Original Article / Çalışma - Araştırma

Optimal treatment of zygomatic fractures: a single-center study results

Zigoma kırıklarının en uygun tedavisi: Tek merkezli çalışma sonuçları

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ABSTRACT

Objectives: This study aims to investigate the epidemiological and operative characteristics of patients undergoing surgery for zygomatic fractures.

Patients and Methods: Between May 2008 and October 2013, a total of 121 patients (98 males, 23 females; mean age 27 years; range, 9 to 63 years) who were operated for zygomatic fractures in our clinic were retrospectively analyzed. Age and sex of the patients, symptoms, fracture and incision sites, length of hospital stay, plate type, treatment options, and complications were recorded.

Results: Assault was the leading cause of trauma (39%), followed by traffic accidents (24%). The most common symptom or clinical sign was the periorbital ecchymosis/hematoma. Conservative treatment was applied in 14 patients (12%). Surgery was performed with a closed reduction in 17 patients (14%) and open reduction in 90 patients (74%). The most common fracture site was the infraorbital rim in 76 patients (62.8%). A total of 48% patients had three-site, 35% had two-site and 12% had one-site of fixations. The major material used for the orbital floor reconstruction was porous polyethylene in 43.7% patients.

Conclusion: Our study results show that surgery is required in the majority of the patients with zygomatic fractures. However, further large studies are required to determine many parameters such as incision sites, plate locations, and the material to be used in orbital floor reconstruction.

Keywords: Complications; surgery; treatment; zygomatic fracture.

ÖZ

Amaç: Bu çalışmada, zigoma kırıkları nedeniyle ameliyat edilen hastaların epidemiyolojik ve cerrahi özellikleri araştırıldı.

Hastalar ve Yöntemler: Mayıs 2008 - Ekim 2013 tarihleri arasında zigoma kırıkları nedeniyle kliniğimizde ameliyat edilen toplam 121 hasta (98 erkek, 23 kadın; ort. yaş 27 yıl; dağılım 9-63 yıl) retrospektif olarak incelendi. Hastaların yaşı ve cinsiyeti, semptomları, kırık ve insizyon alanları, hastanede kalış süresi, plak tipi, tedavi seçenekleri ve komplikasyonları kaydedildi.

Bulgular: Travmanın başlıca nedeni darp (%39) ve takiben trafik kazası (%24) idi. En sık görülen semptom veya klinik bulgu periorbital ekimoz/hematom idi. On dört hastaya (%12) konservatif tedavi uygulandı. On yedi hasta (%14) kapalı redüksiyon ve 90 hasta (%74) açık redüksiyon ile ameliyat edildi. En sık kırık bölgesi, 76 hastada (%62.8) infraorbital rim idi. Hastaların %48'inde üç bölgede, %35'inde iki bölgede ve %12'sinde bir bölgede fiksasyon yapıldı. Hastaların %43.7'sinde orbital taban rekonstrüksiyonunda en sık kullanılan malzeme, poröz polietilen idi.

Sonuç: Çalışma bulgularımız, zigoma kırıkları olan hastaların büyük çoğunluğunda cerrahi gerektiğini göstermektedir. Ancak; insizyon yerleri, plak konumları ve orbita taban rekonstrüksiyonunda kullanılması gereken materyal gibi birçok parametrenin belirlenmesi için geniş serili çalışmalara ihtiyaç vardır.

Anahtar Sözcükler: Komplikasyonlar; cerrahi; tedavi; zigoma kırığı.

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Fractures of the zygomatic bone often cause changes in facial appearance that may result in aesthetic, functional and psychological problems. Approaches to zygomatic fractures and outcomes of management have improved over the last two decades with better understanding of fracture pathophysiology and developments in biomechanics. Advances in diagnostic tools have also enabled acquisition of more detailed and specific information both for diagnosis and the operative plan.

Numerous studies have investigated the causes and frequencies of zygomatic fractures, and found that they varied depending on the sociocultural, economic and environmental factors of the country in which the study was performed.[1] The aim of the study was to investigate the epidemiologic (age, gender, cause of the fracture) and operative data of patients operated on in our department and to compare these with the relevant literature.

