of the outcomes of the various surgical techniques is not of use, data regarding alignment at various postoperative time points were not collected in comparable ways, and ease of adjustment was not quantified nor regularly noted by the surgeons in their chart notes.

Based on this review of clinical practice, the delayed adjustable suture approach is a technique with some significant real and potential advantages. These include (1) enough time (as defined by the surgeon until further works helps predict this) for binocular adaptation for postoperative, preadjustment measurement; (2) decreased interference from immediate pain and oedema on postoperative measurements; (3) increased patient comfort as well as decreased patient anxiety due to no patch, frequent lack of adjustment and thus lack of any manipulation; (4) improved ease of bilateral adjustable sutures as no patching is required; and (5) decreased physician time since most patients do not need adjustment and thus do not need any manipulation. At the physician's choice, the adjustment evaluation can take place in the time period judged most advantageous, rather than mandated within the first 24 h after surgery. A recent report using our closed conjunctival fornix approach, and applying it to children, also reports these advantages.[30]

We agree with the authors of the Cochrane Review regarding adjustable sutures.[17] A prospective randomised trial is needed to address issues of surgical outcome. Until then, the choice of using a closed conjunctival delayed approach to adjustable suture surgery is another valuable option for the strabismologist.

Competing interests None.

Ethics approval This study was conducted with the approval of the University of California, San Diego, Institutional Review Board (#040764).

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