Orbital decompression in Graves' orbitopathy: state of the art and novel perspectives
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Citation for published version (APA):
Baldeschi, L. (2011). Orbital decompression in Graves’ orbitopathy: state of the art and novel perspectives

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Chapter 5

The Removal of the Deep Lateral Wall in Orbital Decompression: Its Contribution to Exophthalmos Reduction and Influence on Consecutive Diplopia

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Abstract

**Purpose:** To evaluate the contribution of maximal removal of the deep lateral wall of the orbit to exophthalmos reduction in Graves’ orbitopathy and its influence on the onset of consecutive diplopia.

**Design:** Case-control study.

**Methods:** The medical records of two cohorts of patients affected by Graves’ orbitopathy with exophthalmos >23 mm, without preoperative diplopia, were retrieved at random from the pool of patients decompressed for rehabilitative reasons at our institution (01/1990 to 12/2003), and retrospectively reviewed. They had been treated with an extended (cases, group 1, n = 15) or conservative (controls, group 2, n = 15) 3-wall orbital decompression performed through a coronal approach. The deep portion of the lateral wall had been removed in the extended decompression group while preserved in the conservative decompression group. Demographics, preoperative characteristics, and surgical outcome were compared. The difference in mean exophthalmos reduction between groups 1 and 2 was considered to be the contribution of the deep lateral wall to reduction of exophthalmos.

**Results:** Groups 1 and 2 were drawn from a pool of 37 and 335 patients, respectively. Demographics and preoperative characteristics of the two groups were not significantly different. The mean contribution of the deep lateral wall to exophthalmos reduction was 2.3 mm. The onset of consecutive diplopia was not significantly different between the two groups (case n = 2/15, controls n = 5/15; P = 0.203). Diplopia resolved spontaneously in all the patients of group 1, while all the patients of group 2 required surgery.

**Conclusions:** Removal of the deep lateral orbital wall as part of a coronal-approach, 3-wall decompression, enhances the degree of exophthalmos reduction without increasing the risk of consecutive diplopia.
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Introduction

The natural history of Graves’ orbitopathy has been known for many years\(^1\) and yet, the etiopathogenesis of this autoimmune disease remains unknown and consequently no specific medical therapy currently exists. Corticosteroids or radiotherapy may modulate the initial inflammatory dynamic phase by reducing its duration and by reducing the tendency to progression towards more severe signs and symptoms. Nevertheless, a considerable proportion of patients require decompression surgery either for functional reasons or for esthetic rehabilitation.

The history of orbital decompression surgery can be dated back to 1911 when Dollinger\(^2\) first proposed orbital enlargement by removing the lateral wall for the cure of exophthalmos. Since then, various osteotomies involving one or more of the other orbital walls have been proposed\(^3-6\), and recently the lateral wall, and in particular its deeper portion, has been described as an elective zone of possible orbital volume expansion.\(^7\) The potential volume for soft orbital tissue expansion after the removal of the lateral wall or its deeper part has been measured\(^8,9\) and in terms of exophthalmos reduction, the possible advantage of the strategic location of the deeper portion, just behind the globe, has been emphasized.\(^9,10\) Additionally, in contrast to medial or inferior orbital decompression, deep lateral wall osteotomy is not at the mercy of potential limitations imposed by coexisting pathology of the paranasal sinuses.

The contribution of any osteotomy to clinical decompression is not only dependent on its volume and location: many patient-related characteristics such as the stage of the orbitopathy at the time of surgery, orbital compliance, and preoperative Hertel readings can play a role in the final reduction of the exophthalmos.\(^11-13\) Consequently, controlled studies are necessary to validate and quantify the actual effect of any given bone removal and although deep lateral wall osteotomy has been described in several clinical studies, its contribution to exophthalmos reduction remains undetermined.\(^9,10,14-16\) We, therefore, found it interesting to measure the contribution of the deep lateral wall to exophthalmos reduction and secondarily to evaluate its influence on the onset of consecutive diplopia.
Patients and Methods

The medical records of a cohort of 15 patients randomly chosen from the pool of patients with Graves’ orbitopathy decompressed at the Orbital Center, Department of Ophthalmology, University of Amsterdam between January 1990 and December 2003, who had the deep portion of the lateral wall extensively removed during a 3-wall orbital decompression performed by a coronal approach (cases, group 1) were retrospectively reviewed.

