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Original Article

The significance of orbital floor exploration during open reduction of zygomaticomaxillary complex fractures

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Abstract

Objective: Zygomaticomaxillary complex (ZMC) fractures represent a common type of facial fractures, sometimes associated with defects of the orbital floor that may escape diagnosis, unless investigated intraoperatively following open reduction. The aim of the study was to determine the frequency of orbital floor defects among cases of ZMC fractures treated with open reduction in our Department and to share our experience in the diagnostic and therapeutic approach of such defects. **Patients and methods:** The files of all patients, treated in our Department for ZMC fractures from January 2010 to October 2014 were retrieved and reviewed retrospectively. Specific related data were registered and submitted to thorough analysis. **Results:** Based on our findings a considerable percentage (34.1%) of the patients with ZMC fractures demonstrated considerable defects of the orbital floor; these were diagnosed through intraoperative exploration of the orbital floor following open reduction of the fractures and appropriately treated. **Conclusions:** Orbital floor defects associated with ZMC fractures may remain undiagnosed and therefore untreated, unless routine exploration of the orbital floor is performed following open reduction of the fractures. This could result in severe morbidity, including enofthalmos, restricted ocular mobility and impaired visual acuity.

Keywords: Zygomaticomaxillary complex fractures, ZMC, Open reduction, Orbital floor defects, Reconstruction

Introduction

Zygomaticomaxillary complex (ZMC) fractures represent one of the most common facial fractures. Their high vulnerability of the ZMC to injury is attributed to its intrinsically prominent convexity[1]. Not only high- but also low- energy ZMC fractures may result in posteriomedial displacement of the fractured bony fragments, thus corrupting the anatomy of the orbit and especially the orbital floor[1-4].

The anatomy of the delicate orbital floor is intricate and crucial for surgeons involved in the treatment of orbital pathology. It is formed by the maxilla (medially to the infraorbital groove), the zygomatic bone (anterolaterally) and a small portion of the palatine bone (posteriorly). The infraorbital neurovascular bundle courses on the orbital floor along the infraorbital groove and infraorbital canal immediately above the maxillary sinus, thus thinning the orbital floor at its junction with the medial wall, before it exits at the infraorbital foramen. Therefore, most fractures tend to occur along the infraorbital groove, between the posterior and medial part of the orbital floor[3,5].

Fractures of the orbital floor occur in one of the following three patterns: a) the fractured fragment(s) collapse(s) into the maxillary sinus, thus producing a defect of the orbital floor; b) the orbital floor gets comminuted and the multiple bony fragments produce a multi-folded appearance; c) the fractured fragments overlap telescopically, i.e. one inside the other. Thus, the only orbital floor fracture pattern associated with orbital floor defects is the first[2,6].

Moreover, the orbital floor is by definition affected in 'blowout' orbital fractures, designated as fractures or defects of one or more internal orbital wall(s); since these

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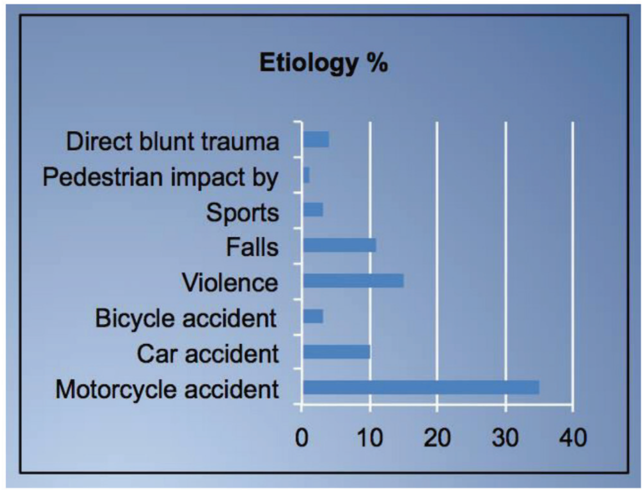

Figure 1. Injury mechanisms of zygomaticomaxillary complex (ZMC) fractures, included in the study.

walls are mostly formed by the ZMC, blowout fractures are a subcategory of ZMC fractures. The former are usually caused by direct blunt trauma to the orbit and typically lead to soft tissue (periorbital fat, extraocular muscles,) entrapment within the maxillary sinus, ethmoid cells or pterygopalatine fossa. They are classified as either impure or pure, involving or not involving the orbital rim respectively[3,5,7,8].

