INTRODUCTION

Nowadays, medial orbital blowout fracture (BOF) operations have become more common. Rapid developments in medical imaging technology over recent years have resulted in computed tomography (CT) becoming a standard tool for the diagnosis of facial trauma [1], and in the more frequent detection and operation of medial BOFs [2,3].

Patients with medial BOFs usually have nonspecific symptoms, such as periorbital edema, ecchymosis, and subcutaneous emphysema. Generally, the immediate symptoms of medial BOFs are not as serious as those of an inferior fracture because injuries of the extraocular muscles or nerves or soft tissue incarcerations are not as common [4]. Functional and aesthetic sequelae, however, such as extraocular muscle disorders, diplopia, and/or enophthalmos could also occur as they do with inferior BOFs. When physicians encounter a patient with periocular trauma, they should suspect the possibility of medial BOF and undertake a radiologic evaluation. The surgeon should preferentially check the axial and coronal cuts of CT scans, because the plain radiographs, such as Caldwell's and Waters’ views, show just nonspecific images of medial wall fractures like haziness of the ethmoidal sinus.

The purpose of this article is to review medial BOF treatment with emphasis on anatomy, fracture mechanisms, surgical approaches, and reconstruction materials and methods.

ANATOMY AND MECHANISM

The medial orbital wall is composed of the frontal process of the maxilla, the lacrimal bone, the orbital plate of the ethmoid, and the lesser wing of the sphenoid, through which the optic nerve traverses in the optic canal. The lamina papyracea, supported by honeycomb-like bony septa of the ethmoid sinuses, constitutes the largest, main portion of the medial wall of the orbit [5], and has a convex orientation with respect to the orbital cavity. Pneumatized ethmoid air cells, which maintain structural stability and resist fractures of the medial orbital wall, act as a safeguard.
for the eyeball during trauma. The foramina of the anterior and posterior ethmoidal arteries are located along the fronto-ethmoidal suture line [6], and the anterior ethmoidal artery, posterior ethmoidal artery, and optic canal have been reported to be at approximately 24 mm, 36 mm, and 42 mm from the medial orbital rim [7,8]. Surgeons should be well acquainted with this anatomy and keep in mind not to dissect over the posterior ethmoid foramen to avoid optic neuropathy [9]. The optic neuropathy can be caused by direct nerve injury or retinal arteriolar occlusion. Careless dissection near the optic ring could tear soft tissues around the optic nerve and cause them to swell. This swelling in the limited bony canal compresses retinal vessels and may induce optic nerve ischemia and resultant optic nerve injury. The optic nerve can also be injured by compression of unrecognized hematoma around the retrobulbar space. For this reason, many experienced surgeons recommend not dissecting over the posterior ethmoidal foramen [10,11].

The mechanism of medial BOF could be largely explained by hydraulic pressure; that is, increased pressure in orbital soft tissue acts on the orbit to outfracture the medial orbital wall [12,13]. The buckling mechanism is a relatively uncommon cause of medial BOF [14]. This bone conduction theory holds that direct trauma to the rigid orbital rim transmits force posteriorly to cause compression fracture of the orbital wall [15,16]. On the other hand, there is another old theory called the “direct globe-to-wall contact” mechanism suggested by Raymond Pfeiffer in 1943. This hypothesis means that when the globe is displaced posteriorly by forces, the fracture is possible with exactly the same displacement of the globe like a footprint [17,18].

Surgeons should consider the kinetics of injury and choose a treatment plan after meticulous clinical examination and precisely analyzing CT images. When a fracture is extensive and enophthalmos is anticipated, surgery is usually recommended within 2 weeks of trauma to prevent soft tissue scarring and contracture in a nonanatomic position [19]. The indications for early surgery are diplopia caused by soft tissue incarceration, a positive forced duction test, a significant change in globe position, and a compressed optic canal [20,21].

**SURGICAL APPROACHES**

**Transcaruncular approach**

The transcaruncular approach is favored by many surgeons for the reconstruction of medial BOF, because it enables medial orbital wall defect exposure without leaving cutaneous scars [22-24].

