Int. J. Oral Maxillofac. Surg. 2019; 48: 461–467
https://doi.org/10.1016/j.ijom.2018.08.016, available online at https://www.sciencedirect.com

International Journal of Oral & Maxillofacial Surgery

Clinical Paper
Clinical Pathology

Comparison of rim-sparing versus rim-removal techniques in deep lateral wall orbital decompression for Graves' orbitopathy

S. Zhang[1,2,a], Y. Li[1,2,a], Y. Wang[1,2], S. Zhong[1,2], X. Liu[1,2], Y. Huang[1,2], S. Fang[1,2], A. Zhuang[1,2], J. Sun[1,2], H. Zhou[1,2], X. Fan[1,2]

[1]Department of Ophthalmology, Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, China; [2]Shanghai Key Laboratory of Orbital Diseases and Ocular Oncology, Shanghai, China

S. Zhang, Y. Li, Y. Wang, S. Zhong, X. Liu, Y. Huang, S. Fang, A. Zhuang, J. Sun, H. Zhou, X. Fan: Comparison of rim-sparing versus rim-removal techniques in deep lateral wall orbital decompression for Graves' orbitopathy. Int. J. Oral Maxillofac. Surg. 2019; 48: 461–467.

Abstract. The aim of this study was to compare the surgical outcomes of deep lateral orbital decompression using the rim-sparing technique versus the rim-removal technique in Graves' orbitopathy (GO). A retrospective cohort study of 75 orbits in 50 patients with GO was performed. Proptosis, best corrected visual acuity (BCVA), intraocular pressure (IOP), upper and lower lid margin to reflex distances (MRD-1 and MRD-2, respectively), diplopia, ocular restriction, and GO quality of life (GO-QOL) questionnaire results were analyzed pre- and postoperatively. The average proptosis reduction ranged from 3.5 mm to 6.7 mm with the rim-sparing technique and from 3.6 mm to 6.7 mm with the rim-removal technique ($P > 0.05$). All orbits with dysthyroid optic neuropathy in the rim-sparing group and 87.5% of such orbits in the rim-removal group showed improved BCVA ($P = 0.321$). Reductions in IOP, MRD-1, and MRD-2 were observed with both techniques. Patients in the rim-sparing group had greater improvements in GO-QOL appearance score ($P = 0.043$). In conclusion, rim-sparing orbital decompression provides efficacious outcomes with greater improvements in patient quality of life than the rim-removal technique. The rim-sparing technique should be considered as a preferable option because it preserves the integrity of the lateral vertical maxillary buttress and bony protection for the orbital contents.

Key words: rim-sparing; proptosis; deep lateral decompression; Graves' orbitopathy.

Accepted for publication 16 August 2018
Available online 12 November 2018

Graves' orbitopathy (GO) is the most common orbital inflammatory disorder and has several manifestations, including proptosis, eyelid retraction, restrictive strabismus, and diplopia[1,2]. In addition, approximately 3–5% of patients experience sight-threatening exposure keratopathy or dysthyroid optic neuropathy

[a] Shuo Zhang and Yinwei Li contributed equally.

0901-5027/040461 + 07

(DON) with serious impacts on quality of life[3,4].

Systemic glucocorticoids, orbital radiotherapy, and rehabilitative surgery are the mainstay treatments for GO. When surgical rehabilitation is indicated, orbital decompression is widely accepted as the first-line procedure to restore visual function in patients with DON and/or exposure keratopathy and to relieve disfiguring proptosis[5]. Orbital decompression involves augmenting the orbit volume by removing orbital wall/walls or reducing the herniated fat, thus creating sufficient space for the orbital contents. The extent of orbital decompression varies from patient to patient depending on the severity of exophthalmos and clinical manifestations[5,6].

Deep lateral wall decompression has been shown to offer favourable outcomes with a low risk of postoperative diplopia[7]. This procedure is usually performed after lateral orbital rim-removal, with or without rim repositioning. Rim-removal lateral wall decompression without rim repositioning is recommended for improved visualization of the surgical field and better proptosis reduction[8]. However, this approach may damage the integrity of the lateral vertical maxillary buttress, resulting in instability of the face, and has a deleterious effect on the function of the lateral canthal tendon[9]. Furthermore, temple-related problems manifesting as temporal hollowing may arise when lateral orbital rim repositioning is not performed[8,10]. Deep lateral wall decompression after temporary rim removal with rim repositioning requires the additional use of individual implants, which may result in various complications, such as long-term sensory disturbances[11]. Mehta and Durrani first reported a new rim-sparing technique in which the lateral orbital wall was removed through a horizontal skin incision placed lateral to the lateral canthus while preserving the lateral rim[12]. This approach achieves ideal proptosis reduction and keeps the lateral rim intact without requiring repositioning of the orbital rim.

