



Comparison of the effects of orbital decompression in Graves' ophthalmopathy

Original Study

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Abstract

Introduction. Graves' disease is an autoimmune disorder. One of the symptoms is an overgrowth of the soft tissues of the orbit. Orbital involvement can cause exophthalmos, diplopia, or vision loss. Treatment strategies include a surgical approach that limits the ailments mentioned above. Decompression can be achieved by reducing the amount of enlarged tissues (fat removal) or increasing the space for enlarged tissues (bone removal). Numerous authors discuss the advantages and disadvantages of various techniques in terms of reducing the exophthalmos, the number and persistence of complications, and the long-term prognosis.

Materials and Methods. A literature search of PubMed and the Poznan University of Medical Sciences Main Medical Library resources from 1993–2022 was performed. Thirty articles were reviewed with attention to the surgical treatment of Graves' ophthalmopathy.

Results. The main surgical techniques include fat decompression and bone wall decompression. The results of exophthalmos fat removal are characterized by a significant decrease in proptosis (5.45mm) with a small percentage of newly formed diplopia (9%). Bone reduction in the lateral wall of the orbit shows similar effects: reducing exophthalmos (4.33mm) and the newly formed diplopia, as with fat removal (3.7%). Bone reduction in the medial- lateral wall, medial- inferior- lateral wall, and medial- inferior wall shows a decrease in proptosis (4.9 mm, 4.6 mm, 3.77 mm) and a higher percentage of new-onset diplopia (18%, 15%, 28%).

Conclusion. The smallest amount of newly formed diplopia at the highest proptosis reduction occurs with the self-removal of fat or resection of the lateral orbital wall.

Keywords

Graves' ophthalmopathy • dysthyroid optic neuropathy • orbital decompression • diplopia • proptosis

1. Introduction

Graves' disease is a complex autoimmune disorder in which the orbital soft tissue becomes hypertrophic due to the infiltration of extraocular muscles and fat with glycosaminoglycans. This phenomenon triggers the proliferation of connective tissue and occurs in the acute phase of the condition. Subsequently, in the chronic course of the disease, fibrosis and increased pressure in the eye socket may develop [1–9].

Therefore, when the disease duration is prolonged, the management of soft tissues is more complicated, as they are hardened and less susceptible to moving into newly created spaces [2, 10]. Young patients tend to develop “fat-predominant” orbitopathy, which exhibits adipocyte hyperplasia and fat overgrowth. In older patients, fat hypertrophy is often accompanied by “muscular” orbitopathy, where the overgrowth of the extraocular muscles causes the exophthalmos. That mainly involves the inferior and medial rectus muscles [1, 11].

Surgical treatment is often performed due to aesthetic complaints such as eyelid retraction and exophthalmia, or due to strabismus with impaired visual function, optic nerve dysfunction, and extraocular muscle involvement, to rescue vision [4]. The most serious complication of the disease is the compression of the retro-orbital tissue, which can lead to blindness. This condition is called dysthyroid optic neuropathy (DON) [12] and requires surgical treatment in emergency mode for the purpose of saving eyesight by removing tissues up to the cone at the orbital apex [13, 14].

Surgery at an early stage of the disease is not recommended, as it does not prevent the recurrence. Often, a series of subsequent procedures is then required. Therefore, it should be considered only when conservative treatment methods, which include endocrinologic therapy, are exhausted. The risk factors of repeated surgical treatment include young age, high preoperative proptosis, unilateral surgery, steroid treatment,

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and normal thyroid function. The risk of reoperation is reduced in combined bone and fat removal, balanced decompression, and African American ethnicity compared to Caucasians [3]. Additionally, the factors predisposing to faster development of DON and worse outcomes of surgical treatment are male gender, old age, smoking, and diabetes, although, in general, women suffer DON more often than men (3: 1) [14–19].

Thus, the stage of the disease, its duration, severity of the course, and level of the oculomotor muscles' enlargement, are the main factors influencing the development of optic nerve neuropathy (DON), which requires more radical surgical treatment, than in people with mild exophthalmos [6, 14].

This study aimed to compare the effect of the decompression methods described in the literature in terms of the extent of proptosis reduction and the percentage of permanent, newly formed diplopia.