PATIENTS AND METHODS

This was a retrospective analysis of 121 patients (98 males, 23 females; mean age 27 years; range 9 to 63 years) with zygomatic fractures who presented to the maxillofacial surgery unit between May 2008 and October 2013. Patients with other associated facial fractures were also included into the study. The data for age, sex, etiologic cause, length of hospital stay, associated fractures, incision sites, location of the fractures, interval between the initial trauma and repair, plate types and insertion sites, surgical technique (open versus closed) were analyzed. In addition, materials used in the reconstruction of the orbital floor in patients with blow out fractures were also evaluated. Results obtained were compared with the current literature available. Controversial issues including best time of surgery following trauma, incision and fixation sites plus the most appropriate material to be used for orbital floor reconstruction were explored and our findings were synthesized with the current literature. The study protocol was approved by the Bağcılar Training and Research Hospital Ethics Committee. A written informed consent was obtained from each patient and the study was conducted in accordance with the principles of the Declaration of Helsinki.

RESULTS

Most of the patients (n=41; 33.8%) were in the age group between 21 and 30 years (Figure 1). The most common cause of trauma was assault (39%), followed by traffic accidents (24%), falls, and sports injuries (Figure 2). The most common symptom or clinical sign was the periorbital ecchymosis-hematoma followed by subconjunctival hemorrhage (Table 1).

Surgery was performed with closed reduction in 17 patients (14%), and open reduction in 90 patients (74%) (Figure 3). Analysis of incision types in the latter group showed that the subciliary incision was the most common (n=84, 93.3%), followed by the gingivobuccal (n=62, 68.8%) and lateral orbital incision (n=52, 57.7%) (Figure 4).

In patients who underwent open reduction and internal fixation, the most commonly used plates were 4- or 6-hole straight miniplates, with 132 plates in total. Table 2 shows the types and numbers of the plates.

The most frequently fractured area of the zygomatic bone was the infraorbital rim,

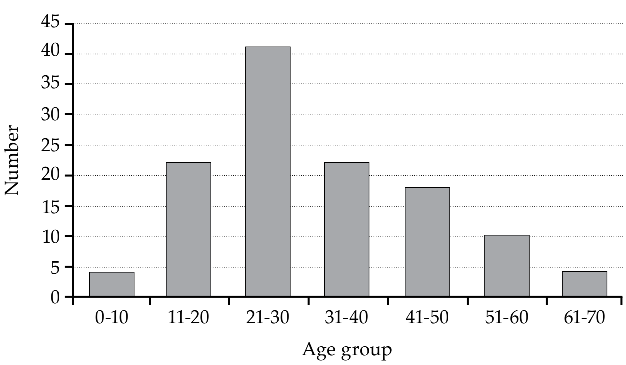

Figure 1. *Age distribution of the patients.*

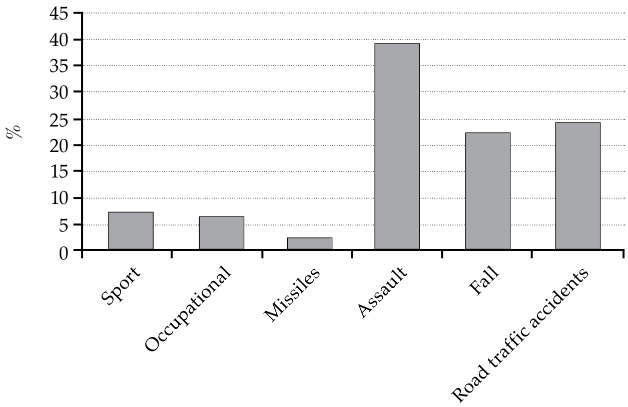

Figure 2. *Etiology of zygomatic fractures.*

Table 1. Signs and symptoms on initial presentation

Symptom	n	%
Periorbital ecchymosis + hematoma	89	73.5
Subconjunctival hemorrhage	66	54.5
Blurred vision	46	38
Crepitation	26	21.4
Hypo/paresthesia	25	20.6
Diplopia	24	19.8
Enophtalmos	15	12.3
Malar flattening	12	9.9
Trismus	12	9.9
Epistaxis	12	9.9

fractured in 76 patients (62.8%), and the least was the zygomaticomaxillary junction, fractured in 34 patients (28.0%) (Figure 5). Only 19 patients (15.7%) had isolated fracture the zygomatic bone. The maxillary bone was the most common to have an associated fracture (Figure 6).

The infraorbital rim was the most common site for insertion of the plates (n=70, 77.7%). Other sites for plate insertion were the zygomaticofrontal junction in 39 patients (43.3%), zygomaticomaxillary junction in 25 patients (27.7%), and the zygomatic arch in six patients (6.6%) (Table 3). Forty-eight percent of patients had three-sites, 35% had two-sites and 12% had one-site of fixation (Figure 7).

