CLOSED REDUCTION AND SKELETAL TRACTION APPARATUS IN THE TREATMENT OF COMPLETE MONOFRAGMENT ZYGOMATIC TETRAPOD FRACTURES

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Abstract

To analyse postoperative results after complete monofragment zygomatic fractures treatment with the use of closed reduction, closed reduction and stabilisation with skeletal traction apparatus, and rigid miniplate osteosynthesis.

Hospital records and radiograms of 342 patients were analysed according to postoperative outcome and complications connected with the procedure.

287 male and 55 female treated for zygomatic fractures (mean age – 38.0±14.95 SD). Complications related to the inaccurate reduction of the fractures were the most common and appeared in 45 patients, among which minor asymmetry was the most frequent. In an overwhelming majority of cases, the function of the infraorbital nerve was fully restored. The opening width of the patients' jaws after the fracture reposition conformed to the norm. These complications ocurred with a similar frequency, regardless of the method of fracture reposition ($p>0.05$).

Closed reduction with the use of the J-shaped curved hook gives good aesthetic and functional outcome in treating some complete monofragment tetrapod fractures. If reduction is not fully stabilised, stabilisation bone fragments with the use of skeletal traction apparatus prevents bone fragments from prolapsing. Closed reduction and its combination with skeletal traction apparatus is a quick, cheap and effective method of treatment for selected patients with zygomatic fractures. It is also easy to perform and burdened with few complications.

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Introduction

Zygomatic fractures present a reasonable proportion of maxillofacial trauma cases. Many classification schemes were described.[1,2] According to the classification proposed by Zingg, there are three types of zygomatico-maxillary complex fractures A, B, and C.[3]

The methods of treatment of such fractures are widely discussed in the literature and include surgical and orthopaedic methods. Surgical methods include different approaches – anterior approache (involving incisions for zygoomaticofrontal suture exposure, incisions for infraorbital rim exposure and incisions for zygomaticomaxillary exposure) standard transcutaneous subciliary or subtarsal incisions, transconjunctival incision, and intraoral incisions.[3-8]

The method of the transcutaneus reposition of zygomatic fractures by the hook was introduced by the Wassmund in the year 1927.[9] Since then many modifications of skeletal traction apparatus have been applied in traumatology as well as other orthopaedic methods have been described.[1,3,10-12] Also rapid development of techniques and materials designed for miniplate osteosynthesis was marked within the past quarter century.[13,14]

This article discusses the place of closed reduction and stabilisation with skeletal traction apparatus in management of complete

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monofragment zygomatic fractures, the so-called 'classic tetrapod fractures'. Concomitant orbital floor fractures are repositioned and reconstructed with various materials, such as polyethylene sheet, lyophilised dura, lyophilised cartilage, ox fascia, titanium mesh, and autogenous bone grafts from ilium.[15-18]

Despite these treatment methods, the aesthetic and functional results are still often not satisfactory and post-operative complications, such as malar asymmetry, orbital complications including visual disturbances, diplopia, enophthalmos, sensory disturbances involving the infraorbital nerve, are presented by many authors.[4,5,6,19,20,21]

The choice of the treatment method depends mainly on the type of fracture, while the effectiveness of bone fragment reposition relies on the adequate reconstruction of three-dimensional anatomical configuration of the zygomatico-maxillary complex. The surgeon must decide what should be exposed during the surgery to achieve the simplest and the most stable repair: he can expose a fracture site to confirm a proper alignment or he can expose fracture site to achieve an adequate fixation of the fracture. The great popularity of miniplates and screws has caused that closed reduction is rarely applied, even in the cases where it could bring satisfying aesthetic and functional effect. Some authors indicate that insufficient post-operative stability of the cheek bones requires open reduction and osteosynthesis.[3]

We believe that such cases can be successfully treated with skeletal traction apparatus.

The aim of this study is to analyse postoperative results after complete monofragment zygomatic fractures treatment with the use of closed reduction, closed reduction and stabilisation with skeletal traction apparatus, and rigid miniplate osteosynthesis. We compared the effectiveness of these methods with regard to the infraorbital nerve dysfunction, aesthetic outcome, and disturbances in mouth opening. Additionally, demographic characteristics of patients with this type of fracture were presented.

