Surgical treatment of diplopia in Graves' Orbitopathy patients
Jellema, H.M.

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BILATERAL INFERIOR RECTUS RECESSION IN PATIENTS WITH GRAVES’ ORBITOPATHY: IS IT EFFECTIVE?

Hinke Marijke Jellema, MMedSci, CO, Peerooz Saeed, MD, PhD, Yolande Everhard-Halm, CO, Liesbeth Prick, MD, PhD and Maarten P Mourits, MD, PhD

Department of Ophthalmology, Academic Medical Center, Amsterdam, the Netherlands

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ABSTRACT

**Purpose:** To evaluate the effect of bilateral inferior rectus recession regarding improvement of elevation, reduction of abnormal head tilt and vertical squint angle in patients with Graves’ Orbitopathy (GO).

**Method:** Retrospective case series. Patients with GO who underwent symmetrical or asymmetrical bilateral inferior rectus recession were selected for this study. Effect on change of elevation, depression cyclodeviation and vertical squint angle was calculated 3 months and 6 to 12 months postoperatively.

**Results:** Forty-three patient could be included, who underwent a recession of both inferior recti by 1 of our 5 surgeons. Three months postoperatively, the elevation changed from $12^\circ \pm 6.9^\circ$ preoperatively to $19^\circ \pm 6.7^\circ$ postoperatively ($p = 0.000$) and the depression from $54^\circ \pm 6.2^\circ$ pre-operatively to $48^\circ \pm 9.2^\circ$ postoperatively ($p = 0.005$). Total duction range remained stable ($p = 0.728$). Three months after surgery, motility did not change significantly anymore. The dose effect response on elevation was $1.7^\circ \pm 1.7^\circ$/mm and was higher in case of severe preoperative elevation restriction ($r = -0.405$). Three months postoperatively, the excyclodeviation changed from $6.4^\circ \pm 6.0^\circ$ to $0.4^\circ \pm 6.0^\circ$ in primary position ($p = 0.000$). However, in downgaze 4 patients developed a significant incyclodeviation of $> 5^\circ$. Muscle volume, prior decompression surgery or performing surgeon did not influence the outcome.

**Conclusion:** Bilateral recession of the inferior rectus muscles in Patients with Graves Orbitopathy results in a shift of vertical duction range towards upgaze and a significant decrease of excyclodeviation. Overcorrection of cyclodeviation in downgaze has to be considered before planning this type of surgery. Poor preoperative elevation contributes to higher dose-effect responses. Concerning all variables, the orthoptic picture does not change anymore after 3 months since surgery.
INTRODUCTION

Graves’ Orbitopathy (GO) is an auto-immune disease, which may present with proptosis, eyelid retraction, periorbital swelling, diplopia and vision loss\(^1\). Active orbitopathy is usually treated with intravenous methylprednisolone pulse therapy\(^2\). Depending on the wide variation in clinical presentation per patient, one or more of the following procedures are necessary in the quiescent stage of the decease: decompression surgery, strabismus surgery and/or if necessary, eyelid correction\(^1,3\). The primary goal of treatment regarding diplopia is to create a useful field of binocular single vision in primary position and downgaze\(^4,5\). The inferior rectus muscles are frequently affected by muscle enlargement due to inflammation, leading to fibrosis which causes impaired elevation and large excyclodeviations. In case of significantly impaired ocular elevation, bilateral inferior rectus recession is the first operation of choice in the authors’ centre. So far, this surgical technique has been poorly represented in literature\(^6,7\). Therefore, this study is designed to strengthen the theoretical basis for this procedure. All consecutive patients with GO who were treated with a bilateral inferior rectus recession over the past 10 years were included in this study.

MATERIALS AND METHODS

The study was conducted according to the principles of the Declaration of Helsinki (seventh edition, October 2008, Seoul).

All patients who underwent recession of both inferior rectus muscles between January 2000 and June 2009 at the ophthalmology department of the Academic Medical Centre in Amsterdam were included in this study. The primary goal of surgery was ocular elevation improvement and reduction of abnormal head posture.