Equipment, such as a headlight and loupes, enable bright and clear visualization of the operative field to simplify surgery. The use of a corneal protector is mandatory during this approach to prevent corneal injury, and a transparent corneal protector permits the early detection of mydriasis and the prevention of optic neuropathy around the optic ring [25]. Through an incision between the caruncle and plica semilunaris conjunctivae, soft tissue dissection is performed up to the periosteum of the medial orbital wall, just behind the rim. Pulling soft tissue upward and downward with small, long retractors, the freer is used for subperiosteal dissection until the area of the fracture is well detected, while avoiding any damage to the lacrimal sac and medial rectus muscle.

This approach provides direct and predictable access to the medial orbit and avoids injury to the canthal tendon and lacrimal apparatus. However, it has the disadvantage of a limited surgical field, which can make placing of a large implant difficult.

**Transcutaneous approach**

The percutaneous, subbrow, or upper eyelid crease approaches could be used via a small linear, curvilinear, Z, or vertical incision [26-28]. The orbicularis oculi muscle is split carefully, preserving the supratrochlear nerve, the hole is enlarged by retractors and periosteal elevator, and a periosteal incision is made along the edge of the medial orbital rim. This method is reliable and predictable for experienced plastic surgeons, but has the disadvantages of leaving a visible scar and possible injury of the medial canthal tendon or the lacrimal apparatus, and numbness of the medial forehead caused by supratrochlear nerve injury [29,30].

Subciliary incision is a familiar method of accessing the lower half or lower two thirds of the medial wall, but it is not easy to obtain full exposure of the operative field, due to soft tissue tethering to the lacrimal sac and inferior oblique muscle. When multiple upper and middle facial fractures are combined, the surgeon could choose a bicoronal incision, which provides excellent visualization for reduction and enables calvarial bone harvesting.

**Transnasal approach**

The transnasal endoscopic approach is another useful tool for repairing fractured bone segments [31]. With visualization of the inner site of the middle meatus, the mucosa of the uncinate process is incised and the process removed to obtain wide access to the fractured wall. Opening the anterior ethmoidal cells then exposes any fractured bones of the lamina papyracea and herniated orbital contents. The transnasal endoscopic approach provides good aesthetic results without an external scar [32,33]. Its disadvantages include difficulties associated with implant insertion and reconstructing large defects. In addition, there is a
learning curve and possibilities of recurrence of BOFs when there are comminuted fractures [34]. Recently, Lim et al. [10] reported good surgical outcomes using a combination of trans-orbital and transnasal approaches that mobilize the fractured orbital wall back to its original position through transnasal manipulation without endoscopic equipment.

**RECONSTRUCTION MATERIALS**

It is well known that the type of material used for orbital reconstruction is less important than the methods in which materials are used. However, the surgeon should decide what materials to use when confronted with an extensive large defect, combined associated injuries, or a pediatric patient, as well as when donor morbidity is considerable [35].

Ideal orbital implants are biocompatible, available in sufficient amounts, strong enough to provide orbital support, easily shaped, and radiopaque. Various repair materials have been introduced for the treatment of medial BOF [35], and available graft materials can be categorized as autologous and alloplastic.

Autologous materials include bone, cartilage, fascia lata, and periosteum. Autologous bone grafts are favored because of their availability, mechanical properties, revascularization potential, and low risks of infection or scarring [36-38]. Donor sites include calvarium, iliac crest, rib, anterior wall of the maxillary sinus, mandibular symphysis [39], and autologous cartilage grafts, such as conchal, septal, or rib cartilage are also candidates. However, autologous materials have unpredictable resorption rates and provide suboptimal volume correction and their malleabilities result in grafts that are less than architecturally accurate. In addition, their utilities are limited by associated donor site morbidity [40,41].

To date, several alloplastic materials, such as titanium, porous polyethylene, resorbable materials, gel film, bioglass, and silastic sheeting have been introduced [42-44]. These materials eliminate donor site morbidity and reduce operative time, and they are readily available [45,46]. Porous polyethylene is an inert, nonabsorbable polymer formulated to contain a network of open and interconnecting pores of 100–250 μm in size; it facilitates tissue ingrowth and reduces foreign body reactions and capsule-associated complications. In fact, vascular and soft tissue ingrowth through its pores can be observed at 1 week after implantation without fixation.

