

# Evaluation Of Clinical Features And Treatment Of Zygomatic Bone Fractures: A 10-Year Retrospective Study

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## Research

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# Abstract

## Background

The pattern of zygomatic bone fractures varies in the literature, their features being frequently masked by the presence of associated soft tissue lesions, which make clinical diagnosis and therapeutic indications difficult. The aim of this study was to evaluate the clinical features of zygomatic bone fractures and their interrelation with concomitant overlying soft tissue lesions, in order to improve the diagnosis and the establishment of the correct treatment. We also aimed to assess the type of treatment methods applied depending on the fracture pattern of the zygomatic bone, as well as their effectiveness depending on the incidence rate of postoperative complications.

## Methods

A 10-year retrospective evaluation of midface fractures was performed in patients diagnosed and treated in a tertiary Clinic of Oral and Maxillofacial Surgery.

## Results

The study included 242 patients with zygomatic bone fractures. The majority of the fractures were displaced  $n = 179$  (73.90%), closed  $n = 179$  (73.90%) and complete  $n = 219$  (90.50%). Hematoma was the most frequent associated soft tissue lesion  $n = 102$  (42.15%) regardless of the fracture pattern ( $p = 1.000$ ). The incidence of lacerations and excoriations was statistically higher in the case of complete (laceration  $p = 0.0028$ / excoriation  $p = 0.037$ ), displaced and comminuted zygomatic fractures (laceration  $p = 0.015$ / excoriation  $p = 0.001$ ). The most frequent type of treatment applied was Gillies reduction (61.98%), followed by ORIF (30.99%). The most frequent postoperative complication was malunion secondary to Gillies treatment ( $p = 0.002$ ).

## Conclusions

Patients presenting lacerations and excoriations on clinical soft tissue examination will most frequently have an underlying complete, displaced or comminuted zygomatic fracture. The most effective treatment method in the case of displaced, open or comminuted fractures was ORIF, while in the case of non-displaced and closed fractures, conservative treatment was the most effective.

## Background

The zygomatic bone through its prominence in the viscerocranium is more exposed to trauma, being currently the most fractured bone of the midface both globally and in our geographical area [1,2]. Due to the anatomical relationships of the zygomatic bone with the orbit, the maxillary sinus, the neurocranium, the coronoid process of the mandible and the masticatory muscles, zygomatic fractures may frequently take the form of a complex clinical picture that can always puzzle a less experienced clinician [2]. The complexity of a case is directly proportional to the degree of bone involvement, the degree of displacement of the fracture fragments, as well as to the relation of the fracture foci to the external environment [3]. Concomitant periorbital and perizygomatic soft tissue lesions can be in some cases characteristic of a certain underlying bone fracture pattern, but at the same time they can mask bone lesions with considerable displacement [4]. Hematomas and post-traumatic edema temporarily compensate facial asymmetry secondary to inferomedial displacement of the zygomatic bone, prevent adequate palpation of key suture points with the adjacent bones and at the same time can mask the presence of enophthalmia or diplopia [2–4]. The absence of correct and immediate diagnosis of zygomatic bone fractures can lead to incorrect treatment with severe aesthetic and morphological implications, much more difficult to correct secondarily [5]. Regardless of the chosen therapeutic method, the treatment of zygomatic fractures is aimed at restoring orbital contour with the recovery of ocular globe functions, opening of the mouth within physiological limits, restoration of the sagittal, vertical and horizontal diameters of the midface by reduction of the fractured fragments in anatomical position and prevention of late complications [1–6].

The therapeutic methods of zygomatic bone fractures are multiple and include conservative techniques, closed reduction techniques of the zygomatic bone (Gillies, Keen, Carroll-Girard) and open reduction and internal fixation (ORIF) techniques using one up to four point fixation [6]. Although there are currently many specialized publications related to this aspect worldwide, unfortunately there is no consensus about the ideal method of treatment, the opinions of different authors diverging [6,7]. However, over the past years, a general increase in the preference for ORIF to the detriment of closed reduction techniques has been observed [2–7].