2. Materials and methods

The literature search of PubMed and the Poznan University of Medical Sciences Main Medical Library resources from 1993–2022 was performed using free-text terms that included Graves ophthalmopathy (GO), dysthyroid orbital neuropathy (DON), orbital decompression, Graves ophthalmology, diplopia, proptosis. The following eligibility criteria were used: publications

in English, the study population of at least 15 patients, follow-up not shorter than six weeks, dimensions given before and after exophthalmia, and percentage of newly developed diplopia calculated. Publications that did not meet all the above criteria, literature and systematic reviews, letters to the editors, case reports, and book chapters were excluded. After verification, 30 articles were reviewed with attention to the surgical treatment of GO. For the purpose of this analysis, the papers were divided into five groups: 1. adipose tissue removal procedures (4 reports), 2. lateral wall decompression (6 reports), 3. balanced wall (5 reports), 4. medial-inferior (5 reports), 5. 3-wall (5 reports).

3. Results

The comparison of the treatment effects resulting from various surgical approaches is presented in a tabular form. The number of patients, the type of surgical technique used to reduce ophthalmopathy, proptosis reduction, and the percentage of patients with new-onset diplopia are compared between the studies.

Table 1 shows the results of exophthalmos fat removal.

The results of these procedures on 2447 people in total were characterized by a significant decrease in proptosis (5.45mm) with a small percentage of newly formed diplopia not exceeding 9%.

Table 1. Summary of studies on fat removal decompression (mean reduction of the proptosis: 5.45 mm; 4.1% new onset of diplopia; mean age: 40 yrs., 2447 people)

Author, country, year	Procedure	Patients (N)	Follow up (months)	Proptosis difference after surgery (mm)	Newly developed diplopia (%)	Newly developed diplopia (N)
Cheng AM et al., Taiwan, 2017 [33]	Fat removal decompression	845	37.9 ± 24.4	4.1 ± 1.3	3	23
Wu CH et al., Taiwan, 2007 [24]	Fat removal decompression	120	10.9 ± 5.1	3.6 ± 1.0	2.8	3
Wu W et al., China, 2015 [32]	Fat removal decompression	108	16 ± 4.2	8.2 ± 1.8	1.9	2
Richter DF et al., Germany, 2007 [20]	Fat removal decompression	1374	32	5.9	8.6	38

Table 2. Summary of studies on lateral orbital wall decompression (mean reduction of the proptosis 4.075 mm; 3.73% new onset diplopia; mean age: 46 yrs., 264 people)

Author, country, year	Procedure	Patients (N)	Follow up (months)	Proptosis difference after surgery (mm)	Newly developed diplopia (%)	Newly developed diplopia (N)
Ueland HO et al., Norway, 2016 [78]	Lateral wall decompression	84	124	3.6 ± 2.1	5%	4
Sellari-Franceschini S et al., Italy, 2010 [48]	Lateral wall decompression	39	6	4.5 ± 1.9	8	3
Chang EL and Piva AP, USA, 2008 [26]	Lateral wall decompression	33	3	4.51	3	1
Gong Y et al., China, 2018 [79]	Lateral wall decompression	38	3	4.18 ± 1.11	0	0
Bengoa-González Á et al., United Kingdom, 2019 [60]	Lateral wall decompression	35	6	4.9 ± 1.54	0	0
Liao SL et al., Taiwan, 2006 [59]	Lateral wall decompression	35	9.5 ± 1.7	3.8 ± 0.91	5.7	2

Table 3. Summary of studies on medial and lateral orbital walls decompression (balanced technique) (mean reduction of the proptosis 4.9 mm; 17% new onset diplopia; mean age: 50 yrs., 455 people)

Author, country, year	Procedure	Patients (N)	Follow up (months)	Proptosis difference after surgery (mm)	Newly developed diplopia (%)	Newly developed diplopia (N)
Graham SM et al., USA, 2003 [44]	Medial and lateral wall decompression (balanced)	40	31.5	4.1	10	4
Dubin MR et al., USA, 2008 [82]	Medial and lateral wall decompression (balanced)	24	6 weeks	6.2	29.2 %	7
Stähr K et al., Germany, 2018 [83]	Medial and lateral wall decompression (balanced)	174	8	4.95	16%	28
Hernández-García E et al., Spain, 2017 [89]	Medial and lateral wall decompression (balanced)	20	44	3.5	15%	3
Rocchi R et al., Italy, 2012 [84]	Medial and lateral wall decompression (balanced)	197	3	5.7 ± 2.2	18	19