Sixteen patients underwent reconstruction of the orbital floor-with porous polyethylene implants (Medpor, Stryker, Michigan, USA) in seven patients, iliac crest bone grafts in four, titanium mesh in four, and cartilage graft

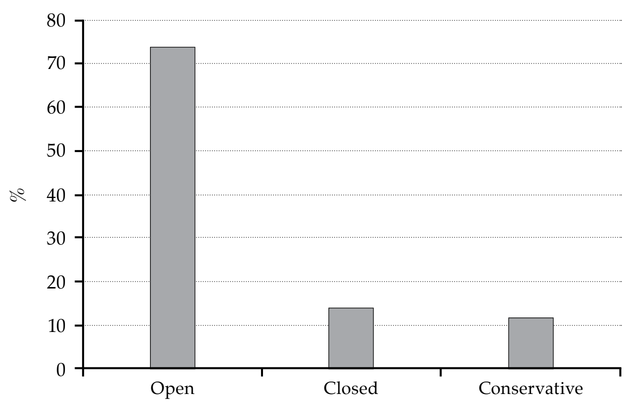

Figure 3. Treatment modalities.

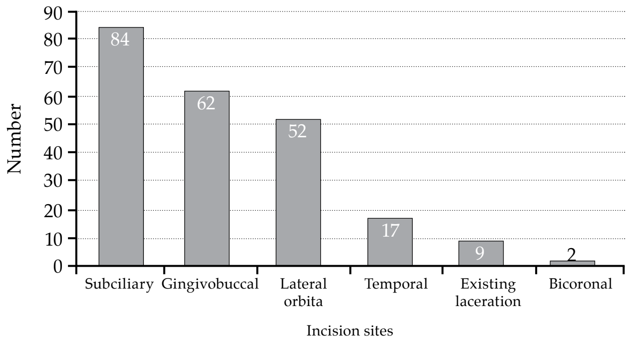

Figure 4. *Incision sites.*

harvested from the nasal septum in one patient (Figure 8).

Analysis of the interval between initial trauma and surgery revealed that most patients were operated on between the fourth and sixth days following injury (Figure 9). Patients stayed in the hospital for 7.2 days on average (range: 2-19, Figure 10).

The patients were followed up for complications including wound site infection, loss of vision, infection and plate exposure. The most common complication was permanent dysfunction of the infraorbital nerve, seen in 29.4% and 31.1% of patients who underwent closed and open reduction, respectively. Five patients had clearly visible malar flattening, and three had malocclusion. The complications are listed in Table 4.

Table 2. Number and type of plates used for fixation

Plate type	Number of patients			
	Mini plate	Micro plate	*Total*	
	n	n	n	%
4-hole straight plate	47	10	57	43.1
6-hole straight plate	19	8	27	20.4
5-hole straight plate	7	0	7	5.3
8-hole straight plate	5	3	8	6.6
3-hole straight plate	6	0	6	4.5
2-hole straight plate	2	0	2	1.5
10-hole straight plate	1	0	1	0.7
4-hole L-shaped plate	14	0	14	10.6
4-hole T-shaped plate	7	0	7	5.3
5-hole T-shaped plate	2	0	2	1.5
5-hole Y-shaped plate	1	0	1	0.7
Total	111	21	132	

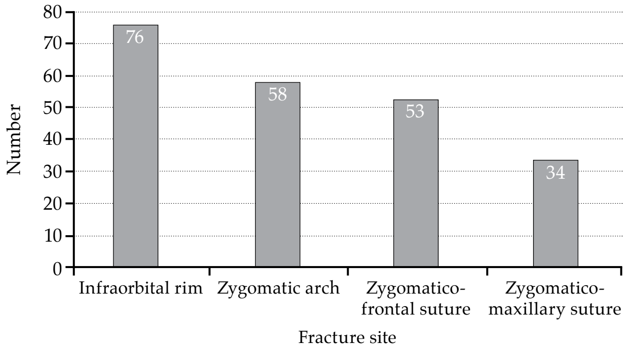

Figure 5. *Fracture sites.*

DISCUSSION

In addition to its role in forming the malar prominence, the zygomatic bone also provides transverse facial width and height. It also forms the anterolateral wall of the orbit and plays an important role in its anatomy. Another significance of the zygoma is its role as a key area in complex craniomaxillofacial trauma. The fracture may present with various different symptoms and signs due to its relationship with neighboring structures.[2]