Until present no such study was performed in our geographical area, data on this aspect being completely missing. In this context, the aim of this study was to retrospectively evaluate the clinical features of zygomatic bone fractures and their interrelation with concomitant overlying soft tissue lesions. Correlating the incidence of the types of associated soft tissue lesions with a certain underlying fracture pattern accelerates the diagnosis and the establishment of the correct treatment. We also aimed to assess the type of treatment methods applied depending on the fracture pattern of the zygomatic bone, as well as their effectiveness depending on the incidence rate of postoperative complications.

## Methods

The study was conducted in patients admitted and treated for zygomatic bone fractures in an University Clinic of Oral and Maxillofacial Surgery in Romania, over a 10-year period. The study was approved by the Institutional Review Board (IRB) of Oradea University (IRB no. 1275/14.02.2018) and was therefore performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. All patients included in the study signed an informed consent at the time of their admission to the clinical service, by which they gave their consent to the use of their anonymized medical data for scientific purposes and publication.

The data were extracted from patients' medical records and the monitored variables were: the degree of bone involvement (incomplete/complete fracture), the degree of bone fragment displacement (displaced/non-displaced/minimally displaced, comminuted), the relationship of the fracture focus with the external environment (closed/intra-orally open/extra-orally open fracture), the type of associated soft tissue lesions (hematoma/excoriation/laceration), type of preoperatively functional impairment (none/diplopia/sensory disturbances in the territory of innervation of the infraorbital nerve/impairment jaw movement), the type of treatment applied (conservative/Gillies/ORIF), the type of postoperative complications. All patients in this study were investigated preoperatively by computed tomography (CT) in order to exclude any intracranial lesions and to identify the pattern of the zygomatic bone fracture. We mention that the term "minimally displaced" is attributed to fractures with less than 2 mm displacement evidenced by CT examination. Also, in our department, closed reduction of zygomatic bone fractures was strictly performed by Gillies temporal approach. Conservative treatment involved non-performance of surgery and patient monitoring for at least 8 weeks.

The evaluation of the postoperative evolution was based on the clinical (evaluation of the visual function, amplitude of jaw movements and facial symmetry assessment) and imagistic examination of the patients (CT-scan).

The study inclusion criteria were: presence of at least one fracture line in the zygomatic bone, an acute trauma episode in the history of the disease, paraclinical examinations (CT examination) confirming the clinical diagnosis of fracture and evidencing its location and characteristics, signing of an informed consent for the use of patient's medical data for scientific purposes, treatment of the fracture in the study host institution, follow-up of the case for at least 8 weeks postoperatively.

Exclusion criteria: patient without fracture lines in the zygomatic bone or its sutures, zygomatic complex fractures associated with orbital fractures, pathological bone fracture, absence of complementary imaging investigations, patient's refusal to sign an informed consent for the use of his/her medical data for scientific purposes, treatment performed in another service, incomplete data, presence of factors favoring the occurrence of fractures such as bisphosphonate treatment, osteopathies, etc., impossibility of following up the case for at least 8 weeks postoperatively.

Data were centralized in electronic format using Microsoft Excel software. Descriptive statistics of the evaluated cases was performed with a 2 decimal percentage accuracy. Statistical analysis was performed with the MedCalc Statistical Software version 19.2 (MedCalc Software bvba, Ostend, Belgium; <https://www.medcalc.org>; 2020). Nominal data were expressed as frequency and

percentage. The comparisons of the frequencies of a nominal variable among the categories of another nominal variable were made using the chi-square test. A value of  $p < 0.05$  was considered statistically significant.

## Results

The study inclusion criteria were met by 242 patients with zygomatic bone fractures. Regarding bone involvement, the following results were obtained:  $n=219$  (90.50%) had complete zygomatic fractures in all 4 points,  $n=21$  (8.68%) had complete zygomatic-alveolar, infraorbital and fronto-zygomatic (tripod) fracture lines and an incomplete fracture line in the temporo-zygomatic arch,  $n=2$  (0.83%) had strictly incomplete temporo-zygomatic arch fractures.