Titanium has been used extensively in the craniofacial surgery and dentistry fields in the form of implants, plates, and screws. Titanium is biocompatible, has excellent physico-mechanical properties, and is strong, rigidly fixable, widely available, relatively familiar to surgeons, and is osseointegrated with minimal foreign body reaction [47], and thus, it could be an ideal implant for covering large anatomical defects. However, titanium is costly and if not cut properly may have irregular edges that impinge on soft tissues. Furthermore, wider incisions are necessary when covering large defects with titanium plates. Hybrid products, such as the titanium reinforced polyethylene fan implant (SynPOR titanium orbital mesh plate, Synthes Inc., West Chester, PA, USA) can also be used.

Bioactive silica glass is bacteriostatic and more rigid than other materials and has potential as an orbital implant, but it is difficult to customize [48].

Silicone sheeting has been widely used for orbital reconstruction. The positive attributes of this material include low cost, flexibility, and ease of handling, while providing adequate support for maintaining orbital contents for even large orbital fractures. Its disadvantages are its lack of rigidity, the possibilities of fibrous capsule formation, infection, and extrusion. Due to the proximity of the medial orbital wall and the mucosa of the ethmoidal sinuses, formation of a capsule could significant increase the risk of infection.

Poly-L-lactide (PLLA) and polyglycolic acid (PGA) are absorbable implants with sufficient biomechanical resistance for orbital wall reconstruction. Both are malleable and impermeant and in time are replaced by bone. The drawbacks of PLLA and PGA implants are radiolucency, the possibility of inflammation with degradation, limited durability, and low strength, and thus, the adoption of PLLA implants for the treatment of large orbital wall defects has been limited.

**RECONSTRUCTION METHODS**

Various methods have been devised to reconstruct the medial BOF, and surgeons may have opportunities to gain valuable new skills to debunk surgical myths.

**The onlay covering method**

The onlay covering method is a widely used, accepted, and effective means of treating for medial BOF [49]. It includes the following procedures: circumferential subperiosteal dissection, reduction of herniated orbital contents, and wider dissection than the defect area followed by onlay covering with thin materials to complete orbital continuity (Fig. 1). When a defect is large, a longer incision and wider dissection are required to provide sufficient space for a large implant to cover the entire defect. However, when orbital bone support is inadequate, inserted materials can sink or be displaced, which increases the risk of BOF recurrence.
Inlay implantation

Inlay implanting methods involve insertion of implant materials layer-by-layer into the ethmoidal sinus to achieve medial orbital wall continuity. After transcaruncular incision and restoring herniated soft tissue, a 3 mm thick porous polyethylene plate is cut into pieces and inserted into the sinus through the defect area (Fig. 2). The advantage of this method is simple and safe. The main surgical procedure is performed in the ethmoidal sinus and not the orbital cavity. This provides adequate restoration of premorbid orbital volume even for comminuted fractures involving the posterior medial wall to the posterior ethmoid foramen, avoiding the possibility of optic nerve injury. As the ethmoidal sinus is filled with implants, one could question whether the blockage of the drainage and infection of the ethmoidal sinus might occur. The inlay implantation technique is not completely filling the ethmoidal sinus but partially rebuilding the orbital continuity, leaving enough space for drainage. The porous polyethylene has excellent biocompatibility providing fibrous tissues and blood vessels to grow into the pores, resisting any infection [23].

The repositioning method

The fractured bone segments of the medial orbital wall can be preserved with periosteum and repositioned in their original positions (Fig. 3). The endoscopic transnasal approach provides an effective means of repositioning fractured segments [31,32] and of maintaining the medial orbital wall in the preinjury position until bone union. When a fracture segment is large and green-stick displaced, the bone segment could be repositioned transcaruncularly. The slender freer is inserted through the fracture line into the ethmoidal sinus, and then by pushing out the tip of the freer from under the displaced segment, the fractured medial orbital wall can be repositioned by leverage. Furthermore, inserting implants into the ethmoidal sinus under the bone segment prevents BOF recurrence. However, it is not recommended for comminuted fracture because small fractured segments could be displaced later.

UP-TO-DATE TECHNIQUES

The determination of the shape of an implant required to treat an extensive orbital fracture is sometimes not straightforward.
Recently, preoperative computer-assisted planning using virtual correction models and patient-specific implants using CT mirror images of the non-affected orbit have been introduced [50]. This procedure could reduce operative times and provide more accurate reconstruction on an individual anatomic basis.

