Surgical treatment of diplopia in Graves' Orbitopathy patients

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OUTCOME OF INFERIOR AND SUPERIOR RECTUS RECESSION IN GRAVES’ ORBITOPATHY PATIENTS

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ABSTRACT

Purpose: To evaluate the surgical effect of unilateral inferior rectus recession (IR-group) with or without a recession of contralateral superior rectus (IR/SR-group) on squint angle and motility restrictions in Graves’ Orbitopathy (GO) patients.

Design: Retrospective case series.

Materials and Methods: Primary outcome parameters were the changes of squint angle 3 months and 6 – 12 months postoperatively. As in a previous study, success was defined as a postoperative vertical squint angle of ≤ 3° in primary position and on downgaze. Secondary outcome parameters were the influence of surgery on duction range and influence of muscle size on dose-effect response.

Results: Fifty-six patients were included in the study; 31 patients in the IR-group and 25 patients in the IR/SR-group. The amount of (fixed suture) recession ranged from 2 mm to 7 mm. Vertical deviations in primary position changed from 8.0° [95% CI 6.6 – 9.7°] to 1.0° [95% CI -0.4 – 6.5°] in the IR-group and from 17.0° [95% CI 15.7 – 20.0°] to 1.5° [95% CI 0.8 – 2.9°] in the IR/SR-group. The success rate was 74% in the IR-group and 64% in the IR/SR-group. In the IR group, depression significantly worsened (p = 0.000). Elevation significantly improved in both groups (IR-group p = 0.007; IR/SR-group p = 0.000). The volume of the inferior or superior rectus muscle as assessed on CT-scans did not influence the dose-effect response.

Conclusions: The highest success rate and highest reduction of depression was found in the IR-group. The total duction range remained stable after strabismus surgery (IR-group) or improved (IR/SR-group). Both squint angle and cyclodeviation remained stable during long time follow up (6 – 12 month after surgery).
INTRODUCTION

Double vision occurs in up to 48% of patients with Graves’ Orbitopathy\(^1\) and significantly interferes with daily life activities such as reading and driving a car\(^2\,^4\). Among types of diplopia seen in GO, vertical deviation is very common, which does not come as a surprise as the most frequently involved muscle in GO is the inferior rectus muscle. Success of strabismus surgery in GO varies from 44% to 100%\(^5\,^6\,^10\), but there is no consensus as how to handle strabismus. Deviations up to 15° are corrected with a recession of only one muscle\(^11\). In large comitant vertical deviations, a tight inferior rectus muscle in combination with an enlarged contralateral superior rectus muscle is mentioned\(^12\). If then the angle exceeds 10-15°, it has been suggested to combine inferior rectus recession with a resection of the ipsilateral superior rectus muscle\(^13\,^14\,^15\). However, resection procedures are not the first choice of surgery in GO-patients. Volpe \textit{et al.} (2012) categorized the strategy of adjustable surgery on the amount of vertical strabismus together with the limitation in upgaze\(^16\).

Overcorrection after a recession of the inferior rectus muscle is common\(^13\,^14\,^17\,^24\). Previous studies showed that both restricted contralateral elevation and increased ipsilateral volume of the superior rectus muscle of the operated inferior rectus muscle are predictors of overcorrection\(^12\,^17\,^24\).

The results of combined recession of the superior rectus muscle and the contralateral inferior rectus muscle for correction of the vertical deviation are poorly described\(^6\,^12\,^16\,^18\,^25\). Moreover, data regarding the influence of strabismus surgery on duction in this patient group are scarce. Therefore, we evaluated our Graves’ patients with vertical deviations who were operated on the inferior rectus muscle with or without the contralateral superior rectus muscle and compared the outcome with the literature. Based on our findings, we present a kind of flow chart for strabismus surgery in GO patients with vertical deviations.

MATERIALS AND METHODS

The study was conducted according to the principles of the Declaration of Helsinki (seventh edition, October 2008, Seoul) and in accordance with the Medical Research Involving Human Subjects Act (WMO). This study was reviewed by the Ethical Board. No approval was needed for this retrospective study.
All consecutive GO patients in our tertiary referral center, operated between January 2000 and February 2012, who underwent a primary recession with fixed sutures of the inferior rectus muscle with or without recession of the contralateral superior rectus muscle, were included in this study. A simultaneously performed medial rectus recession procedure was no reason for exclusion. Both patients with disease induced strabismus and those who developed strabismus after orbital decompression were included. However, patients who also underwent oblique muscle surgery or myopexia procedures were excluded. In addition, patients with pre-existing strabismus, low vision which interfered with the orthoptic examination, or co-existing orbital pathology were excluded. Surgery was only performed when the orbitopathy was inactive and the orthoptic findings were unchanged for at least 3 months.