Demographics (gender and age at surgery), preoperative characteristics (duration of the orbitopathy at surgery, immunosuppressive treatments, Hertel values), and surgical outcome (reduction of exophthalmos, frequency, and time course of postdecompression diplopia) were compared with the same data obtained by reviewing the medical records of another cohort of 15 patients (controls, group 2), also selected at random from the pool of patients treated, in the same time interval, with a 3-wall orbital decompression performed by the same route, but who had a more conservative removal of the lateral orbital wall which, as previously described and is traditional for our center, was limited to its anterior portion.\textsuperscript{12,18} The mean difference in exophthalmos reduction between the two groups was considered to be attributable to the contribution of the deep lateral wall to exophthalmos reduction.

All complications other than consecutive diplopia were recorded. Postoperative Hertel values were considered those measured at the first ophthalmologic examination performed at least 6 months after decompression. Right and left sides were not evaluated separately. Selection of cases and controls was performed with a random number table.

\textit{Inclusion Criteria}

We included patients: (1) who presented with moderate/severe exophthalmos, defined as eye protrusion $\geq 23$ mm on the less affected side; (2) who were operated on bilaterally for rehabilitative reasons; and (3) who did not have preoperative diplopia, defined as double vision within 20 degrees around the primary position of gaze.

\textit{Exclusion criteria}

We excluded patients: (1) who presented with preoperative exophthalmos $< 23$ mm on the less affected side; (2) who underwent surgery on only one side; (3) who underwent decompression for optic neuropathy or exposure keratopathy; (4) who had preoperative diplopia as defined above; and (5) who had a postoperative follow-up period $\leq 6$ months.
Chapter 5

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Selection of cases and controls was performed with a random number table.

Inclusion Criteria

We included patients: (1) who presented with moderate/severe exophthalmos, defined as eye protrusion ≥ 23 mm on the less affected side; (2) who were operated on bilaterally for rehabilitative reasons; and (3) who did not have preoperative diplopia, defined as double vision within 20 degrees around the primary position of gaze.

Exclusion criteria

We excluded patients: (1) who presented with preoperative exophthalmos < 23 mm on the less affected side; (2) who underwent surgery on only one side; (3) who underwent decompression for optic neuropathy or exposure keratopathy; (4) who had preoperative diplopia as defined above; and (5) who had a postoperative follow-up period ≤ 6 months.

Statistical analysis

The analysis was conducted by means of a database created using version 11.5 of the SPSS statistical analysis software package (http://www.spss.com). Student t test was used to compare continuous variables showing no marked deviations from the normal distribution. For other continuous variables or ordinal variables, the Mann-Whitney U-test was used. Categorical preoperative and postoperative data were investigated using the χ² test.

Surgical technique

The surgical approach to orbital decompression was the same for cases and controls: a coronal incision was made with a no. 10 blade from ear to ear, 3 to 4 cm behind the hairline. The incision extended down to the periosteum of the parietal bones centrally, and to the deep temporalis fascia laterally. Bleeding from the wound edges was controlled with Raney scalp clips. In the central portion of the skull, a subperiosteal plane was created by blunt dissection and laterally a surgical plane was bluntly developed between the deep and the superficial temporalis fascia. Laterally and inferiorly, where the deep temporalis fascia divides into a deeper and a more superficial layer to enclose Yasargil’s superficial temporal fat pad, the surgical dissection was carried out directly against the deeper division of the fascia.

The forehead flap thus created was then turned down to expose the superior and lateral orbital rims. The supraorbital nerve was set free by chiselling its bony foramen when present, and the periorbita, including the trochlea, was dissected off the orbital bones and the temporalis muscle was dissected from its anterior origin with a no. 10 blade and periosteal elevators, exposing the lateral orbital wall while leaving sufficient tissue for suturing at the end of surgery.