It appears that no study reported in the literature has compared the surgical effects of this new rim-sparing technique and the rim-removal technique. This study was performed to compare the surgical outcomes of deep lateral wall orbital decompression using the rim-sparing technique versus the rim-removal technique in patients with GO.

Materials and methods

A retrospective study was performed on all consecutive patients with GO who underwent orbital decompression with the rim-sparing or rim-removal technique in the Department of Ophthalmology of Shanghai Ninth People's Hospital between March 2015 and December 2017. The study was approved by the ethics committee of the medical centre and adhered to the tenets of the current version of the Declaration of Helsinki. Written consent was obtained from the participants.

Patients were eligible if they were 18 to 75 years of age, underwent orbital decompression including decompression of the lateral wall due to disfiguring proptosis, DON, or exposure keratopathy, and had well-controlled thyroid function in the past 3 months. Patients who underwent deep lateral wall decompression with rim repositioning were excluded. The data collected included preoperative and postoperative (3 months after surgery) proptosis, best corrected visual acuity (BCVA), intraocular pressure (IOP), upper and lower lid margin to reflex distance (MRD-1 and MRD-2, respectively), diplopia, ocular restriction, and surgical complications. A GO quality of life (GO-QOL) questionnaire concerning visual function and appearance in patients with GO was also completed[5]. Higher scores mean better health-related quality of life. Special attention was paid to the presence of postoperative temple-related problems and oscillopsia. Photographs were taken of the temporal region of each patient.

Demographic data including sex, age, and medical history were reviewed for each patient. Proptosis was assessed using computed tomography (CT) of the orbit (Fig. 1A, B). All CT data were imported into Mimics 17.0 (Materialise, Leuven, Belgium). Previously determined standard anatomical points were applied for proptosis measurements[13]. IOP was measured using a KT-800 tonometer (KOWA, Nagoya, Japan) in primary gaze. Measurements of eyelid retraction were obtained in patients in the primary position. The pres-

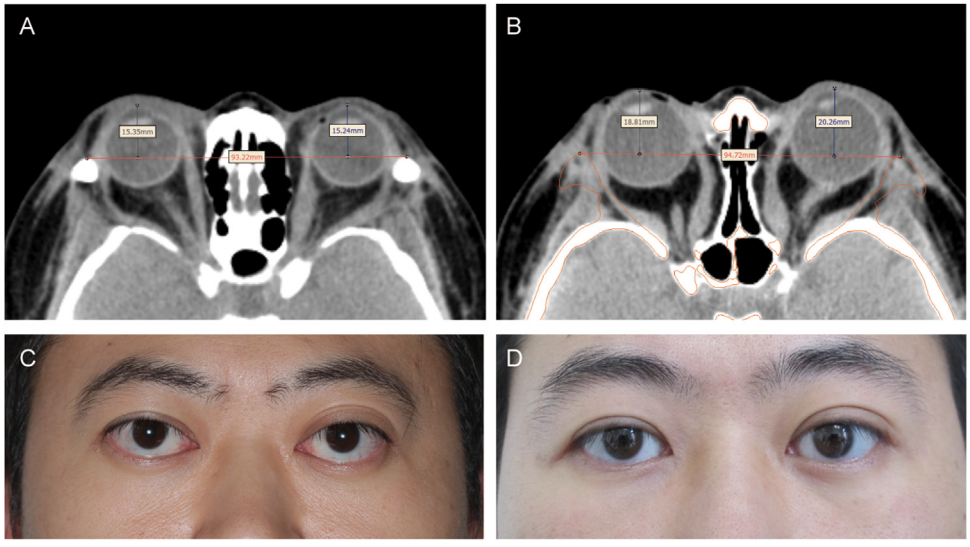

Fig. 1. Measurement of proptosis based on CT images for (A) the rim-sparing technique, and (B) the rim-removal technique. For the rim-removal technique, the preoperative and postoperative CT images were digitally merged using Mimics 17.0 software (Materialise, Belgium). Reconstructed orbital bony structures and measurement lines (orange line) were provided for the measurement of proptosis. The photographs show a patient who underwent bilateral orbital decompression with the rim-sparing technique (C) preoperatively, and (D) and postoperatively.

ence of subjective diplopia was rated according to the VISA classification (vision, inflammation, strabismus, and appearance): 0 = no diplopia, 1 = diplopia with horizontal or vertical gaze, 2 = intermittent diplopia in straight gaze, and 3 = constant diplopia in straight gaze[14]. Ocular restriction was assessed by categorizing patients according to four grades based on the range of duction: $0 \geq 45°$, 1 = 30–45°, 2 = 15–30°, and $3 \leq 15°$. A change of at least one grade was considered to be clinically relevant[14].