Most of the fractures were displaced,  $n=179$  (73.96%), followed by non-displaced/minimally displaced fractures,  $n=45$  (18.61%). Comminuted fractures were in a small proportion,  $n=18$  (7.43%).

From the point of view of the relationship with the external environment, the following results were obtained:  $n=210$  (86.78%) had closed fractures,  $n=30$  (12.40%) had an intra-orally open fracture focus,  $n=1$  (0.41%) had an extra-orally open fronto-zygomatic fracture focus, and  $n=1$  (0.41%) had 2 open fracture foci: an extra-orally open fronto-zygomatic focus and an intra-orally open focus.

The types of preoperative functional disorders were divided in patients as follows:  $n=98$  (40,50%) presented diplopia, limited jaw movement and sensory disturbances all at the same time,  $n=79$  (32,64%) presented both limited jaw movement and sensory disturbances,  $n=28$  (11,57%) presented sensory disturbances only,  $n=20$  (8,26%) presented diplopia only and  $n=17$  (7,02%) present no functional impairment.

The most frequent associated soft tissue lesion was hematoma, being present in  $n=198$  (82.23%) of all patients. Excoriations were present in  $n=103$  (42.15%) and lacerations in  $n=76$  (31.40%), each percentage being in relation to the total number of affected patients. The incidence of the type of associated soft tissue lesion was correlated with the degree of bone involvement and the degree of fracture fragment displacement (Table 1).

Table 1. Incidence of the type of associated soft tissue lesion depending on the degree of bone involvement and fracture displacement

		Hematoma		TTotal	Laceration		Total	Excoriation		Total
		No	Yes		No	Yes		No	Yes	
Degree of bone involvement	Complete tripod and incomplete TZA fracture	4 9.1%	19 9.6%	23 9.5%	10 6.1%	12 15.8%	22 9.1%	8 5.8%	15 14.6%	23 9.5%
	Complete zygomatic fracture - 4 points	40 90.9%	179 90.4%	219 90.5%	155 93.9%	64 84.2%	219 90.9%	131 94.2%	88 85.4%	219 90.5%
Total		44 100.0%	198 100.0%	242 100.0%	165 100.0%	76 100.0%	241 100.0%	139 100.0%	103 100.0%	242 100.0%
P=				1.000			0.028			0.037
Degree of bone displacement	With displacement	38 86.4%	141 71.2%	179 73.96%	128 77.6%	50 65.8%	178 73.9%	108 77.7%	71 68.9%	179 74.0%
	Comminution	1 2.3%	17 8.6%	18 7.43%	7 4.2%	11 14.5%	18 7.5%	3 2.2%	15 14.6%	18 7.4%
	Without/Minimal Displacement	5 11.4%	40 20.2%	45 18.61%	30 18.2%	15 19.7%	45 18.7%	28 20.1%	17 16.5%	45 18.6%
Total		44 100.0%	198 100.0%	242 100.0%	165 100.0%	76 100.0%	241 100.0%	139 100.0%	103 100.0%	242 100.0%
P=				0.102			0.015			0.001

The incidence of lacerations and excoriations was statistically significantly higher in the case of complete (laceration  $p=0.0028$ / excoriation  $p=0.037$ ), displaced and comminuted zygomatic bone fractures (laceration  $p=0.015$ / excoriation  $p=0.001$ ). The incidence of hematomas was also high in the same category of patients, but the result was not statistically significant.

The most frequent treatment method was Gillies temporal approach reduction  $n=150$  (61,98%), followed by ORIF  $n=75$  (30,99%) and conservative treatment  $n=17$  (7,02%). A total number of 225 titanium miniplates 1.7 mm thick and 900 monocortical screws were used. The incidence of the type of treatment was correlated with the relationship of the focus with the external environment and the degree of displacement of the fracture fragments (Table 2).