Table 4. Summary of studies on medial and inferior orbital walls decompression (mean reduction of the proptosis 3.6 mm; 30.5% new onset diplopia; mean age: 50.2 yrs., 682 people)

Author, country, year	Procedure	Patients (N)	Follow up (months)	Proptosis difference after surgery (mm)	Newly developed diplopia (%)	Newly developed diplopia (N)
Tallstedt L et al., Sweden, 2000 [87]	Medial-inferior decompression	63	6	3.2	51	22
Garrity JA et al., USA, 1993 [34]	Medial-inferior decompression	428	8.7 years	4.7	64	74
She YY et al., Taiwan, 2012 [80]	Medial-inferior decompression	25	3	2.07 ± 0.29	4	1
Lund VJ et al., United Kingdom, 1997 [86]	Medial-inferior decompression	20	55.3	3.8	20	4
Jernfors M et al., Finland, 2007 [85]	Medial-inferior decompression	78	5.2 years	4.5	7.7	6
Liao SL et al., Taiwan, 2001 [90]	Medial-inferior decompression	68	12	4.4	21	10

Table 5. Summary of studies on 3-wall (medial, inferior, lateral) orbital walls decompression (mean reduction of the proptosis 5.6 mm; 9.2% new onset diplopia; mean age: 46.9 yrs., 238 people)

Author, country, year	Procedure	Patients (N)	Follow up (months)	Proptosis difference after surgery (mm)	Newly developed diplopia (%)	Newly developed diplopia (N)
Paridaens DA et al., Netherlands, 2000 [51]	Three wall decompression	19	9	5.5	17	2
Kingdom TT et al., USA, 2015 [81]	Three wall decompression	77	31.3	3.2	0	0
Bailey KL et al., USA, 2005 [43]	Three wall decompression	55	11	5	1.8	1
Baldeschi L et al., Netherlands, 2005 [10]	Three wall decompression	15	6	4.9	33	5
Baldeschi L et al., USA, 2006 [88]	Three wall decompression	125	6	4.3	22	27

Table 2 presents the results of bone reduction only in the lateral wall of the orbit.

The effects of reducing exophthalmia and the newly formed diplopia were comparable to those achieved for fat removal.

Table 3 presents the results of bone decompression within the lateral and medial wall (balanced technique), where an average reduction of proptosis was 4.9 mm. However, there was also a significant increase in new diplopia, reaching 18% on average.

Table 4 shows the results of decompression in the area of the medial, inferior, and lateral walls, where the results were similar to those reached for the balanced technique (presented in Table 3). The average reduction of proptosis was estimated as 4.6 mm, while the percentage of newly developed diplopia reached 15.

Table 5 presents the results of the medial and inferior wall reduction technique, where the highest percentage of developed diplopia compared to other techniques was observed

Table 6. Summary of mean proptosis reduction and mean new onset diplopia after decompression of fat or bone reduction

Decompression technique	Proptosis reduction [mm]	New onset diplopia [%]
Fat decompression	5.4	4.1
Lateral wall decompression	4.3	3.7
Medial - Lateral wall decompression	4.9	18
Medial - Inferior - Lateral wall decompression	4.6	15
Medial – Inferior decompression	3.8	28

and reached 28%, while the level of diplopia reduction was the lowest (3.8%).

Table 6 compares all the methods presented in this paper regarding proptosis reduction and newly formed double vision.

4. Discussion

In general, the described orbital decompression methods can be divided into two methods, which are fat removal and individual orbital wall removal. Both types of surgical procedures have different indications and have their advantages and disadvantages.

In the comprehensive study by Richter et al., who used fat removal as an independent treatment method for orbitopathy, it was reported that vision improvement was achieved due to loosening of the extraocular muscle tension and the lengthening of these muscles, which increased their mobility and reduced double vision [20]. Meanwhile, Al-Sharif, who compared fat and bone removal strategies, listed more complications when removing bone than when removing fat. There were no significant differences in the effects between the procedures. However, the outcome of the surgery during bone removal was highly dependent on the operator. Therefore, based on his observations, it is recommended to remove fat only in patients with mild to moderate blurred vision or in patients with absent or slight hypertrophy of the muscles of the eyeball [21, 22].