The surgical techniques were recorded. Safety was assessed based on the incidence of postoperative complications such as severe haemorrhage and cerebrospinal fluid leakage.

Surgical technique

The number of orbital walls decompressed was based on the severity of preoperative proptosis. Deep lateral wall decompression was performed if the proptosis measurement was less than 20 mm. Balanced decompression (deep lateral and medial walls) was performed if the proptosis measurement was between 20 mm and 24 mm. Three-wall decompression (deep lateral, medial, and inferior walls) was performed if the proptosis measurement was more than 24 mm. The decision regarding the surgical technique was made together with the patient after explaining the potential advantages and disadvantages of the rim-sparing and rim-removal techniques. One technique was not favoured over the other technique.

The preoperative surgical plan was created using the virtual surgical software Mimics 17.0 and Endo-Navi (UEG, Shanghai, China). The maximum decompression area and important structures such as the optic nerve and infraorbital nerve bundle were outlined. The plan was exported to the navigation system Endo-Navi.

The dynamic reference frame was attached to the patient's skull and face matching was performed, following which the accuracy of the navigation system with an error of less than 1.5 mm was confirmed. A horizontal skin incision was made along the double eyelid fold. The lateral orbital rim was exposed from the skull base to the level of the orbital floor. The temporalis fascia was exposed along the posterior edge of the lateral rim before reflecting the temporalis muscle laterally. The periosteum was incised 2 mm posterior to the lateral orbital rim in an 'H-like' manner, along the length of the lateral wall.

For the rim-sparing group, the lateral orbital rim was preserved and kept intact. An L-shaped surgical landmark was outlined, and osteotomies were created in the lateral wall 5 mm posterior to the lateral orbital rim at the level of the superior margin of the zygomatic arch. The deep lateral wall to the trigone of the greater wing of the sphenoid, which is the narrow space of the sphenoid between the superior and inferior orbital fissures, was removed (Fig. 2). The lateral window was enlarged widely with rongeurs and a cutting burr. For the rim-removal group, osteotomies