Intraoperative navigation surgery using three-dimensional (3D) CT is also useful for complex orbital fractures [51]. This modality involves the synchronous positioning of instruments with 3D CT images [52], and enables accurate, safe surgery on orbital fractures around the optic canal based on visualizing locations indicated by the intraoperative navigation pointer. Intraoperative CT [53] and the intraoperative 3D C-arm [54] helpfully identify current implant positions and confirm immediate postoperative orbit status.

Orbital volumes can be measured using CT information and software packages, such as Aquarius Workstation (iNtuition Aquarius, version 4.4.6; TeraRecon Inc., San Mateo, CA, USA) and automated rapid stereolithography machine (SLA3500, 3D Systems, Rock Hill, SC, USA) [55]. These volume measurement methods provide objective assessments for preoperative planning and of postoperative outcomes.

**POSTOPERATIVE CARE**

Bedside opthalmologic examinations, which include visual acuity and diplopia, extraocular muscle movement assessments are required after medial orbital wall reconstruction. Intra- and postoperative CTs are useful for assessing surgical results, by providing exact locations of implants, restored soft tissue (including extraocular muscle), and repositioned bone fragments. The patient should be placed in the Semi-Fowler position and informed to avoid physical stimulations, such as, bumps, hard exercise, eye rubbing, and nose blowing, until the medial orbital wall has stabilized. Regular postoperative follow-up is recommended at intervals of several months to assess the degree of enophthalmos, which could be checked with a Hertel or Naugle exophthalmometer or volumetric analysis of CT data at least 1 year postoperatively.

**CONCLUSIONS**

Although medial BOF is less symptomatic than inferior BOF, it may lead to serious sequelae. The goal of medial BOF reconstruction is restoration and maintenance of premorbid orbital

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**Fig. 2. Inlay implantation**

The fractured bone segments were removed and several pieces of 3-mm thick porous polyethylene plate were inserted into the defect area of the ethmoidal sinus. (A, B) Preoperative computed tomographic axial view and coronal view. (C, D) Postoperative computed tomographic axial view and coronal view.
cavity volume. Many surgeons have been devoted to finding a better way to achieve optimal outcome in fields of the medial BOF. The optimal surgical outcomes could be achieved when the surgeon gave sufficient consideration to orbital anatomy, the fracture mechanism, surgical approaches, reconstruction materials and surgical methods.

REFERENCES

1. Park MS, Kim YJ, Kim H, et al. Prevalence of diplopia and extraocular movement limitation according to the location of isolated pure blowout fractures. Arch Plast Surg 2012;39:204-8.
2. Choi KE, Lee J, Lee H, et al. the paradoxical predominance of medial wall injuries in blowout fracture. J Craniomaxfac Surg 2015;26:e752-5.
3. Choi M, Flores RL. Medial orbital wall fractures and the transcaruncular approach. J Craniomaxfac Surg 2012;23:696-701.
4. Burm JS, Oh SJ. Direct local approach through a W-shaped incision in moderate or severe blowout fractures of the medial orbital wall. Plast Reconstr Surg 2001;107:920-8.
5. Rodriguez ED, Dorafshar AH, Manson PN. Facial fractures.