Table 2. Distribution of the type of treatment used depending on the relationship with the external environment and the degree of fracture displacement

		Type of treatment			Total
		Gillies	Conservative	ORIF	
Relationship with the external environment	Closed	150 100.0%	17 100%	43 57,33%	210 86.78%
	Intra-orally open	0 0.0%	0 0.0%	30 40,00%	30 12.40%
	Intra-orally and extraorally open	0 0.0%	0 0.0%	1 1,33%	1 0.41%
	Extra-orally open	0 0.0%	0 0,0%	1 1,33%	1 0.41%
Total P=0.004		150 100.0%	17 100.0%	75 100.0%	242 100.0%
Degree of bone displacement	With displacement	122 81.3%	0 0.0%	57 76.0%	179 74.0%
	Comminution	0 0,0%	0 0.0%	18 24.0%	18 7.4%
	Without/Minimal displacement	28 18.7%	17 100%	0 0.0%	45 18.6%
Total P=0.003		150 100.0%	17 100.0%	75 100.0%	242 100.0%

Most of the displaced and closed fractures were reduced by the Gillies method, displaced, comminuted and open fractures were reduced by ORIF, while non-displaced fractures were treated conservatively. This result was statistically significant.

The majority of the cases had a favorable evolution, without reported complications, n=231 (95.50%). The most frequent postoperative complication was malunion, n=7 (2.90%), followed by osteitis in the fracture focus, n=4 (1.60%). The incidence of the type of postoperative complication was correlated with each type of treatment applied (Table 3).

Table 3. Distribution of postoperative complications depending on the treatment method used

		Type of treatment			Total
		Gillies	Conservative	ORIF	
Complications	No complications	143 95,34%	17 100.0%	71 85.1%	231 95.0%
	Osteitis	0 0.0%	0 0.0%	4 5.4%	4 1.6%
	Malunion	7 4,66%	0 0.0%	0 0,0%	7 2.9%
Total P= 0.002		150 100.0%	17 100.0%	75 100.0%	242 100.0%

Malunion was more frequently found postoperatively, after reduction of the zygomatic bone fracture by the Gillies method, while osteitis in the fracture focus was more frequent after surgical ORIF treatment. These results were statistically significant (p=0.002). We mention that in all 4 patients, osteitis was present strictly in the

zygomatic-alveolar fracture focus surgically approached intra-orally. No patient with malunion had significant functional disorders. All patients presented sensory disturbances only classified as infraorbital nerve paresthesia. In this context all 7 patients refused surgical reintervention at their own responsibility. In the case of patients with osteitis in the fracture foci, the osteosynthesis material was removed, zygomatic bone repositioning being unnecessary. Subsequent evolution was favorable in all 4 cases.

## Discussions

The zygomatic bone is one of the pillars of the viscerocranium, which has the role and the ability to absorb a large part of the forces developed by the impact with a wounding agent [7]. However, when the kinetic energy developed is too high, the zygomatic bone will fracture either as a monoblock, becoming detached at the interosseous suture lines, or in a comminuted manner, depending on the mechanism, the type, the form, the consistency, the surface and the direction of action of the causal agent [7, 8]. In our study, complete fractures with zygomatic bone disjunction were predominant, a result supported by other authors as well [2,4–8]. Incomplete fractures are non-characteristic and rare in the zygomatic complex due to the reduced bone thickness secondary to maxillary sinus pneumatization [9]. In our study, all incomplete fracture lines were found in the temporo-zygomatic arch, either in association with complete anterior tripod fractures of the zygomatic bone or isolated. This result is confirmed in the literature by a number of authors [9–11]. It can be explained by the presence of the cortical bone which is better represented at this level, and also by the fact that the temporo-zygomatic arch can fracture through an indirect flexion mechanism, secondary to direct fracturing and primary inferomedial displacement of the zygomatic bone [10,11]. In this context, secondary to a low-kinetic energy trauma, the temporo-zygomatic arch fracture is not synchronous with the anterior suture lines or is incomplete [8]. Isolated temporo-zygomatic arch fractures are rare, their reported percentage in the literature ranging between 0.5 and 14% [3–5,9–11]. A solitary temporo-zygomatic arch fracture, requires a lateral and perpendicular to the viscerocranium impact direction [10]. Given that the direction of action of wounding agents on the face is most frequently anterior or anterolateral, there are small chances that fractures will occur solely at this level [9–11].