Unilateral inferior rectus recession (2 – 5 mm) was carried out when the vertical deviation was < 15°, and when the deviation was comitant or increased in upgaze. A combined procedure was carried out in large (mostly > 15°) comitant vertical deviations (2 – 6 mm), with typically an ipsilateral elevation impairment with a contralateral depression impairment. If an incomitance was present, then the recession was carried out asymmetrically (for instance 2 mm recession superior rectus and 6 mm recession inferior rectus on the other eye).

In general, the calculation was a dose-effect response of 1.5°/mm was Horizontal and vertical deviation was measured in primary position and in eight directions of gaze (if ductions exceeded 25°) using the Maddox tangent screen at 2½ meters.

The ductions were measured with the modified perimeter as described by Mourits et al. Duction impairment postoperatively was defined as limited if duction worsened ≥ 5° and depression was ≤ 50°. Cyclo deviation was measured with the cycloforometer of Franceschetti at 2½ m, in primary position, 25° up- and downgaze as described by Klainguti et al. Surgery was performed by different orbital surgeons. Success was defined as a vertical angle ≤ 3° of and under- or overcorrection was defined as a vertical deviation of > 3° after surgery. This criteria were set in addition to the criteria in a previous study. Within this vertical deviation, fusion is often possible (with or without prism). Both success definitions apply for primary position and/or downgaze. Dose-effect response was calculated by dividing the ‘preoperative – postoperative squint angle’ by the amount of recession. Orthoptic data from within 3 months before and after surgery and 6 –
12 months after surgery were collected. The size of the extraocular muscles as seen on coronal CT-scans was semi-quantitatively assessed by two orbital specialists (PS and MM) independently and without knowledge of the orthoptic situation and surgical intervention. All available orthoptic data were collected, as well as data concerning onset and severity of the GO and previous decompression surgery. For statistical analysis, SPSS 19.0 software was used.

RESULTS

General
In total, 202 GO patients operated for their vertical strabismus could be identified. 129 patients were excluded because of a simultaneous myopexia procedure, oblique muscle surgery, unilateral superior rectus recession, bilateral inferior rectus recession or reoperation on the inferior rectus muscle. Another 17 patients were excluded due to reactivation of the GO after surgery (changes in Clinical Activity Score), incomplete data, strabismus present before onset of the GO or a co-existing orbital tumor or a supernumerary extra-ocular muscle. Fifty-six patients could be included, of which 36 (64%) were female and 20 (36%) male. Mean age was 58±10 years. An accompanying medial rectus recession was performed in 7 patients of the IR-group and in 2 patients of the IR-SR-group.

Twenty-eight (50%) of all patients underwent an orbital decompression prior to the strabismus surgery. Twenty-one patients had a field of binocular single vision ≥ 20° in all directions of gaze prior to the orbital decompression. Mean time between the orbital decompression and strabismus surgery was 17±22 months.

Strabismus
Table 1 shows the general data before and after surgery for both groups and Table 2 gives an overview of success rate, including the number of over- and undercorrection.

In both the IR group and IR/SR-group, the success and failure rates were not influenced by the amount of recession (IR group $p = 0.394$; IR/SR-group $p = 0.363$).

Dose effect responses are listed in Table 3. No difference was found when comparing the success and failure group (IR-group $p = 0.234$ and IR/SR-group $p = 0.173$).
### Table 1. Pre- and postoperative data