In: Neligan P, Rodriguez ED, Losee JE, editors. Plastic surgery. Philadelphia: Elsevier Saunders; 2013. p.53-7.
6. Hwang K, Baik SH. Surgical anatomy of the orbit of Korean adults. J Craniomaxfac Surg 1999;10:129-34.
7. Janfaza P. Surgical anatomy of the head and the neck. Cambridge: Harvard University Press; 2011.
8. Zide BM, Luce CA, Boutros SG, et al. Surgical anatomy around the orbit : the system of zones. Philadelphia: Lippincott Williams & Wilkins; 2006.
9. Shin KJ, Lee DG, Park HM, et al. The merits of mannitol in the repair of orbital blowout fracture. Arch Plast Surg 2013;40:721-7.
10. Lim NK, Kang DH, Oh SA, et al. Orbital wall restoring surgery in pure blowout fractures. Arch Plast Surg 2014;41:686-92.
11. Chen CT, Huang F, Chen YR. Management of posttraumatic enophthalmos. Chang Gung Med J 2006;29:251-61.
12. Fujino T, Makino K. Entrapment mechanism and ocular injury in orbital blowout fracture. Plast Reconstr Surg 1980;65:571-6.
13. Fujino T. Experimental “blowout” fracture of the orbit. Plast Reconstr Surg 1974;54:81-2.
14. Rhee JS, Kilde J, Yoganadan N, et al. Orbital blowout frac-
tures: experimental evidence for the pure hydraulic theory. Arch Facial Plast Surg 2002;4:98-101.
15. Smith B, Regan WF Jr. Blow-out fracture of the orbit: mechanism and correction of internal orbital fracture. Am J Ophthalmol 1957;44:733-9.
16. Waterhouse N, Lyne J, Urdang M, et al. An investigation into the mechanism of orbital blowout fractures. Br J Plast Surg 1999;52:607-12.
17. Erling BF, Iliff N, Robertson B, et al. Footprints of the globe: a practical look at the mechanism of orbital blowout fractures, with a revisit to the work of Raymond Pfeiffer. Plast Reconstr Surg 1999;103:1313-6.
18. Pfeiffer RL. Traumatic Enophthalmos. Trans Am Ophthalmol Soc 1943;41:293-306.
19. Dubois L, Steenen SA, Gooris PJ, et al. Controversies in orbital reconstruction- II. Timing of post-traumatic orbital reconstruction: a systematic review. Int J Oral Maxillofac Surg 2015;44:433-40.
20. Kim NH, Kang SJ. Correlation between the time to surgery and that to recovery from postoperative diplopia based on a single-center, retrospective experience: a case series of 11 patients. Arch Plast Surg 2014;41:486-92.
21. Sung YS, Chung CM, Hong IP. The correlation between the degree of enophthalmos and the extent of fracture in medial orbital wall fracture left untreated for over six months: a retrospective analysis of 81 cases at a single institution. Arch Plast Surg 2013;40:335-40.
22. Boyette JR, Pemberton JD, Bonilla-Velez J. Management of orbital fractures: challenges and solutions. Clin Ophthalmol 2015;9:2127-37.
23. Kim YH, Kim TG, Lee JH, et al. Inlay implanting technique for the correction of medial orbital wall fracture. Plast Reconstr Surg 2011;127:321-6.
24. Lee JW, Choi JI, Ha W, et al. Analysis and management of complications of open reduction and medpor insertion through transconjunctival incision in blowout fractures. Arch Craniofac Surg 2012;13:22-8.
25. Jung DW, Chung KJ, Kim YH. The use of a transparent corneal protector permits early detection of mydriasis to prevent blindness during orbital wall fracture surgery. Arch Plast Surg 2013;40:791-2.
26. Ellis E, Zide MF. Surgical approaches to the facial skeleton. Philadelphia: Lippincott Williams & Wilkins; 2006.
27. Kim KS, Kim ES, Hwang JH. Combined transcutaneous transthamoidal/transorbital approach for the treatment of medial orbital blowout fractures. Plast Reconstr Surg 2006;117:1947-55.
28. Jung JA, Gong JS, KimYW, et al. modified direct w-incision with silicone sheet to minimize operation scar in reconstruction of mild to moderate symptomatic medial orbital wall fracture. Arch Craniofac Surg 2013;14:30-5.
29. Kim HK, Baek WI, Bae TH, et al. Usefulness of subciliary approach by using lacrimal sac stripping for large isolated medial orbital fracture reconstruction. Ann Plast Surg 2015;75:170-3.
30. Kim HS, Kim SE, Evans GR, et al. The usability of the upper eyelid crease approach for correction of medial orbital wall blowout fracture. Plast Reconstr Surg 2012;130:898-905.
31. Lee MJ, Kang YS, Yang JY, et al. Endoscopic transnasal approach for the treatment of medial orbital blow-out fracture: a technique for controlling the fractured wall with a balloon catheter and Merocel. Plast Reconstr Surg 2002;110:417-26.