The volume of orbital removable fat was positively correlated with Hertel exophthalmometry measurement. Tissue removal from the inferio-lateral quadrant, which accounts for 40% of the orbital fat volume, seems to be an effective method for reducing proptosis [20, 23]. This result indicates that more orbital fat can be removed from the lower lateral quadrant in patients with a higher degree of proptosis. In addition, there is a lower risk of oculomotor nerve branch injury, oblique muscle paralysis, and diplopia [23, 24]. In the case of fat removal from the superior lateral quadrant, as well as from the entire medial region, the risk of damage to the lacrimal artery and the lacrimal nerve, supratrochlear nerve and vessels, and the ethmoid arteries is much higher [20]. However, fat removal is generally burdened

with a low risk of complications. It may include retrobulbar hematoma, infections, palsy and paresthesia, and diplopia [24].

The results of our comparison for fat removal procedures remain in line with the other authors' observations, where the values of proptosis reduction ranged from 3.2mm to 5.2 (mean 4.1) and mean new-onset diplopia reached 9% [25–31]. Noteworthy also is the use of the endoscope described in the Wu et al. study, which allowed the removal of fat from the nasal access, with low new-onset diplopia and significant stabilization of the eyeball without its post-operative displacement, which could trigger diplopia [32].

Observations on isolated fat removal procedures confirm the effect of long-term improvement of vision, reduction of proptosis, and quality of life enhancement [33]. Lipectomy is a predictable procedure with a low risk of serious complications and a high effectiveness in reducing proptosis at the same time [25]. This is especially true when compared with the bone decompression methods [27, 34, 35].

This second method of orbital decompression in Graves' disease, which is bone resection, is recommended in the advanced stage of orbitopathy or if the fat removal did not bring a satisfactory effect [36]. This approach is performed more frequently in men, while the fat removal procedure is done three times more often in women.

The orbit resembles a closed, 4-sided bone can. During the decompression, in each of the walls, an additional space for the soft tissues can be created. The number of decompressed walls correlates not only with the greater amount of space obtained but also with greater risk and number of complications, which occur most often during the decompression of the orbital floor [2]. Decompression in the inferior wall is associated with a high risk of post-operative diplopia (up to one-third of those undergoing this procedure), according to Fabian et al. [37]. The sudden lack of support for significantly overgrown and fibrotic tissues causes them to fall into the sinus. With the current muscle dysfunction and without coordinated activity, new permanent diplopia and strabismus often develop. Therefore, sudden significant enlargement in the range of several orbital walls may not bring the desired results [2, 3, 38–40].

Several authors suggested abandoning the decompression of the inferior wall due to a significant percentage of newly developed diplopia, considering it as the surgery to be done last, or as a treatment option for people whose eyesight deteriorated significantly in a short time [37–39, 41–44].

Despite the high percentage of newly developed diplopia after the surgery on the floor of the orbit and medial wall or in a balanced technique, the operation on the medial-lateral wall is an alternative, according to Ellis. He suggests using the medial wall and floor decompression as an initial surgical treatment, while the lateral wall decompression is instead indicated in worsening proptosis, optic nerve compression, or post-operative strabismus

as a consequence of another procedure [45]. Goldberg's results seem to confirm the above-mentioned observations, as the method of deep lateral decompression treats complications such as strabismus and diplopia and reduces the risk of strabismus surgery. It may help avoid surgery on the eyeball muscles in the future and may provide faster rehabilitation after prior decompression of the medial-lateral wall [46, 47].

In the course of GO, the inflammation most frequently affects the inferior and medial rectus muscles, lying in the area of the medial-inferior orbital wall. Therefore, reducing walls in this area is associated with the highest risk of complications [48].

To prevent "setting sun syndrome" (strabismus and post-operative diplopia), it is recommended to leave the maxilla-ethmoidal strut when decompressing this area [32, 37, 49]. This bone strut supports the medial rectus muscle, and keeping it will help avoid an infero-medial shift of the globe into ethmoid space [43, 50, 51]. Regardless of decompressed walls, leaving a strut achieves a high degree of proptosis reduction with a reduced risk of new-onset diplopia. Many authors confirmed this method as an acceptable treatment strategy [10, 43, 44, 52–56].