<table>
<thead>
<tr>
<th></th>
<th>IR-group (n = 31)</th>
<th>p-value</th>
<th>IR/SR-group (n = 25)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recession (mm)</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>IR eye</td>
<td>2.9 ± 0.8 [2.0 – 5.0]</td>
<td>0.000</td>
<td>3.8 ± 1.2 [2.0 – 6.0]</td>
<td>0.000</td>
</tr>
<tr>
<td>SR eye</td>
<td></td>
<td></td>
<td>4.5 ± 1.0 [3.0 – 6.0]</td>
<td></td>
</tr>
<tr>
<td><strong>Vertical deviation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Primary position</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>preop</td>
<td>8.0 [6.6 – 9.7]</td>
<td>0.000</td>
<td>17.9 [15.7 – 20.0]</td>
<td>0.000</td>
</tr>
<tr>
<td>postop &lt; 3 months</td>
<td>1.0 [-0.4 – 6.5]</td>
<td>0.000</td>
<td>1.5 [0.8 – 2.9]</td>
<td>0.000</td>
</tr>
<tr>
<td>postop 6 – 12 months</td>
<td>2.0 [-0.5 – 5.9]</td>
<td>0.132</td>
<td>2.0 [-0.2 – 4.5]</td>
<td>0.082</td>
</tr>
<tr>
<td><strong>Downgaze</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>preop</td>
<td>6.8 [5.4 – 8.1]</td>
<td>0.000</td>
<td>14.5 [11.5 – 17.4]</td>
<td></td>
</tr>
<tr>
<td>postop &lt; 3 months</td>
<td>3.0 [0.9 – 7]</td>
<td>0.000</td>
<td>1.5 [-0.5 – 6.1]</td>
<td>0.000</td>
</tr>
<tr>
<td>postop 6 – 12 months</td>
<td>1.0 [1.1 – 6.6]</td>
<td>0.796</td>
<td>3.7 [-1.4 – 10.3]</td>
<td>0.304</td>
</tr>
<tr>
<td><strong>Cyclodeviuation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Primary position</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>preop</td>
<td>+3.0 [-0.4 – 8.9]</td>
<td>0.002</td>
<td>+5.0 [-1.8 – 10.8]</td>
<td>0.018</td>
</tr>
<tr>
<td>postop &lt; 3 months</td>
<td>0.0 [-3.3 – 8.1]</td>
<td>0.000</td>
<td>+2.5 [-0.7 – 3.7]</td>
<td></td>
</tr>
<tr>
<td>postop 6 – 12 months</td>
<td>0.0 [-3.0 – 7.6]</td>
<td>0.496</td>
<td>+0.0 [-2.0 – 3.3]</td>
<td>0.340</td>
</tr>
<tr>
<td><strong>Downgaze</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>preop</td>
<td>+1.0 [-4.2 – 7.9]</td>
<td>0.142</td>
<td>+4.0 [-0.8 – 9.5]</td>
<td>0.015</td>
</tr>
<tr>
<td>postop &lt; 3 months</td>
<td>0.0 [-3.4 – 5.7]</td>
<td>0.002</td>
<td>+0.5 [-3.9 – 4.2]</td>
<td></td>
</tr>
<tr>
<td>postop 6 – 12 months</td>
<td>0.0 [-5.2 – 6.1]</td>
<td>0.230</td>
<td>-0.5 [-6.0 – 4.3]</td>
<td>0.167</td>
</tr>
</tbody>
</table>

*median [95% CI] n.a. = not applicable

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### Table 2. Outcome

<table>
<thead>
<tr>
<th></th>
<th>IR group (n)</th>
<th>IR/SR-group (n)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success (≤ 3°)</td>
<td>23</td>
<td>16</td>
<td>0.000*</td>
</tr>
<tr>
<td>Overcorrection (&gt; 3°)</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Undercorrection (&gt; 3°)</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

IR = inferior rectus; SR = superior rectus; *= ANOVA

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### Table 3. Dose-effect response of vertical squint angle

<table>
<thead>
<tr>
<th></th>
<th>IR group median° / 95% CI (n = 31)</th>
<th>IR/SR-group median° / 95% CI (n = 25)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients</td>
<td>2.8 [2.3 – 3.1]</td>
<td>2.0 [1.7 – 2.3]</td>
<td>0.009</td>
</tr>
<tr>
<td>Success (&lt; 4°)</td>
<td>2.8 [1.0 – 3.8] (n = 23)</td>
<td>2.0 [1.1 – 3.1] (n = 16)</td>
<td></td>
</tr>
<tr>
<td>Failure (≥ 4°)</td>
<td>2.9 [1.0 – 6.4] (n = 8)</td>
<td>1.6 [0.4 – 3.6] (n = 9)</td>
<td></td>
</tr>
<tr>
<td>Difference success/failure group</td>
<td>p = 0.234</td>
<td>p = 0.173</td>
<td></td>
</tr>
</tbody>
</table>

Dose-effect response: (preoperative-postoperative angle)° / mm recession

IR = inferior rectus; SR = superior rectus; SD = standard deviation; n.a. = not applicable
Nine patients were simultaneously operated on one or both medial rectus muscles. The dose-effect response did not differ between the patient with and those without a simultaneously performed medial rectus muscle recession (IR-group $p = 0.314$ and IR/SR-group $p = 0.500$). No changes in the horizontal deviation in primary position ($p = 0.658$) or downgaze ($p = 0.233$) were seen in the other 47 patients. No significant difference in change of strabismus angle was found between patients with disease induced strabismus and decompression induced strabismus ($p = 0.501$).