Materials and methods

Hospital charts and radiograms of 342 patients treated for tetrapod zygomatic fractures between January 1990 and December 1995, and between January 2000 and December 2007 were reviewed retrospectively. Standard radiographs with Water's view were applied in patients treated in the years 1990 - 1995 and computed tomography was performed in patients in the years 2000-2007.

In all patients suspected of ocular injury presurgical ophthalmology consultation was obtained. We compared the effectiveness of treatment by closed reduction (with the use of the J-shaped curved hook) with closed reduction and stabilisation with skeletal traction apparatus and with rigid miniplate osteosynthesis. Attention was paid to the presence/absence of the infraorbital nerve disturbances as well as pre- and post-operative jaws opening.

Additionally, the comparison concerned the restoration of anatomical configuration of the zygomatico – maxillary complex and orbit evaluated on the basis of rtg images and CT scans before and after the surgery, as well as face symmetry assessed on the basis of pre- and post-operative photographs and also assessed by the surgeon (the shape of the orbital rims, the zygomatico-maxillary arch, the zygomatico-alveolar crest) and by the patient him/herself was performed. Treatment protocols were analysed in the aspect of postoperative complications and untoward sequelae. In addition, data regarding age, gender, etiology, alcohol usage before injury were collected.

Procedure

The indications for surgical intervention included: displaced fractures, facial contour alteration, visual disturbances, diplopia and impaired mouth opening. We performed reduction of the fractures with the help of the J-shaped curved hook from transcutaneous stab incision in the point where 2 lines cross (the first line is parallel to the midline of the face and goes through the lateral orbital rim, and the second perpendicular line runs through the lower margin of the zygomatic bone).

Most of the patients had a form of fixation stabilising the fracture – skeletal traction apparatus (in cases when closed reduction was performed and bone fragments were not stabilised after fracture reposition) or titanium miniplates (in patients that underwent open reduction). Miniplates were inserted through a lower lid transcutaneous incision and in some cases through additional incisions for zygomaticofrontal suture and zygomatic buttress

exposure. The stabilisation of bone fragments with the use of skeletal traction apparatus depends on the hook inserted under the zygomatic bone which is connected with a metal rod (attached to elements of the plaster cast cap) with rubber rings, whose pulling direction and strength can be changed/regulated. The skeletal traction apparatus is made of stainless steel, neutral to tissues. Bone fragments were stabilised for 14 days (Fig.1).

Figure 1. Patient with skeletal traction apparatus.

Statistical analysis

The Chi-squared test was used to test for significance and p values < 0.05 were regarded as a level of importance. As regards small groups, the Chi-squared test was counted on Yates' correction.

Results

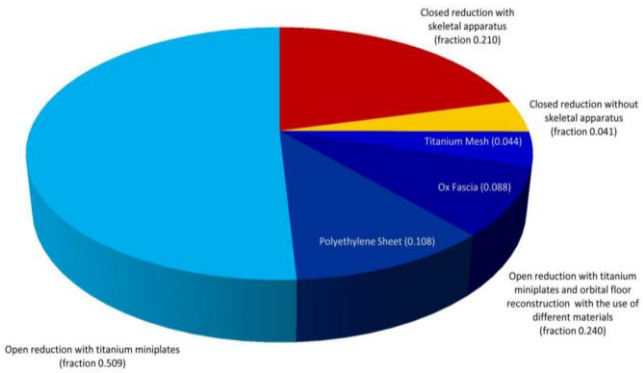
This retrospective research included 342 patients treated surgically, i.e. 287 male and 55 female with complete monofragment zygomatic fractures (male to female ratio – 5.22:1). Their ages ranged from 15 to 85 (mean age – 38.0±14.95 SD). The most common cause of the fractures was assaults (fraction 0.646) followed by traffic accidents (fraction 0.143) and falls (fraction 0.111). The least frequent were accidents at work (fraction 0.026). We reviewed patients in the aspect of alcohol use before the injury. Approximately 37% of all the patients experienced injury after alcohol consumption. The pattern of alcohol use and more detailed demographic characteristics were presented in Table I.