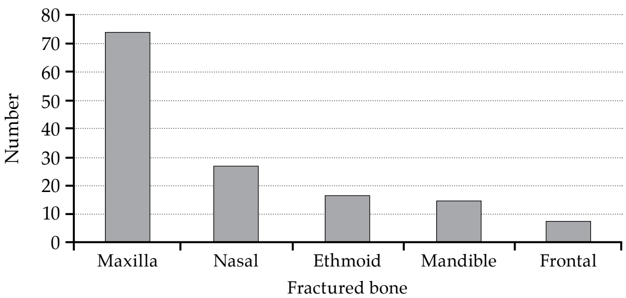

Figure 6. *Associated fractures.*

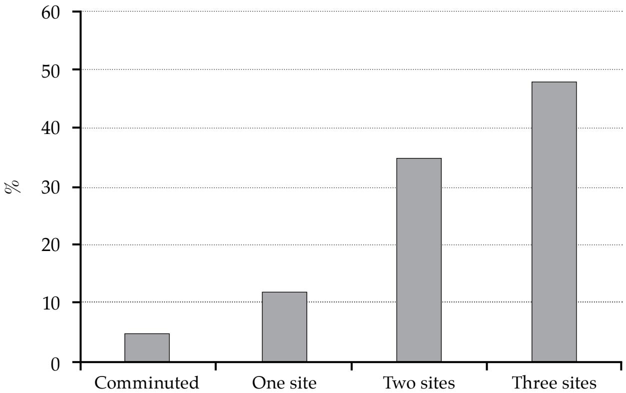

Figure 7. *Treatment approach in terms of number of fixation sites.*

Table 3. Fixation sites

Fixation sites	n	%
Infraorbital rim	70	77.7
Zygomaticofrontal	39	43.3
Zygomaticomaxillary	25	27.7
Zygomatic arch	6	6.6

Epidemiology of the fractures shows that they are more common in males.[3-5] The male to female ratio in developed countries in 3-5:1, which increases to 10-40:1 in developing countries.[4] In a study by Eski et al.[6] performed in the same country of the authors, the male to female ratio was found to be 9:1. There were 98 males and 23 females in our patient group, and the male to female ratio was 4.2:1. This ratio is similar to the figures from developed countries. One explanation for this result might be due to more common exposure of males to assault and higher proportion of male drivers in the country.

There are numerous causes of zygomatic fractures. Interpersonal violence has been found as the most common cause in various developed