Various imaging modalities are available nowadays for ZMC fractures. Occipitomental views distinctly delineate osseous margins but may fail to detect fractures of the orbital walls that consist of thin bony parts, poorly defined in conventional X-rays. Ultrasound is sometimes useful to delineate the orbital floor and medial wall. Thin-cut (1mm to 1.5 mm thick) CT scans and MRI have practically replaced conventional radiographic techniques and orbitography. The orbital volume can be assessed through high-resolution biplanar CT scans, invaluable for decision making in the management of enophthalmos. Furthermore, cone beam CT (CBCT) and especially coronal views, may help in revealing orbital defects, through detection of herniated orbital contents[2,5,9-11].

Despite the multiple sophisticated imaging modalities and meticulous clinical examination, orbital floor defects associated with ZMC fractures may evade diagnosis and appropriate management. Moreover, it should be pointed out that the orbital floor is not routinely explored during open reduction of ZMC fractures; thus, orbital floor defects may remain undiagnosed and untreated even in cases of openly reduced ZMC fractures[5,12,13].

Undiagnosed, untreated or even mistreated orbital floor defects may result in considerable morbidity, impairing the patient's professional and social activity. Complications such as enophthalmos, diplopia or ophalmoplegia may occur. Hence, practitioners should always bear in mind that ZMC fractures may be associated with orbital floor defects, in order to successfully identify them clinically and radiographically and plan appropriate and timely treatment[5,10,14].

The objective of the present study was to investigate the significance/need of routinely exploring the integrity of the orbital floor following open reduction of ZMC fractures, as a prerequisite for the reconstruction of selected orbital floor defects, depending on their size and complexity. Based on a retrospective analysis of all ZMC fractures, treated in our Department from January 2010 to October 2014, the benefits of intraoperative routine exploration of the orbital floor are highlighted. Moreover, the treatment algorithm and the materials implemented for reconstruction of these defects, are concisely discussed.

Patients and methods

The files of all patients treated at the Department of Oral and Maxillofacial Surgery of the 'KAT' General Hospital of Athens for zygomaticomaxillary complex (ZMC) fractures from January 2010 to October 2014 were retrieved and reviewed retrospectively.

Inclusion in the material of the study and further analysis was conducted only for the cases of ZMC fractures that were treated with open reduction through a subciliary, mid-tarsal or orbital rim incision, thus allowing subsequent intraoperative exploration of the orbital floor. All ZMC fractures, preoperatively presenting clinical or imaging indications for orbital floor reconstruction (i.e. findings compatible with orbital floor defects) were excluded from the analysis.

For each of the cases included in the study the following data were recorded: patient's demographical data (age,

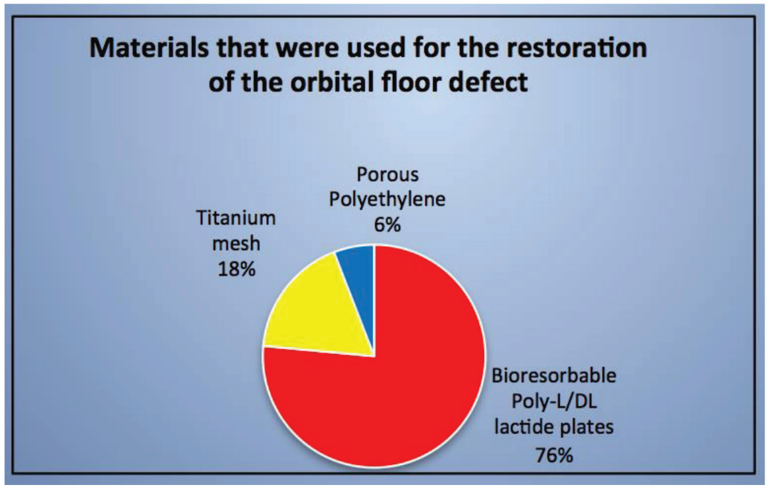

Figure 2. Materials implemented for primary reconstruction of orbital floor defects, associated with zygomaticomaxillary complex (ZMC) fractures, included in the study.

sex and nationality), mechanism of injury/cause of trauma, indications for surgical intervention (open reduction), applied surgical approach, presence and size of concomitant orbital floor defects, detected intraoperatively and materials implemented for their reconstruction.