The majority of the fractures in our study were displaced fractures, which is in accordance with the results of other authors [3–5,9–11]. Contrary to our results, some authors report an increased incidence of non-displaced zygomatic bone fractures [12], while others report a higher incidence of comminuted fractures [13,14]. Biomechanically, displacement in the case of zygomatic bone fractures is primary, being directly proportional to the kinetic energy resulting from the impact, the type of the wounding agent and its direction of action [9–11]. Secondary displacement, following traction of the masseter muscle insertions, occurs rarely, having a reduced biomechanically importance [3]. Comminuted fractures occur in the context of strong traumas such as those from road traffic accidents, firearms or explosives [13,14]. In our study, the small number of comminuted fractures can be attributed to the fact that in our geographical area, injuries caused by interpersonal violence through fist blows are predominant [15]. It is well known that most of the times, the kinetic energy developed by fist blows is rarely sufficient to induce multiple fractures of the viscerocranium [16]. The predominance of injuries to the zygomatic bone through low kinetic energy in our geographical area also explains the high incidence of closed fractures, without communication with the external environment in this study. This is emphasized by the results of other authors [12–17]. The majority of intra-orally open fractures are due to the adherence of the mucoperiosteum to the zygomatic-alveolar ridge, mucoperiosteal laceration occurring secondarily to significant displacement at this level [3–5,9–11]. In contrast, Keller et al.[13] and Kittle et al.[14], in studies conducted in armed conflict zones, report a predominance of extra-orally open zygomatic bone fractures.

Hematoma was the most frequent associated soft tissue lesion in the current study, which is also reported by other authors [2,4,19,20]. Contrary to our results, other authors indicate the highest incidence of laceration [21, 22]. The fact that in the current study hematomas are predominant shows that the severity of the injuries included in this study is reduced.

Gillies temporal approach reduction of the zygomatic bone was the most frequent therapeutic method used in our study, similarly to the results of other authors [2,23,24]. The great number of non-comminuted zygomatic fractures in this study explains this result. Although this method is losing ground to the new modern osteosynthesis techniques (ORIF), it can be useful and provide stable results over time in some cases [2]. The advantages of this method are rapid surgery, minimal scar masked by hair, minimal invasiveness, thus avoiding direct opening of the fracture foci, especially of the zygomatic-alveolar focus into the septic oral

environment, and implicitly, the decrease in the risk of postoperative osteitis [2,33,34]. Another advantage that should not be overlooked is the decrease of hospital costs, the Gillies reduction involving no special materials or equipment, while the duration of hospitalization is minimum [2]. Despite all these advantages, the indications of this method are strictly limited to fractures with reduced displacement, with the integrity of the zygomatic fragment and maintenance of the periosteum on a sufficiently large surface at this level to ensure primary stability of the fractured bone [2,33,34]. This is also confirmed by the results of the current research. Some authors completely avoid using this method, maintaining that perfect reduction of the bone fragments is impossible, which may have consequences over time [3,6,7,17,25]. Rana et al. [17] indicate redisplacement of the zygomatic bone at 6 weeks postoperatively following traction of the masseter muscle insertions during functional movements in the case of all patients in whom ORIF using 3 point fixation was not performed. Contrary to our results, other authors perform zygomatic bone fracture reduction by ORIF, considering it the treatment method of choice for this pathology [3,6,7,17,25–30]. ORIF of zygomatic bone fractures can be carried out using 1, 2, 3 or very rarely 4 point fixation [3]. We mention that in our study, ORIF was performed using 3 point fixation in all operated patients, according to the current protocol of the study host clinic. In contrast, globally, using the minimum number of fixation points is currently attempted to ensure zygomatic bone immobilization in order to reduce the risk of potential postoperative complications [3,4,7,9]. Forounzanfar et al. [7] and Kim et al. [29] present good results by using ORIF with 1 point fixation, the 3 point fixation of the zygomatic bone being rarely necessary. Czerwinski et al. [5,30] also report good results after using the endoscopically assisted ORIF-single incision technique. Correct reduction is systematically checked intraoperatively by fluoroscopy or computed tomography [5,6,30]. There is currently no consensus regarding the ideal number of fixation points in the case of zygomatic bone fractures, this aspect depending on the fracture pattern, surgeon's experience and the available means [7].

