A 10-Year Overview of Double Elevator Muscle Weakening Procedures

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Objective: To report the effect of weakening the superior rectus and inferior oblique (IO) muscles on ocular rotations.

Design: Observational case series. We reviewed a 10-year period of medical records of consecutive patients who underwent bilateral 5- to 11-mm (mean, 8.0 mm; SD, 1.1 mm) superior rectus muscle recessions combined with an IO muscle recession, myectomy, or anterior transposition. The effects on ocular rotations and eyelid position were recorded for the 37 patients (69 eyes) who were followed up for at least 6 months postoperatively. Nonparametric 1-way analysis of variance was used to compare results across the 3 procedures. The setting was a subspecialty practice at an academic institution.

Results: Supraduction deficiency was significantly associated with transposition of the IO muscle anterior to the inferior rectus muscle insertion compared with the standard IO muscle recession ($P = .001$), and IO muscle myectomy ($P = .009$). Y-pattern exotropia occurred more frequently after transposition of the IO muscle anterior to the inferior rectus muscle insertion than other weakening procedures ($P < .001$).

Conclusion: Transposition of the IO muscle anterior to the inferior rectus muscle insertion, combined with ipsilateral superior rectus muscle recession, results in more supraduction deficiency and more frequent Y-pattern exotropia compared with standard IO muscle recession.

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THE COMBINED PROCEDURE OF superior rectus (SR) muscle recession and inferior oblique (IO) muscle weakening has been used effectively to correct large-angle dissociated vertical deviation (DVD) or chin-down torticollis associated with vertical null-point nystagmus.1,2 While several other reports3,4 note this surgical approach, it has not been widely adopted because of concern about postoperative supraduction deficiency and/or habitual chin elevation. Upper eyelid retraction is a recognized complication of large SR muscle recession,5 which may be mitigated by careful dissection of the SR muscle from the levator.6 It is unknown whether IO muscle weakening will exacerbate the eyelid retraction or whether this combined procedure might possibly induce overdepression in adduction (superior oblique muscle “overaction”) or vertically incomitant strabismus. The following report is an observational case series of consecutive patients who underwent double elevator weakening procedures. Data collection and reporting were performed in accordance with guidelines of the institutional human subjects review board.

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METHODS

We reviewed the medical records of 37 patients who underwent bilateral SR muscle recessions of 5 to 11 mm combined with IO muscle recession, myectomy, or anterior transposition, during a 10-year period, from January 1, 1991, through December 31, 2000. All operated on patients were consecutive and included in this report, as long as follow-up criteria were met. The strabismus procedures were either combined or staged, depending on clinical circumstances. When IO muscle overaction was prominent, IO muscle weakening was performed first; when the DVD was prominent and IO muscle overaction was minimal or absent, SR muscle recession was performed first. Subsequent surgical interventions were determined based on existing clinical findings and irrespective of previous vertical surgery. There was no predetermined reduction in dose when both elevators were simultaneously weakened.

Patients were typically examined 1 and 5 weeks postoperatively, then at longer intervals. Minimum postoperative follow-up for inclusion was 6 months, and data used for analysis were based on the most recent office visit. Patients who underwent an IO muscle recession had a standard 10-mm recession, as described by Parks,7 with the exception that we...
placed the double-armed suture after disinserting the muscle from the globe. Both eyes of the 1 patient who underwent “de-
ervation and extirpation” were included in the myectomy
group, as well as the 1 patient who underwent free disinsert-
ton. Anterior transposition of the IO muscle (IOAT) was per-
formed with the muscle tendon cut flush with the sclera. The
muscle was then reattached with a double-armed 6-0 syn-
thetic suture in a manner that narrowed the new muscle in-
sertion, as previously described by Apt and Call. The level of
scleral fixation was noted, and ranged from 2 mm posterior to
the lateral border of the inferior rectus (IR) muscle insertion
to 2 mm anterior to the lateral border of the IR muscle inser-
tion. There was no attempt to spread out the IO muscle later-
ally.

The SR muscle recessions were performed conventionally,
with dissection of the adjacent Tenon capsule posteriorly, be-
cause it was believed this would reduce the risk of postopera-
tive eyelid retraction. All muscles were secured with double-
armed 6-0 synthetic sutures placed directly into the sclera.
“Hang-back” techniques were not used. In the 1 patient who
had a rerecession of the SR muscle for residual DVD, the final
muscle position on the globe was used for statistical analysis.

Preoperative surgical indications included moderate- to large-
angle DVD (typically ≥10 prism diopters) with IO muscle over-
action in 31 patients (84%), small or unquantifiable DVD with IO
muscle overaction in 4 patients (11%), and null-point nys-
tagmus causing chin-down head posture in 2 patients (3%). Of
the 37 patients, 33 underwent unplanned staged operations and
4 received single (combined) procedures. In patients without
nystagmus, the choice of the IO muscle weakening procedure,
when indicated, was based on the degree of elevation in ad-
duction vs the amount of DVD observed. Overaction of the IO
muscle was presumed in cases in which hypotropia could be
demonstrated in the abducting eye or the hypotropia was mark-
edly greater in adduction than primary gaze, representing the
additive effect of DVD and IO muscle overaction. Patients with
marked overelevation in adduction, with little DVD, typically
received an IO muscle myectomy (usually as a subsequent pro-
cedure after recession), while patients with DVD as the prin-
cipal finding underwent IO muscle recession or anterior trans-
position.