All patients had inactive GO with a stable orthoptic evaluation for at least 3 months prior to the squint surgery. Specific ophthalmic data were collected such as prior decompression surgery, muscle enlargement on CT scan, interval between decompression and strabismus surgery, type of squint surgery and the amount of recession of the inferior rectus muscles. The authors based the amount of our inferior rectus recessions in the first place on the severity of the elevation impairment. If elevation was less than 10°, 5 mm recession with or without a hang-back suture was carried out. When the elevation was between 10 - 15°, 4 mm recession was performed and when the elevation was > 15° the inferior rectus muscle
was recessed 3 mm. However, the authors also took into consideration the depression impairment and the vertical squint angle in primary position and downgaze to fine-tune the recession amount. In such a way, an individual approach for each patient was accomplished.

The operations were carried out by 5 different surgeons who all used fixed sutures with Vicryl 5.0. An asymmetrical recession of the inferior recti was performed in case of a manifest vertical deviation in primary position. The ductions were measured with a modified perimeter as described by Mourits et al. If ductions exceeded 25°, the vertical deviation in primary position and in eight directions of gaze was measured using the Maddox tangent screen at 2½ m. Cyclodeviation was measured with the cycloforometer of Franceschetti at 2½ m, in primary position, up- and downgaze as described by Klainguti et al.

Patients with a history of strabismus, neuromuscular diseases, severe amblyopia, or retinal problems were excluded. Also patients who were simultaneously operated on the oblique muscles were excluded. Patient operated simultaneously on the medial or lateral rectus muscle were included. Muscle thickness was analysed, semi-quantitatively, for all available CT scans in coups with a slice thickness of 1.3 mm and a slice increment of 0.7 mm. For interobserver variability, muscle enlargement was assessed 2 orbital surgeons (Peerooz Saeed and Maarten Mourits). They analysed the available CT scans independently and without prior knowledge concerning surgical outcome.

Analysed orthoptic data included orthoptic anamnesis and examinations less than 3 months preoperatively, within 3 months postoperatively and 6 – 12 months postoperatively. Statistical analysis was made with software package SPSS 17.0 (SPSS Inc., Chicago, IL, U.S.A.). Each variable was verified for normal distribution with help of the Kolmogorov-Smirnov test. If the data met the requirements for normal distribution, parametric tests were applied. If not, non-parametric tests were used. To uncover the main and interaction effects of categorical independent variables on an interval dependent variable ANOVA was used.

RESULTS
Between January 2000 and June 2009, 44 patients, 12 male and 33 female, with GO underwent recession of both inferior rectus muscles. Two patients were excluded because recession of the inferior recti was combined with an inferior oblique recession procedure. In 9 (21%) patients, the inferior rectus recession procedure was combined with horizontal squint correction. In 9 (21%) cases, a hang-back suture was carried out. Mean age was
54±12.8 years. Ten patients (24%) had undergone prior coronal decompression surgery, 23 patients (55%) underwent an inferomedial decompression. Nine patients (21%) did not have prior decompression surgery. Prior to the decompression surgery, only 8 (19%) patients experienced diplopia within the 20° field of binocular single vision. The interval between the decompression surgery and squint surgery was 12.7±10.4 months. The degree of muscle volume of both inferior rectus muscles and superior rectus muscles is shown in Table 1.

### Table 1. Muscle enlargement

<table>
<thead>
<tr>
<th></th>
<th>Inferior rectus muscle</th>
<th>Superior rectus muscle</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Mild</td>
<td>16</td>
<td>25</td>
</tr>
<tr>
<td>Moderate</td>
<td>36</td>
<td>28</td>
</tr>
<tr>
<td>Severe</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>Not available</td>
<td>14</td>
<td>14</td>
</tr>
</tbody>
</table>

*p = 0.208*  
*p = 0.796*

*Analysis of variance

### Table 2. Pre- and postoperative measurements of elevation, depression and cyclodeviation

<table>
<thead>
<tr>
<th></th>
<th>&lt; 3 months preoperatively degrees ± SD</th>
<th>&lt; 3 months postoperatively degrees ± SD</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation</td>
<td>12° ± 6.9°</td>
<td>19° ± 6.7°</td>
<td>0.000</td>
</tr>
<tr>
<td>Depression</td>
<td>54° ± 6.2°</td>
<td>48° ± 9.2°</td>
<td>0.005</td>
</tr>
<tr>
<td>Cyclodeviation</td>
<td>6.4° ± 6.0° downgaze 4.2° ± 5.6°</td>
<td>0.4° ± 5.6° downgaze -1.3° ± 6.1°</td>
<td>0.000 0.000</td>
</tr>
</tbody>
</table>