	Tetrapod zygomatic fractures
	n (fraction)
Number of patients	342 (1.000)
Sex	
Female	55 (0.161)
Male	287 (0.839)
Aetiology	
Assault	221 (0.646)
Traffic accident	49 (0.143)
Fall	38 (0.111)
Sport accident	25 (0.073)
Work accident	9 (0.026)
Alcohol use	
Yes	127 (0.371)
No	215 (0.629)

Table 1. Demographic characteristic of the examined group, aetiology and alcohol use before injury.

Data concerning treatment protocols of the closed and open reduction are shown in the Fig. 2. Closed reduction with the J – shaped curved hook was applied in 86 patients (25.1% of all the patients) among which 72 cases (21.0%) needed stabilisation bone fragments with skeletal traction apparatus. The open reduction with rigid fixation by miniplates was performed in 256 cases (74.9% of patients). Tetrapod zygomatic fractures may result in orbital floor disruption and visual disturbances. In our research, 82 patients required additional orbital floor reconstruction with the use of different materials, among which 15 patients obtained combined internal fixation (miniplates with titanium mesh).

A careful radiological, aesthetic and functional analysis of the treatment results was conducted (Table II). Complications related to inaccurate reduction of the fractures were the most common and appeared in 45 patients, among which minor asymmetry was the most frequent and occurred in 28 patients (8.2% of all the patients treated surgically).



	Tetrapod zygomatic fracture
	n (fraction)
Closed reduction without skeletal apparatus	14 (0.041)
Closed reduction with skeletal apparatus	72 (0.210)
Total (closed reduction)	86 (0.251)
Open reduction with titanium miniplates	174 (0.509)
Open reduction with titanium miniplates and orbital floor reconstruction with the use of:	82 (0.240)
- Polyethylene sheet	37 (0.108)
- Ox Fascia	30 (0.088)
- Titanium mesh	15 (0.044)
Total (open reduction)	256 (0.749)
Total	342 (1.000)

Figure 2. Treatment modalities.
Note: n – number of patients.

	Closed reduction	Closed reduction with skeletal apparatus	Open reduction without orbital reconstruction	Open reduction with orbital reconstruction	Total n (fraction)
	Type B fracture n (fraction)	Type B fracture n (fraction)	Type B fracture n (fraction)	Type B fracture n (fraction)	
Number of patients	14 (0.041)	72 (0.211)	174 (0.509)	82 (0.239)	342 (1.000)
Malar asymmetry					
Minor	2 (0.006)	6 (0.018)	11 (0.032)	9 (0.026)	28 (0.082)
Major	0	2 (0.006)	7 (0.020)	8 (0.023)	17 (0.050)
Clinical examination					
Bone slide on the infraorbital rim	2 (0.006)	8 (0.023)	18 (0.053)	17 (0.050)	45 (0.132)
Unevenness of the zygomatico-alveolar crest	0	2 (0.006)	7 (0.020)	8 (0.023)	17 (0.050)
Infraorbital nerve disfunction					
Before surgery	10 (0.029)	59 (0.173)	85 (0.249)	54 (0.158)	208 (0.608)
After surgery	1 (0.003)	2 (0.006)	2 (0.006)	3 (0.009)	8 (0.023)
Impaired mouth opening					
Before surgery	4 (0.012)	29 (0.085)	30 (0.088)	26 (0.076)	89 (0.260)
After surgery	0	0	0	0	0
Diplopia					
Before surgery	1 (0.003)	19 (0.056)	47 (0.137)	57 (0.167)	124 (0.363)
After surgery	0	0	4 (0.012)	5 (0.015)	9 (0.026)
Enophthalmos					
Before surgery	0	0	123 (0.360)	82 (0.239)	205 (0.599)
After surgery	0	0	4 (0.012)	5 (0.015)	9 (0.026)
Exophthalmos					
Before surgery	0	0	0	4 (0.012)	4 (0.012)
After surgery	0	0	0	1 (0.003)	1 (0.003)
Other complications					
Infection	0	0	3 (0.009)	2 (0.006)	5 (0.015)
Plate displacement	0	0	1 (0.003)	1 (0.003)	2 (0.006)
Perception of cold	0	0	1 (0.003)	2 (0.006)	3 (0.009)
Hole in cheek skin left by the hook	2 (0.006)	5 (0.015)	0	0	7 (0.020)

Table 2. Postoperative complications and statistical analysis.