Postoperative evaluation included assessment of ocular ro-
tations and eyelid position, if judged to be abnormal or altered
postoperatively. The amount of postoperative supraduction de-
ficiency was estimated from primary position using a com-
monly used scale of duction deficiency from 0 to −4 in approxi-
mately 10° increments (0 indicates normal duction; −2, 50% duction limitation; and −4, no duction). All grading was done
by a single examiner (R.A.S.) who, in most cases, was naive to
the operative procedure before assigning a value to the duc-
tion deficit. Operated on eyes were grouped according to the
type of IO muscle surgery performed, and the amount of su-
praduction deficiency was subjected to 1-way analysis of vari-
ance, in addition to a Kruskal-Wallis test. The Spearman cor-
relation coefficient was used to evaluate the relationship between
deficiencies of supraduction and the amount of SR muscle re-
cession performed. The presence or absence of a “Y-pattern”
exotropia was noted and subjected to the Fisher exact test. A Y
pattern was defined as at least a 15–prism diopter increase in
the amount of exotropia in upgaze compared with the align-
ment in primary position and downgaze.

Sixty-nine eyes of the 37 patients met the criteria for in-
clusion in data analysis. The mean follow-up from final
surgical intervention was 57 months (range, 6-141 months). Six patients had 6 to 12 months of follow-up, 7 had 13 to 36 months of follow-up, and 24 had longer
than 36 months of follow-up. Thirty-five patients under-
went surgery for the correction of DVD, and 2 for ver-
tical null-point nystagmus with chin-down head pos-
ture. The resulting postoperative supraduction deficiencies
are shown in the Table. The mean postoperative supra-
duction deficiency was −1.1 (range, 0 to −3) in the 16
eyes that underwent IO muscle recession; −1.3 (range, 0 to −2) in the 19 eyes that underwent IO muscle myec-
tomy; −1.7 (range, 0 to −3) in the 15 eyes that under-
went IOAT even with, or posterior to, the insertion of the
IR muscle; and −2.2 (range, −1 to −3) in the 19 eyes that under-
went IOAT 1 to 2 mm anterior to the IR muscle inser-
tion. (The scale for upgaze deficit was given in the “Methods” section.) One-way analysis of variance by ranks
showed overall inequality among groups (Kruskal-
Wallis H = 16.665, P<.001). Pairwise comparisons showed
that supraduction was more likely to be limited after IO
muscle transposition anterior to the IR muscle inser-
tion than IO muscle recession (P=.001) or IO muscle myec-
tomy (P=.009). There was no detected difference in the
mean deficiency of supraduction between IOAT ante-
rior to the insertion of the IR muscle and smaller amounts
of IOAT (ie, even with, or posterior to, the IR muscle inser-
tion). Mean SR muscle recession performed was 8.0
mm (range, 3-11 mm; SD, 1.1 mm). There was no corre-
lation between supraduction deficiency and amount of
SR muscle recession when the type of IO muscle weak-
ening procedure was held constant.

Among the 33 patients undergoing staged pro-
cedures, the supraduction deficiency following initial SR
or IO muscle weakening was usually undetectable clini-
cally and never greater than −1. After subsequent sur-

Table. Mean Supraduction Postoperative Deficit Compared per Inferior Oblique Muscle Weakening Procedure

<table>
<thead>
<tr>
<th>Surgical Procedures</th>
<th>Muscle Recession</th>
<th>Muscle Myectomy</th>
<th>IOAT “Even”*</th>
<th>IOAT “Anterior”†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supraduction deficit‡</td>
<td>−1.1</td>
<td>−1.3</td>
<td>−1.7</td>
<td>−2.2</td>
</tr>
<tr>
<td>No. of eyes</td>
<td>16</td>
<td>19</td>
<td>15</td>
<td>19</td>
</tr>
</tbody>
</table>

Abbreviation: IOAT, anterior transposition of the inferior oblique muscle.

* Inferior oblique muscle attached, even with or posterior to the inferior rectus muscle insertion.
† Inferior oblique muscle attached 1 or 2 mm anterior to the inferior rectus muscle insertion.
‡ Indicates normal supraduction; −2, 50% limitation; and −4, no duction.
surgery on the SR or IO muscles, at least mild supraduction deficiency was present in all patients in the immediate postoperative period and persisted in 52 (85%) of 61 eyes. Marked (−2 or −3) supraduction deficiency occurred in 0 of 19 eyes in the IO muscle myectomy group, in 1 (6%) of 16 eyes in the IO muscle recession group, and in 3 (9%) of 32 eyes in the IOAT group (Figure 1). However, habitual chin-up head posture did not occur in any patient regardless of the surgical procedure. No patient or parent had subjective complaints related to postoperative supraduction deficiency.