In group 2, only the anterior portion of the lateral orbital wall behind the orbital rim (which was left intact) was removed, “allowing a fingertip to pass through”12,18 (Figure 1). In group 1, the osteotomy of the lateral wall was started as for patients of group 2 but was then extended inferiorly up to the inferior orbital fissure with bone punches and posteriorly up to the dura of the middle cranial fossa by mean of bone punches and a surgical high-speed drill equipped with a cutting-burr or a diamond-burr tip (Figure 2). While removing the lateral orbital wall, the soft orbital tissues and the temporalis muscle were retracted and protected with malleable orbital retractors.
Bone removal was discontinued when small spots of dura were exposed through the thin inner cortical bone of the greater wing of the sphenoid, as any further removal might have increased the risk of complications without substantially contributing to creating space (Figure 2, bottom).

In each group, the removal of the medial wall and the floor of the orbit was the same: after having retracted the soft orbital tissues with malleable orbital retractors, a Fraizer suction tip was used to fracture the delicate bone of the medial orbital wall and the floor, and Blakesly forceps no. 1 and no. 2 were used to remove bony fragments and mucosa of the sinuses. The bulla ethmoidalis beneath the fronto-ethmoidal suture was opened towards the orbit from the posterior lacrimal crest up to the orbital apex, and the orbital floor medial to the infra-orbital canal was then removed from 0.5 cm behind the inferior orbital rim up to the posterior wall of the maxillary sinus. The posterior two thirds of the maxillary ethmoidal strut were removed, creating a wide antrostomy, while the anterior one third of the strut was left intact to reduce the risk of globe displacement and the possibility of medial entropion.

Finally, the periorbita was incised to promote maximal prolapse of the orbital tissues into the newly created spaces, the temporalis muscle was sutured back in to position with four to five interrupted 2/0 mersilene sutures and after the insertion of one Redon drain catheter into each temporalis fossa the scalp incision was closed with iron staples.
Chapter 5

Figure 1. Conservative lateral wall osteotomy as part of a 3-wall orbital decompression in a patient with Graves’ orbitopathy. Postoperative computer tomography scan showing the removal of the lateral orbital wall in a patient of group 2. The osteotomy was limited to the anterior portion of the lateral wall. Bone removal was discontinued when small spots of dura were exposed through the thin inner cortical bone of the greater wing of the sphenoid, as any further removal might have increased the risk of complications without substantially contributing to creating space (Figure 2, bottom).

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Figure 2. Extended lateral wall osteotomy as part of a 3-wall orbital decompression in a patient with Graves’ orbitopathy. (Top) Postoperative computer tomography scan showing the removal of the lateral orbital wall in a patient of group 1. The osteotomy was extended to the more posterior portion of the lateral wall. (Bottom) Intraoperative photo showing the removal of the deep lateral orbital wall by a coronal approach. A spot of exposed dura is evident (arrow).

Figure 3. A patient of group 1. (Top) The patient at admittance for orbital decompression. (Bottom) The patient 4 months after surgery. An adequate decompression had been achieved, esophoria, and deficit of accommodation which were present soon after surgery were disappeared, a mild anisocoria persisted.
Chapter 5

Results

Patients in group 1 were drawn from a pool of 37, while patients in group 2 were drawn from a pool of 335. The patients’ demographics and preoperative characteristics are summarized in the table.

The mean reduction of exophthalmos was 7.2 mm (SD = 2.3) in group 1 and 4.9 mm (SD = 1.1) in group 2 and the mean reduction of exophthalmos in group 1 was significantly higher than in group 2 ($P = 0.001$). The contribution of the deep lateral wall to exophthalmos reduction was 2.3 mm, giving the patients of group 1, on average, a 32.0% greater degree of exophthalmos reduction. Decompression-induced diplopia arose in two (13.3%) of the 15 patients of group 1 and in five (33.3%) of the 15 patients of group 2, although the difference in onset of decompression-induced diplopia between the two groups was not statistically significant ($P = 0.203$). Both of the patients of group 1 with postoperative diplopia presented with an esotropia and a deficit of abduction that resolved spontaneously 4 to 6 months after surgery, while all five patients of group 2 with postoperative diplopia presented with esotropia and in two cases there was associated vertical strabismus: all of these patients required subsequent surgical correction once the squint angle became stable. One of the two patients of group 1 with postoperative diplopia presented with mild persistent anisocoria and a transient deficit of accommodation of the left eye (Figure 3).