- = incyclodeviation; SD = standard deviation

A symmetrical inferior rectus recession was performed on 18 patients (symmetrical group), with a mean recession of 3.6±1.0 mm per eye and an asymmetrical inferior rectus recession in 24 patients with a mean of 4.2±1.2 mm per eye (asymmetrical group). This difference in mm recession was significant (p = 0.012).

After bilateral recession of the inferior rectus, 27 (64%) patients needed no further strabismus surgery, 8 (20%) patients needed only 1 horizontal strabismus procedure and 7 (17%) patients needed one or more further vertical strabismus surgeries. At average, a patient needed 2 (range 1 – 6) operations.
Ductions

Both elevation and depression changed significantly after the bilateral inferior rectus recession procedure (elevation $p = 0.000$; depression $p = 0.005$, Table 2). No correlation was found between these changes ($r = -0.009$). Total pre-operative vertical duction range (sum of elevation and depression) was $66.4° ± 10.4°$ and postoperative $67.4° ± 11.4°$ ($r = 0.728$). No correlation between the duction change and duration of the disease was found ($r = -0.127$). No further changes of ductions were seen 6 – 12 months after the inferior rectus surgery (elevation $p = 0.432$; depression $p = 0.968$).

The dose-effect response of improved elevation per mm of recession was $1.7° ± 1.7°/mm$. This dose-effect response was negatively influenced by the preoperative restricted elevation ($r = -0.429$, $p = 0.000$; Fig. 1).

![Figure 1. Preoperative elevation per eye correlated to the dose-effect response ($r = -0.405$).](image)

Prior performed decompression surgery did not influence this outcome ($p = 0.056$). Because of the influence of preoperative elevation on the effect, no correlation was found between the amount of recession of the inferior rectus muscle and the improved elevation ($r = -0.101$) or decreased depression ($r = -0.288$) because a small recession already has a large effect. Age did not influence this correlation (elevation $r = 0.093$; depression $r = -0.196$). When focussing on the group with diplopia prior to the decompression surgery, dose-effect response was not different compared to the group without diplopia prior to the decompression ($p = 0.080$).
Muscle volume analysed on CT scan did not influence outcome on dose-effect response either (inferior rectus muscle $p = 0.208$; superior rectus muscle $p = 0.796$). There were no discrepancies of surgical outcome between the performing surgeons ($p = 0.114$).

No significant differences were found between pre- and postoperative elevation, depression and cyclodeviations when comparing the inferior rectus recession with or without hang-back suture ($p = 0.819$; $p = 0.507$; $p = 0.366$).

**Squint angle**

The average vertical deviation in primary position was $1.4\degree\pm2.1\degree$ in the symmetrical group and $4.8\degree\pm3.1\degree$ in the asymmetrical group. In the latter group the vertical squint angle was significantly reduced after strabismus surgery to $2.3\degree\pm2.4\degree$ ($p = 0.000$). One patient in the asymmetrical group had a postoperative overcorrection in primary position. Nine to 12 months postoperatively, the vertical deviation remained stable ($p = 0.685$).

In downgaze, the angle of vertical squint did not change significantly postoperatively in the symmetrical group ($p = 0.278$).

In the group where no medial rectus recession was carried out, the horizontal squint angle reduced $1.0\degree\pm2.1\degree$ in primary position ($p = 0.016$) and $3.0\degree\pm4.2\degree$ in downgaze ($p = 0.001$).

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**Figure 2.** Pre- and postoperative cyclodeviation in primary position. * and o are outliers.
Cyclotorsion

In the majority of cases, cyclodeviation could only be measured in primary position and downgaze because of severely impaired elevation. Preoperative excyclodeviation diminished significantly postoperatively (Table 2 and Fig. 2). A case example is found in Figure 3. In 4 (18%) patients, incyclodeviation exceeded 5° 6 to 12 months postoperatively. Six to 12 months postoperatively, no significant changes of cyclodeviation were found (primary position \( p = 0.547 \); downgaze \( p = 0.864 \)).