Based on the results of our review, we believe that lateral wall surgery is the decompression method that brings a significant reduction in proptosis, with the lowest percentage of recurring complications that do not require any special treatment and which can be safely performed in the acute phase of inflammation. That is accordant with the observations of Goldberg et al., Sellari-Franceschini et al., and Liao et al. [46, 48, 57–59]. Complications of this procedure include hypoaesthesia in the area innervated by the infraorbital, zygomaticotemporal, and zygomaticofacial nerves, occurring in 57% of patients and usually absent in 6 months [59, 60]. Diplopia occurs two times less frequently than with other decompression methods [61]. Bleeding can be reduced by using piezoelectric devices [60]. A serious complication that may occur, although it is not common, is cerebrospinal fluid leakage. Although this leakage was described as small, it is necessary to control it during and after the procedure [50]. In order to avoid oscillops, which disturbs normal vision and affects the sense of balance, it is recommended to shift the decompression profoundly towards the wing of the more prominent sphenoid bone or leave a thin bone shell to partially cover the deep surface of the temporal muscle [48, 62, 63]. Several authors described a modification of this method as a combination of decompression of the lateral wall of the orbit and the removal of fat from the inferolateral quadrant. Compared to the removal of other walls, this technique achieves good results in proptosis reduction. In addition, it is a safe method characterized by a lower percentage of diplopia, paresthesia, strabismus, or eye dislocation than in the case of balanced decompression or removal of the floor of the orbit [26, 34, 38, 39, 44, 51, 64–68]. The disease is chronic and develops slowly. Very often the leading specialist responsible for the therapy is the endocrinologist.

GO results from an autoimmune process related to a hormonal imbalance. It is essential to achieve euthyroidism for at least five months before the surgical treatment can be started [7, 69]. After exhausting conservative methods of treatment, such as steroid therapy or radiotherapy, the following scales are widely used to qualify the patient for the procedure: EUGOGO (European Group of Graves' Orbitopathy), commonly used in Europe, and VISA (vision, inflammation, strabismus, and appearance) used in the USA. Depending on the stage of the disease defined by the scale, the appropriate therapy is used. Guidelines from the American Thyroid Association and the European Thyroid Association may be of additional help [8, 70–75].

We are aware of the limitations of this study, which include variations in methodology and treatment approaches used depending on the medical center. The patient database created for this analysis covers numerous publications from many centers and constitutes a significant group of patients. The search strategy was limited to the previous 20 years, there was a language restriction (only papers in English were included), and systematic reviews were excluded from the analysis. However, we still hope that the conclusions from this paper are beneficial for clinicians.

5. Conclusions

The orbital decompression in the course of GO is a challenging problem due to the complexity of the disease, the multiplicity of symptoms, the limited number of patients needing decompression, and the numerous dedicated surgical methods with different benefits. Each case must be considered individually, considering criteria such as patient's gender and age, disease duration, extraocular muscle involvement, speed of visual deterioration, and possible reduction of proptosis. The most advantageous surgical technique should be selected based on the above-mentioned criteria and thorough diagnosis. In the event of disease progression, there is a need to reduce exophthalmia and deterioration of vision significantly. In those cases, it is necessary to introduce more invasive treatment methods gradually. Treatment requires the collaboration of a multidisciplinary team, including an endocrinologist and an ophthalmologist, and in later stages, an endocrine surgeon, a radiotherapist, and a maxillofacial surgeon or laryngologist (depending on local conditions). It is recommended to work in a team, so that if conservative treatment methods of one specialist are exhausted, another specialist with more invasive methods can take over the treatment. At the early stage of the disease, surgery is not recommended at all, because the operation does not prevent recurrence. Surgical decompression of the orbit is performed as a last resort in cases of severe ophthalmopathy, preceded by steroid therapy, radiotherapy, and ophthalmological procedures.

Authors' contribution

All the authors contributed equally to the publication. W. Skrzypczak- Research concept and design, acquisition of data; Ł. Słowik- Acquisition of data, literature review, writing, original draft preparation; M. Okła- Original draft preparation; Z. Ślebioda- Supervising the project, literature review, final proofreading and approval of the version for publication; K. Osmola- Supervising the project, final proofreading and approval of the version for publication.

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Conflict of interest

There is no conflict of interest.

Ethics approval

Ethics Committee approval was not required.

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