Discussion

In the 1980s, when the number of orbital decompression procedures being performed started to rise as surgery was being undertaken not only for functional reasons, but also for the esthetic/psychosocial rehabilitation of patients with Graves’ orbitopathy, the antral-ethmoidal decompression by a transantral approach, as described by Walsh and Ogura in 1957, was the mainstay technique. The major disadvantage reported with transantral surgery was subsequent motility imbalance as high as 52% and, therefore, alternative procedures were sought in an attempt to decrease the risk of decompression-induced diplopia. In cases of mild exophthalmos, trans-lid antral-ethmoidal decompression appeared to be a valid alternative, with a risk of iatrogenic diplopia in only 4.6% of patients and for more severe exophthalmos, inferomedial decompression was used in combination with lateral decompression. Such procedures, whether performed with separate periorbital incisions or through a coronal approach, were also related with a low incidence of
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Recently, the lateral orbital wall has been promoted as being the region of first choice for orbital decompression. Its removal, which is connected with a low risk of consecutive diplopia or severe complications such as cerebrospinal fluid leak, perfectly fits the needs of the increasingly demanding patient population. The lateral wall of the orbit is the thickest orbital wall and is composed of the zygomatic bone anteriorly and the greater wing of the sphenoid posteriorly. The thinnest part of the lateral wall is at the zygomaticosphenoid suture, approximately 1 cm behind the orbital rim, and approximately 1 cm behind the

Table. Demographics and Preoperative Characteristics in Patients Treated With Extended (Cases, Group 1) or Conservative (Controls, Group 2) Removal of the Lateral Orbital Wall as Part of a Coronal-approach, 3-wall Decompression

<table>
<thead>
<tr>
<th></th>
<th>Cases (n=15)</th>
<th>Controls (n=15)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>80%</td>
<td>86.66%</td>
<td>$P = 0.624$</td>
</tr>
<tr>
<td>Age at surgery (yrs ± SD)</td>
<td>40.9 (9.7)</td>
<td>40.1 (12.4)</td>
<td>$P = 0.852$</td>
</tr>
<tr>
<td>Duration of Graves’ orbitopathy at surgery (yrs ± SD)</td>
<td>5.43 (5.8)</td>
<td>3.78 (2.1)</td>
<td>$P = 0.314$</td>
</tr>
<tr>
<td>Preop. immunosuppressive therapy:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) corticosteroids</td>
<td>20%</td>
<td>13%</td>
<td>$P = 0.500$</td>
</tr>
<tr>
<td>b) orbital radiotherapy</td>
<td>27%</td>
<td>47%</td>
<td>$P = 0.225$</td>
</tr>
<tr>
<td>c) corticosteroids and orbital radiotherapy</td>
<td>13%</td>
<td>7%</td>
<td>$P = 0.500$</td>
</tr>
<tr>
<td>d) neither corticosteroids nor orbital radiotherapy</td>
<td>40%</td>
<td>33%</td>
<td>$P = 0.500$</td>
</tr>
<tr>
<td>Preoperative Hertel values (mm ± SD)</td>
<td>26.3 (2.4)</td>
<td>25.0 (1.4)</td>
<td>$P = 0.123$</td>
</tr>
</tbody>
</table>
zygomaticosphenoid suture the sphenoid bone thickens where it divides to form the anterior corner of the middle cranial fossa.22 Here compact bone passes into thick cancellous bone to form a trigonus, nicknamed the “door-jamb” by Goldberg who, more than any other author, has stressed the importance of this zone of possible orbital expansion.9,10 Experimental studies on the basis of dry skulls and clinical radiologic surveys have quantified the absolute volume expected from the lateral orbital wall to clinical decompressions.8,9 Although there is considerable interindividual variability, the door-jamb represents a mean volume of 2.9 cm³ and because of its anatomical position located directly behind the globe, an almost millimeter-for-millimeter relationship between door-jamb removal and exophthalmos reduction was hypothesized.9,10 However, even by the use of a coronal approach where excellent access to the deep lateral wall can be obtained, thus permitting the possibility of performing the widest possible osteotomy, the volume of the door-jamb should be regarded as an idealized measurement that is impossible to be used fully for clinical decompressions.9 In addition to the volume and location of a given orbital wall, several disease-dependent variables can, in clinical practice, influence the possible reduction of exophthalmos. The stage of the orbitopathy at the time of surgery, the distensibility and plasticity of the soft orbital tissues and the degree of preoperative exophthalmos have all been highlighted as possible factors determining the final outcome of decompression surgery.11-13