**Figure 1.** Elevation, depression and total duction range before and after strabismus surgery.

**Duction**

In general, elevation increased significantly after surgery when the inferior rectus muscle was recessed (Fig 1). Comparing the IR-group and IR/SR-group, the depression after surgery was significantly lower ($p = 0.000$) in the IR-group. However, smaller recessions were carried out in that group compared to the IR/SR-group ($p = 0.011$). No correlation was found between the amount of muscle surgery and the amount of depression (IR-group $r = 0.034$; IR/SR-group $r = 0.029$). When dividing the IR-group in a success and failure group, depression changed to $51.0\pm4.9$ in the success group and to $44.6\pm9.3$ in the failure group ($p = 0.09$). Total duction range increased only in the inferior rectus eye of the IR/SR-group. All other duction ranges remained stable (Fig. 1).
Chapter 5

Cyclodeviation

Excyclodeviation in primary position diminished significantly in the IR-group \((p = 0.000)\) and IR/SR-group \((p = 0.015)\). Overall, no incyclodeviations were seen (Table 1).

Muscle enlargement

Table 4 shows the results of the muscle enlargement reassessed on the available CT-scans. No significant difference was found between the severity of muscle enlargement of the operated rectus muscle and outcome of the surgery.

<table>
<thead>
<tr>
<th></th>
<th>IR group (n)</th>
<th>IR/SR-group (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Operated IR</td>
<td>Ipsilateral SR</td>
</tr>
<tr>
<td>No</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Mild</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Moderate</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Severe</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Not available</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Influence on success/failure</td>
<td>(p = 0.446)</td>
<td>(p = 0.947)</td>
</tr>
</tbody>
</table>

*Kruskal-Wallis test

DISCUSSION

After dysthyroid optic neuropathy, diplopia is one of the most serious quality of life threatening conditions within GO. Unfortunately, compared to decompression surgery, only a few studies are available how to treat the diplopia. The present study tries to add to this subject and evaluates the largest series of combined inferior and contralateral superior rectus recessions in GO patients and presents the dose-effect response of this patient group.

Success rate according to our stringent criteria of a postoperative strabismus \(\leq 3^\circ\) in primary position and downgaze varied from 64 – 74%. We assessed that the total duction range of the operated eye remained unchanged or even improved postoperatively. We found no differences in outcome between GO patients with primary strabismus (e.g. caused by the disease itself) and with decompression induced strabismus.

Only a few studies (with small numbers) describe the combined procedure of the inferior rectus muscle and the contralateral superior rectus muscle recession\(^6,12,18\). Success criteria within this group of strabismic patients were defined as amount of reoperations\(^12,18,25\), binocular single vision in primary position and reading gaze\(^16\) or postoperative orthotropia\(^6\).
Most strabismus studies concern unilateral inferior rectus recessions. Comparison with our results is hard to make, because we used other and more stringent criteria for success by including the downgaze position. In a comparable study by de Hoog et al. (2009), 37% of patients, operated on one or both inferior rectus muscles, a depression impairment and in 24% an overcorrection was found. Eckstein et al. (2004) reported an overcorrection range of 7%–56%, depending on the combined uni-or bilateral medial rectus recession procedure. They also found a significantly higher dose-effect response when the vertical strabismus procedure was combined with a medial rectus recession. We did not find such a difference (IR-group $p = 0.314$ and IR/SR-group $p = 0.500$). Our dose effect responses of the IR-group are slightly higher compared to their dose-effect response. No dose-effect response was found in the literature for the IR/SR-group.

Several explanations for overcorrection after inferior rectus recessions are described in literature.

1) The connection to the inferior oblique muscle with the capsulopalpebral fascia of Lockwood ligaments is said to cause a medial movement of the globe, when the muscle is not securely attached to the sclera.

2) A subtle restriction in upgaze of the fellow eye or an ipsilateral subclinical superior rectus restriction can create an overcorrection after surgery. By recessing the inferior rectus muscles bilaterally and asymmetrically on adjustable sutures, depression impairment can be prevented. We agree with these studies that if the patient suffers from contralateral elevation impairment an (a)symmetrical bilateral inferior rectus recession has to be performed.