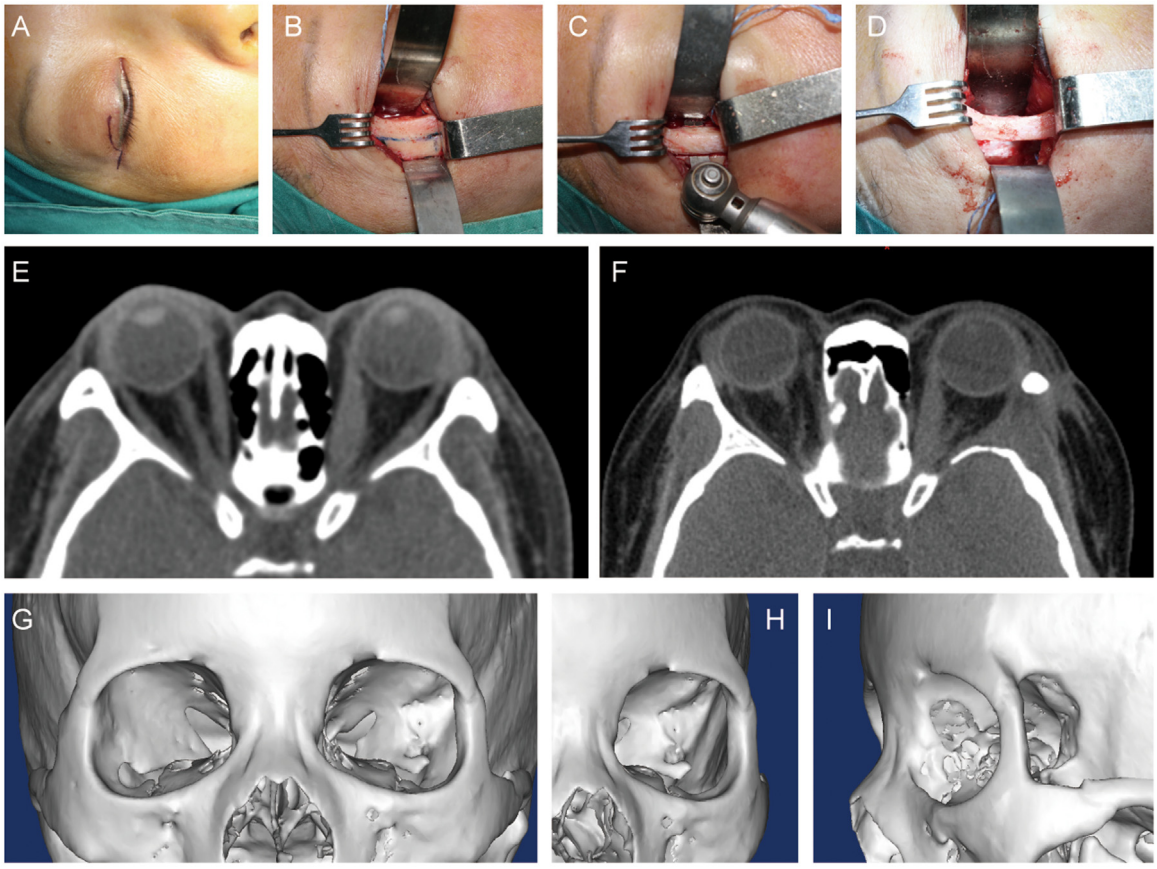

Fig. 2. (A) Photograph showing the intraoperative landmarks for the incision along the double eyelid fold. (B) Photograph showing the L-shaped landmark of the osteotomy made in the lateral wall 5 mm posterior to the lateral rim. (C and D) Photographs showing the intact orbital rim and bony window following osteotomy. (E) Preoperative and (F) postoperative CT images of a patient who underwent left deep lateral wall orbital decompression with the rim-sparing technique. (G–I) Postoperative three-dimensional CT reconstruction; the left orbital rim was left intact.

were made 1 cm above the frontozygomatic suture and the level of the superior margin of the zygomatic arch. En bloc removal of the lateral orbital rim was performed, and the rim was not repositioned. The deep lateral wall decompression was then performed. Additional medial wall and/or inferior wall decompression was performed successively by transconjunctival and transcaruncular approaches as planned. No strabismus or eyelid surgery was performed at the time of the orbital decompression or prior to the postoperative assessment in any case.

Statistical analysis

The statistical analysis was performed using SPSS version 14.0 (SPSS Inc., Chicago, IL, USA). The Student *t*-test and paired *t*-test were used to compare the means of continuous variables and normally distributed data; otherwise, the Mann–Whitney *U*-test and Wilcoxon test were used. The χ^2 test was used to compare categorical data. BCVA was converted to the logarithm of the minimal angle of resolution (logMAR) for statistical analysis. *P*-values of <0.05 were considered statistically significant.

Results

Seventy-five orbits in 50 patients (16 male and 34 female) who underwent orbital decompression were included (Table 1). The mean age of the patients was 40.2 ± 13.3 years. Follow-up ranged from 4 to 36 months. All surgeries were performed by a single surgeon. The rim-sparing technique was performed on 23 orbits and the rim-removal technique was performed on 52 orbits. Forty-seven orbits underwent surgery due to disfiguring proptosis and 28 orbits underwent surgery due to DON, including five orbits that also had exposure keratopathy. One-wall decompression (deep lateral wall) was performed in 18 orbits. Twenty-four orbits underwent balanced decompression (deep lateral and medial walls), while 33 orbits underwent three-wall decompression (deep lateral, medial, and inferior walls).

No significant differences in preoperative proptosis were observed between decompression with the rim-sparing technique and decompression with the rim-removal technique in patients who underwent deep lateral wall decompression, balanced decompression, and three-wall decompression (all $P > 0.05$) (Table 2). No significant difference in proptosis reduction was found between the decompression with rim-sparing technique and the decompression with rim-removal technique. The average proptosis reduction was 3.5 ± 0.5 mm in the rim-sparing group and 3.6 ± 1.1 mm in the rim-removal group for patients who underwent deep lateral wall decompression ($P = 0.907$). For balanced decompression, the average proptosis reductions were 4.9 ± 0.7 mm and 4.6 ± 1.2 mm in the rim-sparing group and rim-removal group, respectively ($P = 0.559$). For three-wall decompression, the average proptosis reduction was 6.7 ± 0.3 mm for the rim-sparing group and 6.7 ± 1.2 mm for the rim-removal group ($P = 0.995$). A greater degree of proptosis before surgery resulted in a greater reduction ($r = 0.678$, $P < 0.001$ vs. $r = 0.686$, $P < 0.001$), regardless of the technique used.

Four orbits (17.4%) in the rim-sparing group and 24 orbits (46.2%) in the rim-removal group had reduced BCVA and underwent decompression due to DON. All patients in the rim-sparing group and 87.5% (21/24) of the patients in the rim-removal group showed improvements after surgery ($P = 0.321$). The improvement in BCVA was similar in the two groups (0.460 ± 0.201 vs. 0.571 ± 0.300 logMAR, $P = 0.489$). BCVA did not worsen in any orbit.