Results

A total of 143 fractures of the zygomaticomaxillary complex (ZMC) were treated in our Department from January 2010 to October 2014. Of these, 82 cases (57.3%) met the inclusion criteria of the study and were included in the analysis.

The patients' age ranged from 16 to 57 years (mean age: 36.4 years); 71 patients (87%) were male and 11 (13%) were female.

The injury mechanisms of ZMC fractures are summarized in Figure 1 and included in decreasing frequency motor vehicle accidents (MVAs) (49 out of the 82 cases or 59.8%), violent assaults (15 out of the 82 cases or 18.3%), falls (11 out of the 82 cases or 13.4%), direct blunt trauma (4 out of the 82 cases or 4.9%) and sport accidents (3 out of the 82 cases or 3.6%). The vast majority of the MVAs were motorcycle (39%) than car accidents (10%).

Open reduction of the above ZMC fractures was opted for due to varying displacement degree of the fractured segments in all cases. The fracture line(s) were approached through a subciliary (27 out of the 82 cases), mid-tarsal (36 out of the 82 cases) or orbital rim (19 out of the 82 cases) incision.

Intraoperative exploration of the orbital floor following open reduction of ZMC fractures revealed orbital floor defects in 28 of the cases (34.1%). Of these, 11 defects (13.4%) were classified as small (<2 cm^2) and did not require reconstruction, while 17 (20.7%) were classified as large (>2 cm^2), requiring primary reconstruction. In the remaining 54 ZMC fractures (65.9%) no orbital floor defects were detected.

Of the 17 cases of large (>2 cm^2) orbital floor defects, requiring reconstruction, 13 (76%) were restored with bioresorbable Poly-L/DL lactide plates, 3 (18%) with titanium mesh and 1 (6%) with a porous polyethylene graft. The related data are schematically depicted in Figure 2.

Discussion

The appearance of the facial skeleton can be dramatically altered due to fractures of the zygomaticomaxillary complex (ZMC) that represent a common type of maxillofacial trauma, potentially impairing ocular mobility and/or visual acuity.

Based on our findings, ZMC fractures were mostly encountered in young male patients as a result of motor vehicle accidents (MVAs) - with the vast majority of them involving motorcycle accidents than cars, violent assaults, falls and sports. These findings are consistent with those registered in the pertinent literature[15]. In contrast, Ellis et al. found that only 13% of the fractures in Glasgow, Scotland were attributed to MVAs and the great majority of them resulted from assault, falls and sport injuries[16].

Fractures of the orbital floor - a subcategory of ZMC fractures - may cause restricted action of the extraocular muscles, paraesthesia of the infraorbital nerve (which provide sensation to the anterior cheek, lateral nose, upper lip and maxillary anterior teeth), hypoglobus, enophthalmos and diplopia, easily ascertained through clinical examination. However, orbital floor defects associated with ZMC fractures may be asymptomatic and/or undetectable through imaging, thus escaping clinical and radiographic diagnosis.

Intraoperative exploration of the orbit remains a controversial issue, since it has been associated with postsurgical lower eyelid ectropion and scleral show, especially when a subciliary approach is used to access the orbit. Its opponents claim that orbital floor exploration should be avoided on a routine basis and is only warranted when clinical signs (preoperative diplopia that does not improve over 7 to 14 days from the day of injury, enophthalmos or other globe malpositioning) or radiographic findings of ocular involvement are present, especially given the fact that axial and coronal CT scans can adequately detect any orbital defect[3,10,17].