A small bone slide on the lower orbital rim was reported in a clinical examination in 0.006 of the patients after a closed reduction, in 0.023 of the patients after closed reduction and stabilisation with skeletal traction apparatus, and in 0.103 of the patients after rigid miniplate osteosynthesis. Unevenness of the zygomatico-alveolar crest was observed in 0.006 of the patients after closed reduction and stabilisation with skeletal traction apparatus and in 0.043 of the patients after rigid miniplate osteosynthesis.

We did not observe any statistical correlation between inadequate fracture reduction and the method of fracture reposition ($p>0.05$). The feeling disturbances in the area of the infraorbital nerve (in the form of anesthesia, paresthesia of the cheek, nose, upper lip and lower eyelid) directly after the trauma were reported by 208 patients (60.8% of all the patients.) Higher rate of the infraorbital nerve dysfunction was noted in patients submitted to open reductions in comparison with closed reductions (139 vs. 69 patients; $chi^2=18.172$, $p<0.001$). In the majority of cases, the function of the infraorbital nerve was fully restored. Only 8 patients (2.3% of all) reported feeling disturbances a year after the trauma. The fraction of patients with feeling disorders was similar in the all analysed groups of patients a year after treatment. Impaired mouth opening was more frequent in patients qualified for open reduction ($chi^2=9.101$, $p<0.01$). The opening width of jaws of patients after fracture reposition was within the norm and did not vary significantly for the groups analysed.

In patients with orbital floor disruptions an ophtalmic evaluation was performed before and after the surgery. Preoperative diplopia occurred in 124 patients, enophthalmos in 205 and exophthalmos in 4 and they were in most cases properly corrected. Only in 9 patients (2.6% of the whole group analysed) the diplopia did not disappear despite the surgery. The most probable explanation for this is insufficient floor reconstruction or atrophy of perioorbital tissues as a result of trauma or insufficient reduction of the zygoma enlargening the orbital cavity.

Postoperative infection was diagnosed in 5 patients (1.5% of all the patients). Local wound care, local antimicrobial application and oral antibiotics were administered to these patients. Other complications were strictly associated with the treatment method applied.

In long-term follow-up of miniplate osteosynthesis technique (256 cases) we found that plate came out in 2 cases and 3 patients

reported the 'feeling of cold' associated with the miniplates presence during autumn-winter period (in total: 5 patients, 0.019 of all the patients who underwent miniplate osteosynthesis). A hole in the cheek left by the hook was observed in 7 patients, which constituted 0.081 of the patients subjected to closed reduction and closed reduction and stabilisation with skeletal traction apparatus.