Dose-effect response for improvement of cyclodeviation per mm of recession was \( 0.74^\circ \pm 0.61^\circ /\text{mm} \) in primary position and \( 0.7^\circ \pm 0.6^\circ /\text{mm} \) in downgaze.

No correlation was found between the amount of recession and postoperative reduction of cyclodeviation in primary position \( (r = 0.007) \) or downgaze \( (r = 0.067) \).

**Figure 3.** Above: preoperative large excyclodeviation due to secondary overaction of the inferior oblique. Below: after surgery: 3.5 mm OD and 3.0 mm OS recession of the inferior rectus muscle. Postoperative decrease of overaction of inferior oblique muscle because of decrease of restriction of elevation.
DISCUSSION

To the authors’ knowledge, this is the first large case series describing the effects of the bilateral inferior rectus recession in patients with GO (Table 3). This treatment significantly improves elevation (with a mean of 37%), decreases depression (with a mean of 12%) and decreases exyclodeviation, unrelated to the amount of recession carried out. However, poor preoperative elevation was related to higher dose-effect response.

<table>
<thead>
<tr>
<th>Study</th>
<th>Procedure</th>
<th>Population (n)</th>
<th>Limitation of depression</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flanders and Hasting (1997)</td>
<td>unilateral recession</td>
<td>5 – 10 mm</td>
<td>10</td>
<td>not measured 6/10 had BSV primary position and reading gaze</td>
</tr>
<tr>
<td></td>
<td>bilateral recession</td>
<td>5 – 10 mm</td>
<td>3</td>
<td>not measured 3/3 had BSV in primary position and reading gaze</td>
</tr>
<tr>
<td>Cruz and Davitt (1999)</td>
<td>bilateral recession</td>
<td>6 mm adjustable suture on hypotropic eye 2–3 mm other eye</td>
<td>8</td>
<td>2 Patients undercorrected successful without overcorrection</td>
</tr>
<tr>
<td>Prendiville et al. (2000)</td>
<td>bilateral recession</td>
<td>not specified</td>
<td>11</td>
<td>not measured overall: 37/50 BSV in primary position with AHP in 4/37</td>
</tr>
<tr>
<td>Kose et al. (2002)</td>
<td>unilateral recession + adjustable loop</td>
<td>4 + Loop</td>
<td>5</td>
<td>2 Patients undercorrected successful without overcorrection</td>
</tr>
<tr>
<td>Eckstein, Schulz and Esser (2004)</td>
<td>unilateral recession</td>
<td>1.5 – 8 mm</td>
<td>187</td>
<td>not measured 69% orthophore in primary position 24% undercorrection / 7% overcorrection</td>
</tr>
<tr>
<td>Schittkowski, Fichter and Gutthoff (2004)</td>
<td>unilateral recession</td>
<td>2.5 – 10 mm</td>
<td>21</td>
<td>no change 76% – 88% BSV with prism</td>
</tr>
<tr>
<td>Dal Canto et al. (2006)</td>
<td>bilateral recession</td>
<td>3.5 – 9 mm</td>
<td>8</td>
<td>not measured no correlation between amount recession and preoperative angle (bilateral $r = 0.448$; unilateral $r = 0.5583$)</td>
</tr>
<tr>
<td>De Hoog, Stravers and Kalmann (2009)</td>
<td>unilateral recession</td>
<td>2 – 4 mm</td>
<td>24</td>
<td>37% (&gt; 4° worse and &lt; 55°) increased volume superior rectus predictor overcorrection</td>
</tr>
<tr>
<td>Present study (2012)</td>
<td>bilateral recession</td>
<td>4 – 7 mm (&gt; 5 mm; loop)</td>
<td>42</td>
<td>40% (&gt; 4° worse and &lt; 55°) shift of duction range towards upgaze</td>
</tr>
</tbody>
</table>

BSV = Binocular single vision; AHP = Abnormal head posture
Postoperative changes in ductions were not influenced by prior decompression surgery, muscle volume, surgeon, surgical technique, or duration of the GO. The total vertical duction range remained stable. This vertical duction range is comparable to the range found by Gerling et al. who found a mean vertical duction range of 71.5° in patients with GO.