Although removal of the deep lateral wall has been reported in several clinical trials9, 10, 14-17, its contribution to exophthalmos reduction has never been specifically studied. Additionally, the extreme heterogeneity of the patients included in each series and the variation of applied surgical techniques do not permit any attempt of its quantification on the basis of the data already available in the literature. In our study, the calculated contribution of the deep lateral wall to exophthalmos reduction can be regarded as maximal and on the basis of a homogeneous population of patients with Graves’ orbitopathy. We selected patients operated by the coronal approach, which permitted maximal removal of the deep lateral wall in the group 1 patients, and we chose to consider the reduction of exophthalmos later than 6 months after decompression as exophthalmos reduction is expected to be maximal in most of the decompressed patients by this time.18 Furthermore,
in our study, surgical access and inclusion and exclusion criteria were identical for the two groups, and we found no difference in the demographics or preoperative characteristics between groups 1 and 2.

We found that removal of the deep lateral wall contributed a mean of 2.3 mm to exophthalmos reduction. Interestingly, the standard deviation of the exophthalmos reduction in group 1 was approximately twice that of group 2 and we interpret this finding as a manifestation of the known interindividual variability of the volume of the deep lateral wall.

Removal of the deep lateral wall during 3-wall orbital decompression was not found to be associated with an increased risk of consecutive diplopia when compared with the more conservative 3-wall orbital decompression applied in group 2. Furthermore, both patients in group 1 who presented with consecutive esotropia and deficit of abduction after removal of the deep lateral wall experienced a spontaneous resolution of their strabismus 4 to 6 months after surgery. Transient strabismus after deep lateral wall removal has previously been reported. Deep mechanical contusions of the soft orbital tissues associated with the wide exposure that is necessary to accomplish the osteotomy with a cutting-burr can be regarded as a possible cause of this transient strabismus that most probably has a paralytic, rather than a restrictive, etiology and this hypothesis is supported by the simultaneous, mild anisocoria, and transient deficit of accommodation demonstrated by one of our patients.

Given the multifaceted nature of Graves’ orbitopathy, the numerous indications for decompression surgery and the many variations in surgical techniques, an ideal attempt to quantify the contribution of a specific osteotomy to exophthalmos reduction and consecutive diplopia must take the influence of these variables into account. We attempted to do this by selecting patients at random from a homogeneous group of patients with Graves’ orbitopathy undergoing surgery for the same indication and by utilizing a consistent surgical approach in each group. Nevertheless, we wish to acknowledge the limitations of our study. Our observations are retrospective, and patients were not randomly allocated to either of the two treatment groups. Additionally, our findings are only applicable to the specific population of patients with Graves’ orbitopathy as selected in this study, although our population, which was composed of individuals affected by moderate/severe exophthalmos, with no preoperative diplopia and treated exclusively for esthetic reasons, may be considered to be representative of a numerically significant and,
for obvious reasons, demanding subpopulation of patients with Graves’ orbitopathy. We, therefore, believe that our findings are of practical relevance when planning decompression surgery.
References