	Comparison of patients after closed reduction without skeletal apparatus with patients after closed reduction and stabilisation with skeletal apparatus		Comparison of patients after closed reduction with skeletal apparatus with patients after open reduction without the use different materials for the orbital floor reconstruction		Comparison of patients after closed reduction in total (with and without skeletal apparatus) with patients after open reduction without the use different materials for the orbital floor reconstruction		Comparison of patients after closed reduction in total (with and without skeletal apparatus) with patients after open reduction in total (with and without the use different materials for the orbital floor reconstruction)	
	chi ²	p	chi ²	p	chi ²	p	chi ²	p
Malar asymmetry								
Minor	0.060	p>0.05	0.320	p>0.05	0.755	p>0.05	0.190	p>0.05
Major	0.114	p>0.05	0.010	p>0.05	0.118	p>0.05	1.046	p>0.05
Clinical examination								
Uneveness of the orbital rim	0.014	p>0.05	0.032	p>0.05	0.099	p>0.05	0.235	p>0.05
Uneveness of the crest	0.114	p>0.05	0.010	p>0.05	0.118	p>0.05	1.046	p>0.05
Feeling disorders								
Before surgery	0.289	p>0.05	**22.980**	**p<0.001**	**23.472**	**p<0.001**	**18.172**	**p<0.001**
After surgery	0.001	p>0.05	0.133	p>0.05	0.001	p>0.05	0.162	p>0.05
Impaired mouth opening								
Before surgery	**14.427**	**p<0.001**	**14.824**	**p<0.001**	**14.427**	**p<0.001**	**9.101**	**p<0.01**
After surgery	-	-	-	-	-	-	-	-
Diplopia								
Before surgery	1.427	p>0.05	1.427	p>0.05	1.427	p>0.05	**8.403**	**p<0.01**
After surgery	-	-	0.010	p>0.05	0.777	p>0.05	0.777	p>0.05
Exophthalmos								
Before surgery	-	-	**98.985**	**p<0.001**	**112.555**	**p<0.001**	**112.555**	**p<0.001**
After surgery	-	-	0.010	p>0.05	0.777	p>0.05	1.885	p>0.05
Exophthalmos								
Before surgery	-	-	-	-	-	-	0.344	p>0.05
After surgery	-	-	-	-	-	-	0.329	p>0.05
Other complications								
Infection	-	-	0.233	p>0.05	0.369	p>0.05	0.618	p>0.05
Plate displacement	-	-	0.208	p>0.05	0.130	p>0.05	0.001	p>0.05
Perception of cold	-	-	0.208	p>0.05	0.130	p>0.05	0.116	p>0.05
Hole in cheek skin	0.148	p>0.0	**9.093**	**p<0.001**	**11.614**	**p<0.001**	**17.406**	**p<0.001**

Note: n – number of patients Statistical significances were marked with bold font.

Discussion

In Poland, like in most developed countries, assaults are the most common causes of zygomatic fractures.[22-24] The incidence and aetiology of injuries presented in this research are similar to those presented in the previous studies.

The correct three-dimension restoration of anatomical structures and adequate orbital reconstruction are the factors of optimal reduction of zygomatic fractures. Among numerous methods of treatment of zygomatico-maxillary complex fractures, such as closed reduction, miniplate osteosynthesis and osteosynthesis with biodegradable materials, it is miniplate osteosynthesis that is considered to be the method yielding best results and stabilisation of bone fragments.[13,25,26]

A few authors indicate that, because of high costs of miniplate osteosynthesis treatment and the necessity to remove, in some cases, merging elements, closed reduction should still be a method employed in traumatology.[13,25,26]

At the same time, the popularity and advantages of miniplate osteosynthesis sometimes lead to extensive plating of the facial skeleton even in cases when other methods of treatment may be adequate to preserve correct reduction of the fracture. For instance, in the case of isolated zygomatic arch fractures miniplate osteosynthesis may even lead to unsatisfactory result of fracture reduction caused by secondary dislocation of bone fragments consequent upon the fact that the long arm of the zygomatic arch starts performing the function of a lever after miniplate bonding. Besides, it is very difficult to reach an appropriate angle and positioning of the fragments via titanium miniplates owing to the anatomic changeability of the zygomatic arch.[27]

Although cosmetic and functional results of ZMC fractures treatment are frequently less than satisfactory, unacceptably poor outcomes are very rare in the literature.[4-6,19-21]

Surgical revision due to significant facial asymmetry is needed in 3 – 4% of the patients. [3] In our study, major asymmetry occurred in 0.050 of the patients – in 2 patients after closed reposition with skeletal traction apparatus and 15 patients after rigid osteosynthesis. To avoid complications connected with postoperative facial asymmetry some researches recommendate the intraoperative CT evaluation to determine immediate assessment of bone fragments position during reduction of zygomatic fractures.[28]

In our clinic the accurate position of ZMC during surgical reduction of the fracture is largely based on surgeon's experience, previous physical examination and radiological scans. During open reduction accurate position of bone fragments is carried out under visual control – the approach uses two or three incisions for zygomaticofrontal suture exposure, for inferior orbital rim exposure and for zygomaticomaxillary exposure. In case of closed reduction the proper position of the relocated bone segment is confirmed by visible reduction of facial asymmetry and also by palpation (lack of bone slide on lower orbital rim, lack of displacement of the malar prominence and depression of the zygomatic arch). Also a pronounced click may be heard during repositioning bone fragment into its proper position.