32. Lee TH, Lee HM, Lee JM, et al. Endoscopic reduction of orbital medial wall fracture using rotational repositioning of the fractured: lamina papyracea fragment. J Craniofac Surg 2014;25:460-2.
33. We J, Kim Y, Jung T, et al. Modified technique for endoscopic endonasal reduction of medial orbital wall fracture using a resorbable panel. Ophthal Plast Reconstr Surg 2009;25:303-5.
34. Jeon SY, Kim C, Ma Y, et al. Microsurgical intranasal reconstruction of isolated blowout fractures of the medial orbital wall. Laryngoscope 1996;106:910-3.
35. Dubois L, Steenen SA, Gooris PJ, et al. Controversies in orbital reconstruction- III. Biomaterials for orbital reconstruction: a review with clinical recommendations. Int J Oral Maxillofac Surg 2016;45:41-50.
36. Avashia YJ, Sastry A, Fan KL, et al. Materials used for reconstruction after orbital floor fracture. J Craniofac Surg 2012;23:1991-7.
37. Chowdhury K, Krause GE. Selection of materials for orbital floor reconstruction. Arch Otolaryngol Head Neck Surg 1998;124:1398-401.
38. Ilankovan V, Jackson IT. Experience in the use of calvarial bone grafts in orbital reconstruction. Br J Oral Maxillofac Surg 1992;30:92-6.
39. Talesh KT, Babaee S, Vahdati SA, et al. Effectiveness of a nasoseptal cartilaginous graft for repairing traumatic fractures of the inferior orbital wall. Br J Oral Maxillofac Surg 2009;47:10-3.
40. Young VL, Schuster RH, Harris LW. Intracerebral hematoma complicating split calvarial bone-graft harvesting. Plast Reconstr Surg 1990;86:763-5.
41. Zins JE, Whitaker LA. Membranous versus endochondral bone: implications for craniofacial reconstruction. Plast Re-
42. Lee KM, Park JU, Kwon ST, et al. Three-dimensional present titanium implant for concomitant orbital floor and medial wall fractures in an East Asian population. Arch Plast Surg 2014;41:480-5.
43. Baek WJ, Kim HK, Kim WS, et al. Comparison of absorbable mesh plate versus titanium-dynamic mesh plate in reconstruction of blow-out fracture: an analysis of long-term outcomes. Arch Plast Surg 2014;41:355-61.
44. Mackenzie DJ, Arora B, Hansen J. Orbital floor repair with titanium mesh screen. J Craniofac Surg 1999;10:9-16.
45. Schubert W, Gear AJ, Lee C, et al. Incorporation of titanium mesh in orbital and midface reconstruction. Plast Reconstr Surg 2002;110:1022-30.
46. Reich D, Seidel D, Bredehorn-Mayr T, et al. Reconstruction of isolated orbital floor fractures with a prefabricated titanium mesh. Klin Monbl Augenheilkd 2014;231:246-55.
47. Choi TJ, Burm JS, Yang WY, et al. A wrapping method for inserting titanium micro-mesh implants in the reconstruction of blowout fractures. Arch Plast Surg 2016;43:84-7.
48. Mok D, Lessard L, Cordoba C, et al. A review of materials currently used in orbital floor reconstruction. Can J Plast Surg 2004;12:134-40.
49. Dubois L, Steenen SA, Gooris PJ, et al. Controversies in orbital reconstruction--I. Defect-driven orbital reconstruction: a systematic review. Int J Oral Maxillofac Surg 2015;44:308-15.
50. Bell RB, Markiewicz MR. Computer-assisted planning, stereolithographic modeling, and intraoperative navigation for complex orbital reconstruction: a descriptive study in a preliminary cohort. J Oral Maxillofac Surg 2009;67:2559-70.
51. Kim YH, Jung DW, Kim TG, et al. Correction of orbital wall fracture close to the optic canal using computer-assisted navigation surgery. J Craniofac Surg 2013;24:1118-22.
52. Hassfeld S, Muhling J, Zoller J. Intraoperative navigation in oral and maxillofacial surgery. Int J Oral Maxillofac Surg 1995;24:111-9.
53. Hoelzle F, Klein M, Schwerdtner O, et al. Intraoperative computed tomography with the mobile CT Tomoscan M during surgical treatment of orbital fractures. Int J Oral Maxillofac Surg 2001;30:26-31.
54. Wilde F, Lorenz K, Ebner AK, et al. Intraoperative imaging with a 3D C-arm system after zygomatico-orbital complex fracture reduction. J Oral Maxillofac Surg 2013;71:894-910.
55. Liu XZ, Shu DL, Ran W, et al. Digital surgical templates for managing high-energy zygomaticomaxillary complex injuries associated with orbital volume change: a quantitative assessment. J Oral Maxillofac Surg 2013;71:1712-23.