Late overcorrections in unilateral inferior rectus recessions are widely discussed in literature, as also the other side effects as proptosis, lower eyelid retraction, and iatrogenic deviations in downgaze due to depression impairment. However, no clear data are available for bilateral inferior rectus recession cases. The assessment of the incidence of all these side effects was beyond the scope of the present study. De Hoog et al. described a series of 124 Patients with GO who underwent uni- or bilateral inferior rectus recession, of which 24 bilateral inferior rectus recessions. Depression impairment was found in 37% of all cases. De Hoog et al. did not record results of improved elevation, changes in cyclodeviation, or dose-effect response. They suggest that in case of a contralateral impairment of elevation, bilateral recession of the inferior rectus should be performed. Cruz and Davitt described 8 patients who were treated with a bilateral inferior rectus recession for the correction of a vertical squint, with the use of an adjustable suture on the most hypotropic eye. They found no late overcorrections 6 – 40 months postoperatively. It must be mentioned that they only measured the vertical deviation without measuring ductions in downgaze. Dal Canto et al. operated on 4 patients with GO on both inferior rectus muscles symmetrically (4 – 6 mm each eye) and 5 patients asymmetrically. They also found unlimited depression, but no depression measurement was recorded within the study. With the authors’ motility meter, small differences of depression can be easily measured and were indeed found in our case series. The authors did not find overcorrections in downgaze in the asymmetrical group. Possibly, the simultaneous recession of the fellow inferior rectus prevents this overcorrection. The authors thereby agree with Cruz et al. to recess both inferior rectus muscles in patients with GO with hypotropia, but not in all cases. Careful investigation of the ductions of both eyes, the preoperative angle in right-, left- and downgaze is important in properly planning the surgery. With regard to muscle volume, de Hoog et al. found that limited depression was significantly related to superior rectus muscle enlargement on CT-scan. By reanalyzing the CT-scans in the present study, the authors too did not find statistical significant relations between ductions and muscle enlargement.
In the literature, the described dose-effect responses of unilateral recessions of the inferior rectus muscle, vary from $1.6^\circ$ to $2.1^\circ$/mm$^{3,18,20}$. To the authors knowledge no dose-effect responses are available of bilateral inferior rectus recession in relation to elevation improvement. The dose-effect response measured in this study on elevation improvement was $1.7^\circ\pm1.7^\circ$/mm. A side-effect of this procedure is a reduction of the horizontal squint angle, especially in downgaze, without creating a real A pattern in the authors’ series. This A pattern is described in literature as a complication of decompression or inferior rectus surgery$^{21,22}$.

Some studies suggest to correct contralateral eye muscles like the superior rectus or inferior oblique muscle to correct the hypotropia and cyclo deviation$^{23,24}$. The authors’ are, however, convinced that the cause of the hypotropia should be treated first by recessing the tight inferior rectus muscles. By doing this, excyclodeviation will reduce as a result of improved elevation as well as a reduction of inferior oblique muscle overaction (Fig. 3). As already described in literature, treatment has to be primarily focused on minimizing restrictions and differences in ductions$^{11}$. A possible created incyclodeviation as arose in some of our patients can be treated with a superior oblique recession procedure. As previous suggested by Kushner, one could argue to simultaneously recess the inferior rectus muscles and superior oblique muscles to prevent this incyclodeviation$^{25}$.

The authors’ found that within 3 months postoperatively, long term stability of squint surgery can be predicted, as supported by other authors$^{6,19}$.

The authors’ are aware that this retrospective type of study creates bias. They regret that the abnormal head posture and the field of binocular single vision were not measured consequently to be included in this analysis. Also, it would have been interesting to relate the postoperative objective result to the subjective improvement most patients report. In addition, missing data and lack of a standard surgical plan influences the reliability of our results. However, the authors believe that the conclusions are strong enough to set a basis for future studies. In future studies, more attention should be given to the measurement of the field of binocular single vision and a quality of life questionnaire in this patient group$^{26}$. These 2 outcomes would be more accurate in evaluating the effect of squint treatment in patients with GO.
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Bilateral inferior rectus recession, is it effective?


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