The analysis of our results shows that, in cases of the complete monofragment zygomatic fractures without indications for orbital floor

reconstruction, miniplates osteosynthesis yields a similar aesthetic and functional result as closed reduction and closed reduction and stabilisation with skeletal traction apparatus. We applied successfully the skeletal traction apparatus for the stabilisation of the fractures in the cases where we detected instability of the fragments of the fractured bones. We did not observe any statistical difference between these methods with regard to postoperative frequency of malar asymmetry, the infraorbital nerve dysfunction, impaired mouth opening or infection.

Although postoperative infection was observed only in patients after miniplate osteosynthesis and occurred in 1.5% of all surgically reduced fractures. This can be explained by the fact that miniplates are believed to intensify the loss of vascularisation and, as a result, they may lead to complete or partial resorption and inflammation.[3]

Other complications observed were strictly associated with the treatment method applied. In the literature, complications connected with miniplate osteosynthesis appear in around 13% of patients.[29,30] In our study, we found 2 cases when plate came out and 3 patients with the 'feeling of cold' during autumn-winter period (0.019 of all the patients who underwent this technique).

A hole in the cheek left by the J-shaped curved hook described in the literature occurs in about 7% of patients subjected to closed reduction.[9,31] We noted it in 0.083 of the patients subjected to closed reduction and closed reduction and stabilisation with skeletal traction apparatus, which means that this complication occurred in the analysed group more frequently than reported in the literature.

What remains to be discussed is the case of patients that needed orbital floor reconstruction with different materials. It is obvious that concomitant orbital floor fractures with visual disturbances necessitate open reduction and orbital floor reconstruction and even minor inaccuracies may lead to less than adequate results. The most common sequelae of these fractures are enophthalmos and diplopia. The rate of this complication described in recent studies varies from 3.9% to 5%.[3,5,20]

In the present study, enophthalmos and diplopia was observed in 9 patients after surgery (0.026 of the whole examined group).

In the end of the discussion it is worth to summarize the advantages and disadvantages of closed reduction with the hook and skeletal traction apparatus application. This method of immobilization of bone fragments in comparison to rigid miniplate osteosynthesis is connected with shorter time of surgery, smaller and in most cases aesthetical scar, fewer inflammatory complications and lower costs of surgery. Limitations of this method are mainly due to the restricted indications for its use – closed reduction with a hook and fixation with skeletal traction apparatus some types of zygomatico-maxillary complex fractures would give worse aesthetic and functional results then open reduction and minplate osteosynthesis (these types are a contraindication for its use).

In our opinion the specific indications for closed reduction and skeletal traction apparatus are:

- isolated zygomatic arch fractures,
- monofragment zygomatic fractures uncomplicated with visual disturbances and with bone fragment displaced posteriorly and inferiorly,
- and in some cases: severe condition of the patient, patient with multiorgan trauma, when surgery brings high and additional risk of general complications.

Another inconvenience of closed reduction performed with the use of the J-shaped curved hook is that in some cases there is a need of the additional stabilisation of the bone fragments which is connected with troublesome wearing by the patient plaster cast cap and skeletal traction apparatus or with additional incisions for miniplates insertion.

Conclusions

In conclusion, closed reduction with the use of the J-shaped curved hook gives aesthetic and functional outcome in treating some complete monofragment tetrapod fractures similar to the miniplate osteosynthesis. If reduction is not fully stabilised stabilisation bone fragments with the use of skeletal traction apparatus prevents bone fragments from prolapsing.

Closed reduction and its combination with skeletal traction apparatus is a quick, cheap and effective method of treatment for selected patients with zygomatic fractures. It is also easy to perform and burdened with few complications.

Declaration of Interest

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