Despite normal preoperative IOP, mean reductions of 2.6 mmHg and 3.1 mmHg ($P < 0.001$) were observed after orbital decompression with the rim-sparing and rim-removal techniques, respectively. The reduction in the rim-sparing group was not significantly different from that measured in the rim-removal group ($P = 0.451$). Median reductions of 1.0 mm in both MRD-1 and MRD-2 were achieved in the rim-sparing group ($P < 0.001$). Similarly, median reductions of 1.0 mm and 1.5 mm in MRD-1 and MRD-2, respectively, were achieved in the rim-removal group ($P < 0.001$). Removal of the orbital rim did not contribute to a greater improvement in upper eyelid retraction ($P = 0.129$) or lower eyelid retraction ($P = 0.863$).

Among the patients who underwent decompression due to disfiguring proptosis, no patient (0/13) in the rim-sparing group but four patients (22.2%, 4/18) in the rim-removal group experienced worsening diplopia (new-onset diplopia or worsening of pre-existing diplopia); the difference between the two groups was significant ($P = 0.029$). One patient had undergone deep lateral wall decompression, one had undergone balanced decompression, and two had undergone three-wall decompression. On multivariate analysis, neither the orbital walls decompressed nor the surgical technique used (rim-sparing or rim-removal) were associated with the rate of postoperative worsening diplopia ($P > 0.05$). Two patients (12.5%, 2/16) with DON in the rim-removal group also experienced worsening diplopia. One orbit (3.6%, 1/28) experienced new-onset esotropia after rim-removal three-wall decompression. An improvement in ocular restriction occurred in three orbits (13.0%, 3/23) with the rim-sparing technique and in four orbits (7.7%, 4/52) with the rim-removal technique ($P = 0.761$).

Three orbits (5.8%) in the rim-removal group but no orbits in the rim-sparing group experienced slight but not disturbing temporal hollowing ($P = 0.133$) (Fig. 1C, D). No patients complained of oscillopsia.

No significant differences in preoperative GO-QOL appearance score or visual functioning score were observed between the rim-sparing group and the rim-removal group. The GO-QOL scores showed significant improvements postoperatively. The average improvement in the GO-QOL appearance score was 25.9 ± 14.1 in the rim-sparing group and 17.7 ± 12.8 in the rim-removal group ($P = 0.043$). The average improvement in the GO-QOL visual functioning score was 10.8 ± 14.5 in the rim-sparing group and 12.1 ± 13.2 in the rim-removal group ($P = 0.751$). Patients in the rim-sparing group had sig-

Table 1. Demographic characteristics of the patients enrolled in this study.

Characteristics	Rim-sparing ($n = 23$)	Rim-removal ($n = 52$)	*P*-value
Sex, *n* (%)			0.681
Male	6 (26.1)	16 (30.8)	
Female	17 (73.9)	36 (69.2)	
Age (years), mean ± SD	37.5 ± 10.3	41.4 ± 14.4	0.196
Side, *n* (%)			0.713
Right	13 (56.5)	27 (51.9)	
Left	10 (43.5)	25 (48.1)	
Disease duration (months), median (IQR)	24.0 (12.5–44.0)	18.5 (10.0–43.0)	0.501

SD, standard deviation; IQR, interquartile range.

Table 2. Proptosis reduction (millimetres) in the rim-sparing group versus the rim-removal group[a].

		Rim-sparing	Rim-removal	*P*-value
One-wall	Preoperative proptosis	18.7 ± 1.1	19.2 ± 0.7	0.297
R-S: *n* = 8	Postoperative proptosis	15.2 ± 1.3	15.7 ± 1.7	0.533
R-R: *n* = 10	Proptosis reduction	3.5 ± 0.5	3.6 ± 1.1	0.907
	P-value	<0.001	<0.001	
Two-wall	Preoperative proptosis	21.5 ± 0.7	21.3 ± 1.1	0.600
R-S: *n* = 10	Postoperative proptosis	16.6 ± 0.7	16.6 ± 1.2	0.921
R-R: *n* = 14	Proptosis reduction	4.9 ± 0.7	4.6 ± 1.2	0.559
	P-value	0.001	<0.001	
Three-wall	Preoperative proptosis	24.9 ± 0.7	25.1 ± 1.2	0.790
R-S: *n* = 5	Postoperative proptosis	18.2 ± 0.6	18.4 ± 1.7	0.838
R-R: *n* = 28	Proptosis reduction	6.7 ± 0.3	6.7 ± 1.2	0.995
	P-value	<0.001	<0.001	

R-S, rim-sparing; R-R, rim-removal.
[a] All data are presented as the mean ± standard deviation.

nificantly greater improvements in the GO-QOL appearance score.