3) Excessive scarring which causes fibrosis and weakness of the inferior rectus muscle, especially in downgaze.

Overcorrection is often caused by restriction of depression postoperatively. Careful examination of the ductions is essential in this patient group. However, a lot of studies lack accurate measurement of ductions. Schittkowsky et al. (2004) did measure ductions with the Kestenbaumbrille (0–10 mm), but found no depression impairment in their operated IR-group. In the present study, depression impairment after surgery exists but is not significantly different between the success and failure group. As said before, our stringent criteria for overcorrection also for duction make comparison with other
publications difficult. We emphasize that depression can be accurately measured with the performed modified motility meter (up to 58°)\textsuperscript{26} or Goldmann perimeter\textsuperscript{38}.

The total duction range after surgery found in the present study was a little bit higher compared to the vertical duction range found by Gerling \textit{et al.} (1997) (71.5°)\textsuperscript{38}.

Interestingly, no noticeable depression impairment arose in the IR-SR-group. This difference could be caused by the small patient group. Or one could assume that more muscles are enlarged in this group, but the diversity in muscle volume was not significantly different compared to the IR-group. Also, a lower volume of the superior rectus in the IR/SR-group could possibly account for this difference, but in our series we found no support for this assumption ($p = 0.174$). Possibly, subtle differences in muscle volume which cannot be seen on coronal CT-scans can count for this difference. Hopefully, exact muscle volume measurements in the future can give new keystones. It is also reasonable to think that the amount of recession was higher in the IR-group to explain the depression impairment in that subgroup. However, the amount of recession in the present study was higher in the IR/SR-group compared the amount in the IR-group (Table 1). This particular finding requires further research.

Recent experiments seem to indicate that tendon elongation can successfully be used to treat large vertical deviations without creating depression impairments\textsuperscript{31}. Although the reported patient numbers are low and the results have to be confirmed by other studies, the technique may open new opportunities for the presented patient group.

It has been suggested that the nature of the strabismus induced by the decompression surgery differs from the strabismus induced by the orbitopathy itself. For that reason, we compared the subgroup that underwent a decompression with those who did not and we found no support for this hypothesis.

Although we now believe that the changes of the field of binocular single vision in combination with changes in quality of life questionnaires are the best outcome parameters for strabismus surgery, we did not use these parameters as there is no consensus yet as how to apply such parameters. Also, the retrospective nature of this study made it impossible to collect this data. Instead we used the change of strabismus and the duction range. Some previous studies have judged successful outcome only by the strabismus in primary position\textsuperscript{5;17;23;36;37;39}. If we would have applied those criteria, our success rates would have been higher. However, we feel that such criteria do not justify the real life situations such as
reading or walking down on a flight of stairs. The field of binocular single vision is a good predictor for patients’ quality of life, together with the GO-quality of life (GO-QoL) questionnaire of Terwee et al. (1998)\(^4^0\). Patients with GO often have increased vertical fusional amplitudes, which enables them to fuse small vertical angles. Future studies, like a recent study of our department\(^4^1\), have to clarify if our measurement criteria for success match the patients’ experience in daily life situations.

In conclusion, this study shows results and compares outcomes of two surgical approaches to correct vertical strabismus in GO-patients. Interestingly, less decrease of depression and lower dose-effect response was found in the IR/SR-group, despite the higher amount of muscle recession. Total duction range remains stable or even improves after surgery. The optimal surgical plan has to be made after careful evaluation of strabismus, ductions and ocular incomitance. A guideline for surgery, based on previous and present results, is presented in Figure 2\(^3^3\).
Figure 2. Surgical treatment plans for different motility problems shown on motility schemes. Motility schemes in nine directions of gaze measured with help of the Maddox rod en Maddoxcross on 2½ meter. Cyclodeviation measured in primary position, 25° downgaze and 25° upgaze. IR = inferior rectus; SR = superior rectus.

Small concomitant squint angle – in small concomitant squint angles a unilateral inferior rectus recession is surgery of choice. Incomitant squint angle with severe elevation impairment of one eye – with decrease of vertical deviation in downgaze; asymmetrical recession of the inferior rectus muscle is surgery of choice.

Large concomitant squint angle – combined recession of the inferior rectus muscle of the hypotropic eye combined with a recession of the other eye is recommended. Small incomitant squint angle – incomitant angle with more vertical deviation in left or right downgaze a recession of the superior rectus muscle is preferred.
REFERENCES