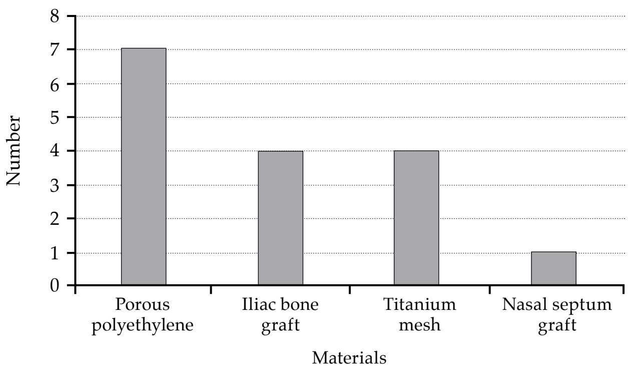

Figure 8. *Materials used for orbital floor reconstruction.*

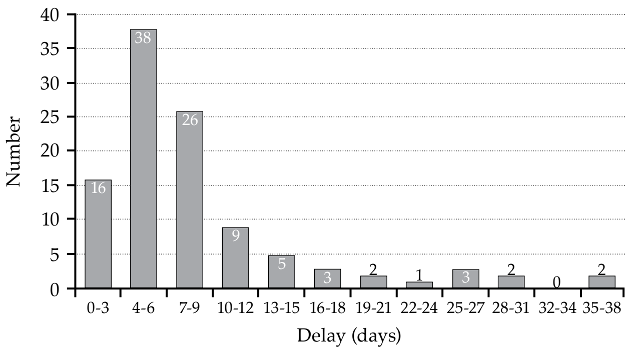

Figure 9. *Time interval between trauma and surgical treatment.*

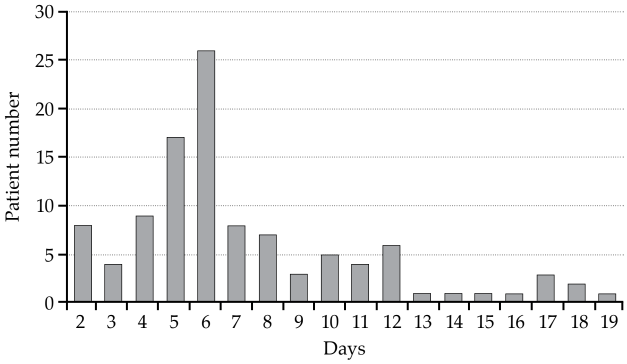

Figure 10. *Hospital stay.*

countries.[5,7,8] Alcohol intake was proposed as an influencing factor leading to assault in these countries.[9,10] In contrast, traffic accidents take first place in developing countries.[3,11] This might be due to less use of seat belts, helmets or other safety devices. In addition, more strict laws in traffic and alcohol use might decrease the rate of traffic accidents as an etiology of zygomatic fractures.[3,7,10] In our study, the fractures were mainly caused by assault in 47 patients (39%), followed by traffic accidents in 29 (24%), and falls in 27 (22%). These values actually correspond to the values of developed countries although we regard our country as a developing country. The decreasing rate of accidents in etiology of zygoma fractures might be due to stricter rules regarding speed limits and alcohol use in our country. This is particularly important because a study performed at other centers of the same country several years ago demonstrated traffic accidents as the leading cause of zygoma fractures.[12,13]

The diagnosis of zygomatic fractures is relatively easy, especially for physicians working on maxillofacial surgery. It is one of those fractures that can be diagnosed as the patient enters the physical examination room. The most common signs have been reported as ecchymosis and malar depression in various studies.[1,14,15] In addition to these, decreased or lost sensation in the cheek, upper lip and gingiva, decreased mouth opening or trismus due to impingement of the coronoid process under the fracture have been reported in various rates.[1,15,16] Enophthalmos and hypoglobus may be seen in displaced zygomatic fractures due to displacement of the lateral canthal ligament. Palpation of the injury site may show a step deformity or crepitation. Diplopia may be seen in patients with orbital floor fractures. The most common sign in our patient group was periorbital ecchymosis-hematoma (n=89, 73.5%) followed by subconjunctival hemorrhage (n=66, 54.5%). Another sign is trismus that develops generally in zygomatic arch fractures as a result of compression of the coronoid process of the mandible by the fractured zygomatic arch. The presence of this sign may be an indication for correction of the malposition.[17]

The diagnosis of zygomatic fractures can be made with physical examination and radiologic studies. The most frequently used

Table 4. Complications

	Conservative (n=14)		Closed reduction (n=17)		Open reduction (n=90)		*Total* (n=121)	
	n	%	n	%	n	%	n	%
Constant inferior orbital nerve dysfunction	2	14.2	5	29.4	28	31.1	35	28.9
Diplopia	1	7.1	2	11.7	6	6.6	9	7.4
Hematoma	0	0	1	5.8	5	5.5	6	4.9
Eyelid retraction	0	0	0	0	6	6.6	6	4.9
Facial deformity	0	0	1	5.8	4	4.4	5	4.1
Dry eye	0	0	2	11.7	3	3.3	5	4.1
Malar flattening	1	7.1	1	5.8	3	3.3	5	4.1
Enophthalmos	0	0	0	0	4	4.4	4	3.3
Wound infection	0	0	0	0	3	3.3	3	2.4
Malocclusion	0	0	0	0	3	3.3	3	2.4
Plate exposition	0	0	0	0	3	3.3	3	2.4

radiologic methods are plain X rays, (including submentovertex, Waters, Caldwell, lateral views), and computer tomography (CT). Although there are different opinions on the type of imaging that should be requested, in most of our patients we obtained a maxillofacial CT, which is accepted as the gold standard in preoperative evaluation.[18] In the last few years, we have been ordering post-operative CT as well. However, we suppose the cost-effectiveness of an additional CT scan and extra radiation may be questionable.

Most authors agree on the necessity of open reduction and fixation in serious fractures. On the other hand, the management of less-serious cases is controversial. Some surgeons prefer a conservative approach. These authors have claimed that better results could be obtained with simple procedures, and that complications could be reduced by avoiding extra incisions and manipulations.[19] Authors who disagree with these opinions argue that one cannot risk the poor results in cases treated conservatively without considering the stability of the repair.[15] There is agreement on the need for open reduction and fixation in fractures that are already displaced at initial presentation or that have displaced during the follow-up of conservative management.[19] The main goals of treatment are restoration of facial appearance, reconstruction of the periorbital bony structures to protect the eye, correction of diplopia, and re-establishment of the mandibular movement. Although some authors prefer one- or two-point fixation in the surgical treatment of zygomatic fractures, others prefer three-point fixation.[9] The reason for the latter is the possibility of masseteric forces displacing the zygoma after fixation, especially in two-point fixations. On the other hand, there are studies that state the advantages of single point fixation in the treatment of tripod fractures.[20,21] In our study, 48% of the patients had a three-point fixation, 35% had two-point fixation and 12% had one-point fixation. In the early years of our practice, we used to be strict about performing three-point fixations. However, in last few years, we think that two-point or even single point fixations can be done in selected cases once the stability of the zygomaticomaxillary buttress is maintained.