No cases of severe haemorrhage or cerebrospinal fluid leakage were noted.

Discussion

Augmenting the orbit volume to reduce proptosis for functional and aesthetic improvements and relieving compression of the optic nerve due to retrobulbar inflammation and tissue proliferation in DON are the overall goals of the planning and evaluation of orbital decompression. This study showed similar outcomes for proptosis reduction and BCVA improvement in the rim-sparing group and rim-removal group, with greater improvements in patient quality of life in the rim-sparing group.

The rim-sparing orbital decompression technique used on the study patients resulted in a comparable degree of proptosis reduction to that achieved with the rim-removal technique, suggesting that removing the orbital rim does not contribute to a more effective reduction in proptosis. As reported by Goldberg et al.[7], the amount of proptosis reduction achieved through deep lateral wall decompression is highly dependent on the removal of bone from the deep lateral orbit, including the lacrimal keyhole, the orbital door jamb, and the basin of the inferior orbital fissure. The lateral orbital rim plays a limited role in proptosis reduction but an important role in preserving a bony protection for the globe and the outer shape of the orbit[10,15,16]. The lateral vertical maxillary buttress, which is essential to the stability of the face by interfacing with the cranium or skull base, extends down from the frontal bone through the zygomaticofrontal suture, down the lateral orbital rim, across the zygoma and zygomaticomaxillary suture, and into the columns of bone above the posterior molars[9]. Therefore, the lateral orbital rim acts as a vital lateral support structure.

Furthermore, some studies have raised concerns regarding temple-related problems following lateral wall decompression, such as temporal hollowing[17]. Fichter et al.[18] reported that three of 18 patients had temporal hollowing after rim-removal lateral wall decompression. In the study by Ueland et al.[17], a surprisingly high incidence (56%) of patients with postoperative temporal hollowing was reported, but hollowing occurred to a lesser extent when the orbital rim was left intact. The rim-sparing technique is recommended to minimize disruption to the anatomy of the temporalis muscle and minimize the complication of temporal hollowing[15,17,19–21]. Under these circumstances, a comparable gain in proptosis reduction with the rim-sparing technique and a lower incidence of depressed iatrogenic deformity is a better choice.

Sagiv et al.[10] found that proptosis reduction was similar in patients with or without rim repositioning in balanced decompression and three-wall decompression. The results of the present study are consistent with those of their study. Since the orbital rim in the present study was left intact, the orbital rim did not require repositioning, which saved the time for repositioning of the rim. Repositioning of the orbital rim also requires the additional use of titanium plates and leads to higher hospitalization expenses. In addition, various complications may result from internal fixation using titanium plates; infection and long-term sensory disturbances including discomfort, cold intolerance, palpability, and pain are causes for plate removal[11]. The literature-reported rates of plate removal in craniofacial surgery vary from 2.6% to 33.3%[11,22,23]. A significantly higher risk of plate removal has been reported for plates situated in the orbital rim than for plates situated in the maxilla or the frontal bone[22]. The thin soft tissue cover in the midface and the upper third of the face causes greater awareness of plates inserted in these regions.

Concerning visual acuity, 89.3% of orbits with DON showed improved visual acuity after decompression surgery. A satisfactory improvement in BCVA was obtained in both the rim-sparing group and the rim-removal group, indicating that the rim-sparing technique is applicable to GO with DON. Three of the orbits with DON without sufficient improvement had already achieved maximal decompression (three-wall decompression). It is presumed that the residual visual deficits were likely attributable to the long disease duration of DON (13, 13, and 40 months), which may have led to irreversible optic nerve dysfunction.

In both groups, IOP decreased significantly after orbital decompression regardless of the number of walls removed or the technique used, consistent with the results shown in other studies[6,24]. Significant decreases in MRD-1 and MRD-2 were also observed, suggesting that orbital decompression does not only contribute to proptosis reduction but also improves additional aesthetic outcomes such as eyelid retraction. The literature tends to support this beneficial effect[6,18,25].