Nevertheless, this approach cannot completely exclude the possibility of preoperatively insignificant (unworthy of reconstruction) orbital floor defects, expanding to considerable dimensions following reduction of ZMC fractures. In cases of medially displaced ZMC fractures reduction usually requires lateral rotation of the zygoma around the frontozygomatic suture; this may, at least theoretically, result in enlargement of the original orbital defect, potential herniation of soft tissues inside the maxillary sinus and development of enophthalmos. Therefore, it has been advocated that intraoperative exploration of the orbital floor following open reduction of ZMC fractures is crucial, to rule out the possibility of iatrogenically induced or enlarged orbital floor defects. Moreover, this approach might allow the surgeon to diagnose entrapment of orbital soft tissues by bony spicules[18,19].

Retrospective analysis of our patients' data confirmed that a considerable percentage (28 out of the 82 or 34,1%) of ZMC fractures were associated with orbital floor defects that had not been detected preoperatively and were only diagnosed upon intraoperative exploration of the orbital floor following open reduction. This is consistent with findings by Kevin et al. (1997) who found that almost 70% of their patients with ZMC fractures were managed successfully without the need of orbital exploration[20]. Remarkably, 17 out of the 28 intraoperatively discovered defects in our study were large (>2 cm^2), thus requiring primary reconstruction with alloplastic materials. Unfortunately, no reliable conclusions could be drawn regarding the origin of these defects in our patients, i.e. whether they were present preoperatively or occurred as a result of manoeuvres during open reduction. Nevertheless, this is of minimal impact to our patients, since all orbital floor defects were identified and those requiring reconstruction (larger than 2 cm^2) were appropriately restored at the same surgical time.

Reconstruction of such defects with materials that allow reshaping of the orbit to its initial form, is essential to resolve functional and/or aesthetical issues. Various reconstructive modalities have been implemented worldwide, including autologous bone grafts (from the calvarium, iliac crest or ribs), autologous fascia (i.e. tensor fascia lata, temporal fascia), xenografts (i.e. bovine bone or sclera) and alloplastic materials including metals, polymers and bioactive glasses[19,21,22]. Regardless of the material and technique used, the complete anatomic restoration of the orbital volume is required to prevent postoperative enophthalmos[23]. Dubois et al. (2016) proposed a treatment algorithm for trauma-related orbital floor defects, depending on the size and complexity of the defect. According to that, small (<2 cm^2) and low-complexity defects (class I) can be safely and reliably restored with most available reconstructive modalities, including resorbable materials. For moderate defects (class II) a variety of reconstructive options from autologous (bone or fascial) grafts to alloplastic materials may be considered, depending mostly on the surgeon's experience. Finally, for sizeable and high-complexity defects (classes III-VI) titanium mesh is the reconstructive material of choice[13].

The final outcome following reconstruction of orbital floor defects associated with ZMC fractures is dependent on various factors, apart from the applied reconstructive modality (autologous grafts, alloplastic materiasl etc). For instance, distortion of the periorbita may not only complicate reconstruction but also compromise the final outcome: intraoperative visibility is restricted, even following repositioning of the herniated soft tissues (periorbital fat and/or extraocular muscles) and minor malpositioning of the orbital floor implant may lead to serious complications[24].

Conclusions

In conclusion, fractures of the zygomaticomaxillary complex (ZMC) may sometimes be associated with orbital floor defects. Despite careful clinical examination and thorough radiographic evaluation, orbital floor defects associated with ZMC fractures may escape diagnosis and remain untreated. Moreover, such defects may occur or enlarge iatrogenically upon reduction of the fractures. Moreover, considerable morbidity, including impaired ocular mobility and/or visual acuity, has been attributed to untreated orbital floor defects.

Therefore, it is strongly suggested not only to submit all patients with ZMC fractures to a meticulous clinical and radiographic examination - when considered necessary with CT scans - to detect preoperative orbital floor defects, but also to routinely proceed to intraoperative exploration of the orbital floor following open reduction of ZMC fractures, in order to expose iatrogenically induced or enlarged ones. The timely identification and appropriate reconstruction of orbital floor defects are prerequisites for minimizing the overall morbidity associated with ZMC fractures.

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