In our study, the rate of open reduction and fixation was found to be 74% (open reduction was performed in 90 patients and closed reduction in 17). The ratio of open versus closed reduction ranges between 17:1 and 1:4 in the literature.[22,23] Open reduction can be performed with plates and screws, or wires. It is generally accepted that plate and screws are superior to wires with respect to stability.[24,25] For example, Rohrich et al.[24] reported better malar and global symmetry in patients who underwent fixation with rigid miniplates compared to interosseous wires. There was also less incidence of infraorbital nerve injury and nonunion. Linn et al.[26] observed that bone grafts fixed rigidly had superior preservation of position and volume. Also, bones that underwent rigid fixation were shown to heal by a direct primary process instead of a fibroelastic process.[27] Concerning postoperative stability, we preferred rigid fixation whenever possible. We did not encounter any problems related to stability of the osteosynthesis during the postoperative follow-up.

In patients who undergo open reduction, numerous incisions for gaining access to the fracture site have been previously described. The incision of choice depends on the type of the fracture. For example, in a patient who has isolated depression in the malar arch, the supraorbital approach described by Dingman and Natvig[28] or Gillies[29] may be used. In unstable fractures, the most commonly used incisions are subciliary, lateral orbital and gingivobuccal incisions.[28] Other incisions that can be used are the transconjunctival incision described first by Tessier[30] in 1973, which provides excellent exposure to the orbital floor and inferior rim, and bicoronal incisions that can be used in high energy and unstable fractures. In order to avoid complications including facial nerve injury, alopecia, external scar, and orbital edema, endoscope assisted techniques emerged recently. There are numerous experimental and clinical studies on this topic.[31] The most common incision we used was the subciliary incision, where a skin-muscle flap was raised as in most other studies.[14,17] However transient or constant lower lid retraction should be taken into account in subciliary incision. We reported six cases (6.6%) of lower lid retraction, which was quite similar to ratios observed in various studies.[10,14,32]

The fixation sites in the literature differ between studies. In our series, the most common site of fixation was the inferior orbital rim in

70 patients (77.7%), followed by the lateral orbit in 39 patients (43.3%), zygomaticomaxillary buttress in 25 patients (27.7%), and zygomatic arch in six patients (6.6%). These figures are similar to others in the literature.[17,23,25] The total number of plates used was 132. Twenty-one of these were microplates and were used on the inferior orbital rim. Four straight-hole plates were used in 57 patients (43.1%), and six-hole straight plates were used in 27 patients (20.4%). These two plates constituted the two most common types of plates in our patients.

Orbital floor fractures may be problematic both for patients and surgeons. Severe complications may occur during or after the operation. Various materials to reconstruct the orbital floor have been previously described. Silastic sheet, hydroxyapatite, titanium mesh, and autologous bone or cartilage grafts are some examples.[14,33-35] Advantages of silastic sheet over autogenous bone grafts are shorter operative times and absence of the need for a donor site. The major advantage of titanium mesh is its easy adaptability to the posterior aspect of the orbital floor.[17] He et al.[27] used titanium mesh in most of their patients, however they obtained the best results in the group of patients in whom titanium mesh was used together with porous polyethylene implants. The same authors state that porous polyethylene implants and hydroxyapatite were preferred less commonly due to their characteristic structures which caused difficulties in shaping. In our series, 16 of the 25 orbital floor fractures required reconstruction. The orbital floor was reconstructed with porous polyethylene implants in seven patients (43.7%), autogenous bone grafts in four (25.0%), titanium meshes in four (25.0%), and cartilage graft in one (6.2%). It can be concluded that exogenous materials (porous polyethylene and titanium mesh) constituted the majority of orbital floor reconstructions. This might be mainly due to prevention of donor site morbidity and less operative time. However, rarely reported complications such as infection, extrusion and fistula formation together with financial issues should be considered.[7,35]

The timing of surgery is one of the parameters that directly affect complications. Carr and Mathog[15] operated on 68% of their patients between days 3 and 10 following trauma. Calderoni et al.[14] reported this interval as 16.2 days in average. The elapsed time between the trauma and surgery depends on many factors. The severity of accompanying trauma, proximity of the trauma area to the maxillofacial center and surgeon preferences are major factors. There are conflicting reports in the literature concerning the optimal time for fracture fixation.[7,32] We generally wait at least several days for the edema to subside. However previously mentioned factors may prolong the interval and delay the surgery. In our study, 38 out of 107 patients were operated on between days 4 and 6 (35.5%) similar to the results obtained by Carr and Mathog.[15]