Reducing the incidence of postoperative diplopia has been a goal of many reported variations in orbital decompression, and rates of new-onset strabismus vary among surgeons and techniques, ranging from 0% to 62.5%[26,27]. In this study, these incidences were assessed only in orbits without DON and exposure keratopathy, because restoring visual function is the main goal in these orbits. It is also speculated that the BCVA improvement in two patients with DON may have led to subjective worsening of diplopia. The rate of worsening postoperative diplopia was 0% in the rim-sparing group and 22.2% in the rim-removal group in the present study ($P = 0.029$). Although the rate of worsening diplopia was significantly higher in the rim-removal group, more orbits in the rim-removal group had undergone balanced and three-wall decompression (Table 3). Patients with deep lateral wall decompression exhibit a lower incidence of postoperative diplopia due to limited lateral shifting of the intraorbital contents[19], whereas inferior-medial wall decompression is associated with a relatively high rate of new-onset diplopia with disturbance of the extraocular muscle balance[28]. On multivariate analysis, the surgical technique and the orbital walls

Table 3. The number of walls decompressed among orbits undergoing decompression due to disfiguring proptosis.

	Rim-sparing (n = 19)	Rim-removal (n = 28)	P-value
One-wall, n (%)	7 (36.8)	9 (32.1)	0.595
Two-wall, n (%)	9 (47.4)	11 (39.3)	
Three-wall, n (%)	3 (15.8)	8 (28.6)	

decompressed were not risk factors for a higher rate of postoperative worsening diplopia in the present study. The surgical influence of decompression on diplopia reflects the feasibility of performing decompression prior to strabismus surgery.

This study has some limitations given its nature as a retrospective study. Furthermore, the rim-sparing technique is challenging with a limited view of the surgical fields, although the Endo-Navi system compensated for this disadvantage. Differences in surgical skills for each technique may have resulted in more favourable outcomes for the rim-removal technique. In addition, temple-related problems may be late complications of decompression surgery. Long-term aesthetic outcomes remain to be observed as they manifest over time. Prospective, randomized controlled trials will provide more definitive evidence to confirm the present study findings.

In conclusion, the rim-sparing technique provides efficacious outcomes for the treatment of GO with a greater improvement in patient quality of life than the rim-removal technique. The rim-sparing technique preserves the important components of the lateral vertical maxillary buttress and provides a bony protection for the orbital contents. It also eliminates the need to reposition the orbital rim, which requires the additional use of titanium plates. The rim-sparing technique should be considered as a preferable option for deep lateral wall orbital decompression in GO.

Funding

This work was supported by the National Natural Science Foundation of China (81770974, 81761168037, 31701046); the Clinical Research Plan of SHDC (16CR1004A); the Clinical Research Program of Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine (JYLJ036); the Shanghai Municipal Education Commission-Gaofeng Clinical Medicine Grant Support (20152228); the Multicenter Clinical Research Program of Shanghai Jiao Tong University School of Medicine (DYL201615); Shanghai Science and Technology Commission Research Project (16411950600, 14411968000); and the Science and Technology Commission of Shanghai (17DZ2260100). The funding organizations had no role in the design or conduct of this study.

Competing interests

None declared.

Ethical approval

The study was approved by the Ethics Committee of Shanghai Ninth People's Hospital (2017-390-T287).

Patient consent

Written consent was obtained for publication of the patient data and photographs.