Overdepression in adduction did not develop during follow-up. Y-pattern strabismus was noted on version testing in 7 patients, which represents 19% of the total cohort, but 58% of the 12 patients with IOAT anterior to the IR insertion. All 7 of these patients had undergone IOAT anterior to the IR muscle insertion in at least 1 eye (Figure 2). This association was significant (P < .001) based on the Fisher exact test.

Clinically important upper eyelid retraction occurred infrequently. While often noted in the immediate postoperative period, it persisted in only 1 patient. This occurred after a rerecession of the SR muscle, but before IO muscle surgery was performed. Recession of the levator muscle aponeurosis was eventually required to achieve an acceptable cosmetic result.

COMMENT

To our knowledge, the clinical outcomes of combined large SR muscle recession and IO muscle weakening have not been previously described in the English-language medical literature. Magoon and colleagues9 reported the complications secondary to large bilateral SR muscle recession in 25 consecutive patients undergoing surgical correction of DVD. Supraduction deficiency on the first postoperative day ranged from 0° to 20°, but improved spontaneously to an average of less than 10°. The maximum supraduction deficiency reported was 20°, which corresponds approximately to a −2 duction deficit. In addition, the researchers observed no surgically induced oblique muscle dysfunction or pattern strabismus.

In our series, the amount of supraduction deficiency after a combined IO and SR muscle weakening procedure was unpredictable. For example, 1 patient with large DVD underwent 10-mm SR muscle recession combined with IOAT (even with the IR muscle insertion), but had only −1 supraduction deficiency postoperatively. In contrast, another patient with a large DVD underwent a 7-mm SR muscle recession and IO muscle recession and had a −3 supraduction deficiency. This variability may be related to the underlying diagnosis, differences in surgical technique, or individual patient response. While it was difficult to differentiate the contribution of each procedure on the duction deficit based on the combined effect, our study suggests that the choice of IO muscle weakening procedure was the primary contributor to the final supraduction deficiency. Both patients with vertical null-point nystagmus underwent 4-muscle surgery as a single operation (IOAT 2 mm anterior to the IR insertion plus 8- or 9-mm SR muscle recessions), which resulted in bilateral −3 supraduction deficiency postoperatively. In 1 of these patients, the deficit spontaneously improved to −2 over several years. It is possible that the surgical effect obtained in a combined operation is greater than in a staged procedure. Alternatively, there may be a greater propensity for upward rotation in eyes with DVD, as opposed to in those with nystagmus.

Kushner10 has described an “antielevation” syndrome of restriction of elevation in abduction after IOAT. This syndrome consists of an apparent overelevation of the adducting eye in attempted upgaze associated with a clinically important Y or V pattern. Kushner postulates that IOAT changes the function of the IO muscle from an elevator to an antielevator by redirecting the vector force of the muscle anteriorly. In our cohort, this antielevation effect was seen as a Y-pattern exotropia in 7 (37%) of 19 patients who had IOAT anterior to the IR muscle insertion.
muscle in at least 1 eye. However, a relative increase of elevation in adduction was rarely observed, perhaps because the ipsilateral SR muscle recession produces a more comitant supraduction deficiency in these eyes (Figure 1). The Y-pattern exotropia, when present, was sufficiently objectionable to require subsequent operation in only 1 case, in which the strabismus was believed to be cosmetically objectionable when the patient reached early adolescence (Figure 2). The condition was improved after conversion of both IOATs to IO muscle recessions.

In a retrospective study of 200 patients from 2 practices, Mims and Wood found a significant association of the antielevation syndrome with lateral displacement of the posterior fibers of the IO muscle. Interestingly, this occurred only in patients in whom the IO muscle was reattached 2 mm or more anterior to the IR muscle insertion. There was no control group that received smaller amounts of IOAT. In our study, limiting the IO muscle anterior transposition even with, or posterior to, the IR muscle insertion seemed protective against developing Y-pattern exotropia postoperatively. Furthermore, IOAT anterior to the IR muscle insertion has not been shown to be more effective in controlling DVD than placement even with the IR insertion.

Our study has limitations typical of retrospective medical record reviews. While we attempted to achieve 100% capture, selection bias was possible. Postoperative follow-up varied substantially, and it is possible that patients undergoing longer follow-up may have had better or worse outcomes than those with shorter follow-up. Most, but not all, patients were operated on for DVD and typically underwent staged procedures. Only 4 patients underwent simultaneous SR and IO muscle weakening. While this reflects the reality of clinical practice, it makes it harder to draw firm conclusions regarding treatment effect and/or complications.

The functional importance of surgically induced supraduction deficiency is unclear. While it is theoretically desirable to preserve full ocular rotations, mild deficiencies of supraduction are usually asymptomatic and may be required to achieve the desired surgical outcome of controlling DVD. However, more severe deficiencies of supraduction may be undesirable, potentially causing or exacerbating habitual chin elevation, upper eyelid retraction, or Y-pattern exotropia. Because there seems to be an increased risk of significant supraduction deficiency and Y-pattern exotropia when the IO muscle is transposed anterior to the IR muscle insertion, we recommend that the IO muscle, when transposed, is placed no more anteriorly than the IR muscle insertion.

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REFERENCES


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