Zygomatic fractures can result in numerous secondary problems. Constant infraorbital nerve dysfunction is one of the most common resulting in anesthesia in the cheek, lower lid, gingiva, and teeth. The rates of nerve disfunction encountered during close follow-up are reported to range between 20 and 94%.[36] Diplopia in zygomatic fractures may be caused by the mass effect of hematoma, or injury to the muscles and nerves. In a series of 2,067 patients reported by Ellis et al.,[19] the rate of diplopia was 12%. Barclay reported that 60% of the diplopia seen in zygomatic fractures were transient.[37] Another important finding is enophthalmos, reported to be between 3-4% by Zingg et al.,[23] and considered to result from displacement of soft tissues from the orbit. It is expected to occur especially in blow-out fractures and high energy multiple fractures. Apart from the complications listed above, infection, surgical wound problems, scar formation, and problems related to the use of plates and screws including exposure, might be expected.[25] In our series of 121 patients, nine (7.4%) had diplopia, five (4.1%) had facial deformity, four (3.3%) had enophthalmos, and 35 (28.0%) had permanent infraorbital nerve deficit. Complications developed in 40 patients, and 80% of these were in the group that underwent open reduction and fixation. The overall complication rate was within the range of previously reported studies.[1,6,8]

In conclusion, zygomatic fractures play an important role among maxillofacial injuries particularly in the male, and young population. Assault and traffic accidents are still the two major causes of zygomatic fractures. Every effort (including education, preventive campaigns, and better enforcement of the law together with strict rules) should be made to prevent zygomatic fractures in this active population. During therapy, the mechanism, anatomic location, associated pathologies, treatment methods and timing should be taken into consideration. Provided that the indications are appropriate, fractures can be managed either by conservative means or surgically, using closed or open fixation. The evaluation and analysis of the results, and their comparison with other treatment methods will certainly aid in the application of optimal treatment.