References

1. Hiromatsu Y, Eguchi H, Tani J, Kasaoka M, Teshima Y. Graves' ophthalmopathy: epidemiology and natural history. *Intern Med* 2014;**53**:353–60.
2. Smith TJ, Hegedus L. Graves' disease. *N Engl J Med* 2016;**375**:1552–65.
3. Bahn RS. Graves' ophthalmopathy. *N Engl J Med* 2010;**362**:726–38.
4. Bartalena L, Pinchera A, Marcocci C. Management of Graves' ophthalmopathy: reality and perspectives. *Endocr Rev* 2000;**21**:168–99.
5. Bartalena L, Baldeschi L, Boboridis K, Eckstein A, Kahaly GJ, Marcocci C, Perros P, Salvi M, Wiersinga WM, European Group on Graves' Orbitopathy (EUGOGO). The 2016 European Thyroid Association/European Group on Graves' Orbitopathy guidelines for the management of Graves' orbitopathy. *Eur Thyroid J* 2016;**5**:9–26.
6. Kikkawa DO, Pornpanich K, Cruz Jr RC, Levi L, Granet DB. Graded orbital decompression based on severity of proptosis. *Ophthalmology* 2002;**109**:1219–24.
7. Goldberg RA, Kim AJ, Kerivan KM. The lacrimal keyhole, orbital door jamb, and basin of the inferior orbital fissure. Three areas of deep bone in the lateral orbit. *Arch Ophthalmol* 1998;**116**:1618–24.
8. Fichter N, Guthoff RF. Results after en bloc lateral wall decompression surgery with orbital fat resection in 111 patients with Graves' orbitopathy. *Int J Endocrinol* 2015;**2015**:860849.
9. Ellstrom CL, Evans GR. Evidence-based medicine: zygoma fractures. *Plast Reconstr Surg* 2013;**132**:1649–57.
10. Sagiv O, Satchi K, Kinori M, Fabian ID, Rosen N, Ben Simon GJ, McNab A. Comparison of lateral orbital decompression with and without rim repositioning in thyroid eye disease. *Graefes Arch Clin Exp Ophthalmol* 2016;**254**:791–6.
11. Nagase DY, Courtemanche DJ, Peters DA. Plate removal in traumatic facial fractures: 13-year practice review. *Ann Plast Surg* 2005;**55**:608–11.
12. Mehta P, Durrani OM. Outcome of deep lateral wall rim-sparing orbital decompression in thyroid-associated orbitopathy: a new technique and results of a case series. *Orbit* 2011;**30**:265–8.
13. Li Y, Su Y, Song X, Zhou H, Fan X. What is the main potential factor influencing ocular protrusion. *Med Sci Monit* 2017;**23**:57–64.
14. Barrio-Barrio J, Sabater AL, Bonet-Farriol E, Velázquez-Villoria Á. Galofré JC. Graves' ophthalmopathy: VISA versus EUGOGO classification, assessment, and management. *J Ophthalmol* 2015;**2015**:249125.
15. Paridaens DA, Verhoeff K, Bouwens D, van Den Bosch WA. Transconjunctival orbital decompression in Graves' ophthalmopathy: lateral wall approach ab interno. *Br J Ophthalmol* 2000;**84**:775–81.
16. Spalthoff S, Jehn P, Zimmerer R, Rana M, Gellrich NC, Dittmann J. Modified lateral orbital wall decompression in Graves' orbitopathy using computer-assisted planning. *Int J Oral Maxillofac Surg* 2018;**47**:167–74.
17. Ueland HO, Haugen OH, Rodahl E. Temporal hollowing and other adverse effects after lateral orbital wall decompression. *Acta Ophthalmol* 2016;**94**:793–7.
18. Fichter N, Krentz H, Guthoff RF. Functional and esthetic outcome after bony lateral wall decompression with orbital rim removal and additional fat resection in Graves' orbitopathy with regard to the configuration of the lateral canthal region. *Orbit* 2013;**32**:239–46.
19. Chang EL, Piva AP. Temporal fossa orbital decompression for treatment of disfiguring thyroid-related orbitopathy. *Ophthalmology* 2008;**115**:1613–9.
20. Siah WF, Patel BC, Malhotra R. Surgical management of temple-related problems following lateral wall rim-sparing orbital decompression for thyroid-related orbitopathy. *Br J Ophthalmol* 2016;**100**:1144–50.
21. Vaca EE, Purnell CA, Gosain AK, Alghoul MS. Postoperative temporal hollowing: is there a surgical approach that prevents this complication? A systematic review and anatomic illustration. *J Plast Reconstr Aesthet Surg* 2017;**70**:401–15.
22. Thorén H, Snäll J, Kormi E, Lindqvist C, Suominen-Taipale L, Törnwall J. Symptomatic plate removal after treatment of facial

fractures. *J Craniomaxillofac Surg* 2010;**38**:505–10.
23. Llandro H, Langford R. Reasons for plate removal after treatment of orbitozygomatic complex fractures. *J Craniomaxillofac Surg* 2015;**43**:17–20.
24. Danesh-Meyer HV, Savino PJ, Deramo V, Sergott RC, Smith AF. Intraocular pressure changes after treatment for Graves' orbitopathy. *Ophthalmology* 2001;**108**:145–50.
25. Cho RI, Elner VM, Nelson CC, Frueh BR. The effect of orbital decompression surgery on lid retraction in thyroid eye disease. *Ophthal Plast Reconstr Surg* 2011;**27**:436–8.
26. Mainville NP, Jordan DR. Effect of orbital decompression on diplopia in thyroid-related orbitopathy. *Ophthal Plast Reconstr Surg* 2014;**30**:137–40.
27. Ben Simon GJ, Wang L, McCann JD, Goldberg RA. Primary-gaze diplopia in patients with thyroid-related orbitopathy undergoing deep lateral orbital decompression with intraconal fat debulking: a retrospective analysis of treatment outcome. *Thyroid* 2004;**14**:379–83.
28. Fabian ID, Rosen N, Ben Simon GJ. Strabismus after inferior-medial wall orbital decompression in thyroid-related orbitopathy. *Curr Eye Res* 2013;**38**:204–9.

Address:
Xianqun Fan or Huifang Zhou
Department of Ophthalmology
Ninth People's Hospital
Shanghai Jiao Tong University School of Medicine
No. 639 ZhiZaoJu Road
Shanghai 200011
China
E-mails: fangzzfang@163.com,