In zygomatic bone fractures without displacement and without functional disorders, conservative treatment and follow-up of the patient are indicated, which are unanimously accepted in the literature [3,6,7,17,25–30]. Patient follow-up is absolutely necessary given that subsequent zygomatic bone displacement, either secondary to functional movements or due to novo trauma may occur, surgery being required under these conditions [3,6,7,17,25–30]. In our study, all cases in which conservative treatment was chosen had a favorable evolution. This shows that the indications of this method were entirely respected.

The most frequent postoperative complication was malunion, which occurred postoperatively in the case of Gillies reduction, in accordance with the results of other authors [7]. This result is not surprising given the inaccuracy of this method [9,17,19,26–28]. In contrast, other authors indicate an increased incidence of postoperative osteitis [3,28]. Osteitis in this study occurred only in 4 cases in the intra-oral osteosynthesis focus, probably due to bacterial contamination from the septic environment of the oral cavity. Removal of the osteosynthesis material under these circumstances led to a favorable result [9,17,19,26–28]. The persistence of infraorbital nerve sensory disturbances postoperatively was not considered a postoperative complication in this study, it is known that post-traumatic sensory recovery can last up to 2 years or it may never occur. Also, the sensory disorders were not due to the surgical interventions, they being present clinically preoperatively. This fact is sustained also by other specialized studies [26–30].

The aim of this study was attained. The zygomatic bone fracture pattern and the interrelation between bone lesions and associated soft tissue lesions, as well as the most effective treatment were determined in a significant group of patients. Knowing the frequency of the association between a certain type of soft tissue lesion and a certain underlying zygomatic bone fracture pattern significantly contributes to a rapid and complete diagnosis, the maxillofacial surgeon knowing when to suspect the presence of a fracture masked by other clinical signs.

However, this study has a number of limitations. One of the most important limitations of the current study results from its retrospective nature; the data being collected from patients' medical records, they might have been incomplete or incorrect. To minimize this drawback, only complete medical records were selected, but in this way, a number of cases from the statistical database were lost. Another limitation is the fact that in the midface, zygomatic bone fractures are frequently combined with orbital fractures, being difficult to evaluate retrospectively. Strictly including zygomatic bone fractures in this study resulted in the loss of a significant number of cases.

## Conclusions

Most of the zygomatic bone fractures were complete, closed and with bone fragment displacement. Patients presenting soft tissue lacerations on clinical examination will most frequently have a complete, displaced or comminuted underlying zygomatic fracture. The diagnostic approach of zygomatic bone trauma in our country must be related to this aspect. The most effective treatment

method in the case of displaced, open or comminuted fractures was ORIF, while in the case of non-displaced and closed fractures, conservative treatment was the most effective. The greatest number of postoperative complications occurred secondarily to Gillies temporal reduction, the most frequent being malunion.

## Declarations

**Ethics approval and consent to participate:** The study was approved by the Institutional Review Board (IRB) of Oradea University (IRB no. 1275/14.02.2018) and was therefore performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

**Consent for publication:** All patients included in the study signed an informed consent at the time of their admission to the clinical service, by which they gave their consent to the use of their anonymized medical data for scientific purposes and publication.

**Availability of data and materials:** The data and materials are available through e-mail from the corresponding author.

**Competing interests:** There are no competing interests to declare

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