Declaration of conflicting interests

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REFERENCES

1. Gomes PP, Passeri LA, Barbosa JR. A 5-year retrospective study of zygomatico-orbital complex and zygomatic arch fractures in Sao Paulo State, Brazil.J Oral Maxillofac Surg 2006;64:63-7.
2. Kelley P, Hopper R, Gruss J. Evaluation and treatment of zygomatic fractures. Plast Reconstr Surg 2007;120:5-15.
3. Hogg NJ, Stewart TC, Armstrong JE, Girotti MJ. Epidemiology of maxillofacial injuries at trauma hospitals in Ontario, Canada, between 1992 and 1997. J Trauma 2000;49:425-32.
4. Al Ahmed HE, Jaber MA, Abu Fanas SH, Karas M. The pattern of maxillofacial fractures in Sharjah, United Arab Emirates: a review of 230 cases. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004;98:166-70.
5. Motta MM. Análise epidemiológica das fraturas faciais em um hospital secundário. Rev Bras Cir Plást 2009;24:162-9.
6. Eski M, Sahin I, Deveci M, Turegun M, Isik S, Sengezer M. A retrospective analysis of 101 zygomatico-orbital fractures. J Craniofac Surg 2006;17:1059-64.
7. Kontio R, Suuronen R, Ponkkonen H, Lindqvist C, Laine P. Have the causes of maxillofacial fractures changed over the last 16 years in Finland? An epidemiological study of 725 fractures. Dent Traumatol 2005;21:14-9.
8. Bogusiak K, Arkuszewski P. Characteristics and epidemiology of zygomaticomaxillary complex fractures. J Craniofac Surg 2010;21:1018-23.
9. Holmes PJ, Koehler J, McGwin G Jr, Rue LW. Frequency of maxillofacial injuries in all-terrain vehicle collisions. J Oral Maxillofac Surg 2004;62:697-701.
10. van Beek GJ, Merkx CA. Changes in the pattern of fractures of the maxillofacial skeleton. Int J Oral Maxillofac Surg 1999;28:424-8.
11. Fasola AO, Nyako EA, Obiechina AE, Arotiba JT. Trends in the characteristics of maxillofacial fractures in Nigeria. J Oral Maxillofac Surg 2003;61:1140-3.
12. Aksoy E, Unlü E, Sensöz O. A retrospective study on epidemiology and treatment of maxillofacial fractures. J Craniofac Surg 2002;13:772-5.
13. Güven O. A comparative study on maxillofacial fractures in central and eastern Anatolia. A retrospective study. J Craniomaxillofac Surg 1988;16:126-9.
14. Calderoni DR, Guidi Mde C, Kharmandayan P, Nunes PH. Seven-year institutional experience in the surgical treatment of orbito-zygomatic fractures. J Craniomaxillofac Surg 2011;39:593-9.
15. Carr RM, Mathog RH. Early and delayed repair of orbitozygomatic complex fractures. J Oral Maxillofac Surg 1997;55:253-8.
16. Tong L, Bauer RJ, Buchman SR. A current 10-year retrospective survey of 199 surgically treated orbital floor fractures in a nonurban tertiary care center. Plast Reconstr Surg 2001;108:612-21.
17. Tadj A, Kimble FW. Fractured zygomas. ANZ J Surg 2003;73:49-54.
18. McLoughlin P, Gilhooly M, Wood G. The management of zygomatic complex fractures--results of a survey. Br J Oral Maxillofac Surg 1994;32:284-8.
19. Ellis E, Kittidumkerng W. Analysis of treatment for isolated zygomaticomaxillary complex fractures. J Oral Maxillofac Surg 1996;54:386-400.
20. Kim JH, Lee JH, Hong SM, Park CH. The effectiveness of 1-point fixation for zygomaticomaxillary complex fractures. Arch Otolaryngol Head Neck Surg 2012;138:828-32.
21. Holmes KD, Matthews BL. Three-point alignment of zygoma fractures with miniplate fixation. Arch Otolaryngol Head Neck Surg 1989;115:961-3.
22. Hwang K, Kim DH. Analysis of zygomatic fractures. J Craniofac Surg 2011;22:1416-21.
23. Zingg M, Laedrach K, Chen J, Chowdhury K, Vuillemin T, Sutter F, et al. Classification and treatment of zygomatic fractures: a review of 1,025 cases. J Oral Maxillofac Surg 1992;50:778-90.
24. Rohrich RJ, Janis JE, Adams WP Jr. Subciliary versus subtarsal approaches to orbitozygomatic fractures. Plast Reconstr Surg 2003;111:1708-14.
25. O'Hara DE, DelVecchio DA, Bartlett SP, Whitaker LA. The role of microfixation in malar fractures: a quantitative biophysical study. Plast Reconstr Surg 1996;97:345-50.
26. Linn EW, Vrijhoef MM, de Wijn JR, Coops RP, Cliteur BF, Meerloo R. Facial injuries sustained during sports and games. J Maxillofac Surg 1986;14:83-8.
27. He D, Li Z, Shi W, Sun Y, Zhu H, Lin M, et al. Orbitozygomatic fractures with enophthalmos: analysis of 64 cases treated late. J Oral Maxillofac Surg 2012;70:562-76.
28. Dingman RO, Natvig P. Surgery of facial fractures. Philadelphia: Saunders; 1964. p. 211-43.
29. Gillies HD, Kilner TP, Stone D. Fractures of the Malar-zygomatic compound: With a description of a new X-ray position. Br J Surg 1927;14:651-6.
30. Tessier P. The conjunctival approach to the orbital floor and maxilla in congenital malformation and trauma. J Maxillofac Surg 1973;1:3-8.
31. Czerwinski M, Lee C. Traumatic arch injury: indications and an endoscopic method of repair. Facial Plast Surg 2004;20:231-8.

32. Zachariades N, Mezitis M, Anagnostopoulos D. Changing trends in the treatment of zygomaticomaxillary complex fractures: a 12-year evaluation of methods used. J Oral Maxillofac Surg 1998;56:1152-6.
33. Iatrou I, Theologie-Lygidakis N, Angelopoulos A. Use of membrane and bone grafts in the reconstruction of orbital fractures. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2001;91:281-6.
34. Castellani A, Negrini S, Zanetti U. Treatment of orbital floor blowout fractures with conchal auricular cartilage graft: a report on 14 cases. J Oral Maxillofac Surg 2002;60:1413-7.
35. Ozyazgan I, Eskitaşçioğlu T, Baykan H, Coruh A. Repair of traumatic orbital wall defects using conchal cartilage. Plast Reconstr Surg 2006;117:1269-76.
36. Vriens JP, van der Glas HW, Moos KF, Koole R. Infraorbital nerve function following treatment of orbitozygomatic complex fractures. A multitest approach. Int J Oral Maxillofac Surg 1998;27:27-32.
37. Barclay TL. Some aspects of treatment of traumatic diplopia. Br J Plast Surg 1963;16:214-20.