SURGICAL TREATMENT OF PATIENTS SUFFERING FROM FRACTURES AND DEFORMATIONS OF THE FACIAL CRANIUM BONES, BY VARIOUS FIXATION OSTEOSYNTHESIS DEVICES

E. ASTAPENKO¹, V. MALANCHUK², N. TIMOSHCHENKO³

¹Associate Prof., PhD, Dept. Oral and Maxillofacial Surgery, Faculty of Medical Dentistry, Bogomolets National Medical University Kiev, Ukraine
²Prof., PhD, Dept. Oral and Maxillofacial Surgery, Faculty of Medical Dentistry, Bogomolets National Medical University Kiev, Ukraine
³Univ. Assist., PhD, Dept. Oral and Maxillofacial Surgery, Faculty of Medical Dentistry, Bogomolets National Medical University Kiev, Ukraine
Corresponding author: mioche@ukr.net

Abstract

Summary. The article analyzes the surgical treatment of fractures and deformations of visceral cranium bones in comparative groups, by the use of resorptive bioactive polymer and titanium bone plates completed with screws as fixation osteosynthesis devices. In early and distant (relative osteosynthesis) terms, positive clinical study results have been obtained, which is indicative of the effectiveness and promising nature of the resorptive polymer mini plates use in the surgical treatment of fractures and deformations of the facial cranium. Due to a correct treatment planning and a biomechanically substantiated use of plates, 98% of the patients with polymer fixation devices have been fully rehabilitated. The use of the proposed plates for osteosynthesis helps prevent a number of complications in the postoperative period and permits avoiding a second operation for fixing device removal.

Keywords: fractures of facial cranium bones, facial cranium bone deformations, bioactive resorptive plates and osteosynthesis screws, polymer osteosynthesis

1. INTRODUCTION

The modern maxillofacial surgery is capable of eliminating deformations and effectively repositioning and fixing facial cranium bones in cases of fractures. The active deployment of various systems of fixation osteosynthesis devices in the practical surgery (the same fixation devices being implemented in the form of mini-bone plates and screws made mainly of titanium [1-3] has been instrumented in the realization of the above progress. Nevertheless, despite the positive properties of such fixation systems, a large number of publications have appeared in recent years stating the necessity of metal fixators removal in the distant postoperative period, due to the emergence of discomfort, cold reaction and implant perceptibility, as well as to the appearance of neurological signs in the area of fixation structure location [1,5-8]. This resulted in the development of an alternative osteosynthesis method, using bioresorptive plates and screws. Considered as a most promising procedure, it is applied in foreign surgery practice on an increasingly larger scale [4-7].

Previous experimental studies, as well as the obtained results, have encouraged the authors to use osteosynthesis fixators made of a bioresorptive material characterized by bioactive properties; the proposed material has been used in clinical practice for the treatment of facial cranium fractures and deformations. That is why, the present study proposes a comparative analysis of the surgical methods of facial cranium fractures and deformations treatment with different types of fixation devices.

2. MATERIALS AND METHODS

The clinical material of study consisted of 215 patients with facial cranium bone fractures of varying localization and time terms, that required surgical treatment; the patients were divided into the main and control groups. The main group (105 patients) included 79 patients with 149 facial cranium fractures, who have undergone...
143 osteosynthesis procedures in which 152 resorptive polymer plates with screws have been used. 76 patients with facial cranium fractures were treated (during osteosynthesis, for the fixation of bone fragments) with polymer plates with EPU–GAP–LEV (epoxy and polyurethane composition containing hydroxyapatite and levamisole) screws (Declaration Patent of Ukraine for Utility Model No. 13318 of March 15, 2006; Utility Patent of Ukraine No. 79557 of June 25, 2007); in the treatment of 3 patients, resorptive plates and foams made of polylactic acid (KLS Martin, Germany) were used; there were also 26 patients with primary and secondary deformations of the facial cranium (in 22 of them the deformation being the result of trauma, while the other 4 were caused by midface underdevelopment after a radical uranostaphyloplasty) who have undergone surgical treatment including 36 osteosynthesis procedures, using 41 resorptive polymer plates with screws utilized for fixing the bone fragments and for securing them in a correct position (37 EPU–GAP–LEV plates and 4 plates made of polylactic acid). The control group consisted of 110 patients with 139 facial cranium bone fractures who have undergone 128 osteosynthesis operations with 128 titanium osteosynthesis plates produced by reputed foreign manufacturers (KONMET, Russia and KLS Martin, Germany). The distribution of patients in groups is presented in Table 1.

Table 1. Distribution of patients in groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Treatment method</th>
<th>Number of patients</th>
<th>Number of osteosynthesis zones</th>
<th>Number of fixation devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main</td>
<td>Osteosynthesis with the use of polymer resorptive plates and screws</td>
<td>105</td>
<td>143</td>
<td>152</td>
</tr>
<tr>
<td>Control</td>
<td>Osteosynthesis with the use of titanium plates and screws</td>
<td>110</td>
<td>128</td>
<td>128</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>215</td>
<td>271</td>
<td>280</td>
</tr>
</tbody>
</table>

Most of the patients were aged 18-29 (young age group) and 30-48 (mature age group), that is, all of them were of an able-bodied age. Among the patients that underwent surgery, 207 were males and 8 were females.

According to their localization, all facial cranium fractures - 280 fractures in 215 patients (including the intraoperative ones sustained in the process of facial cranium bone fractures) - with different osteosynthesis fixators used during the surgical treatment (resorptive osteosynthesis polymer and titanium plates and screws) were divided into subgroups, namely: fractures of the zygomatic complex (including fractures of the jugal bridge), fractures of the upper' and lower jaw in the angle and branch areas. In the process, 271 fracture zones required osteosynthesis.

Table 2. Distribution of patients from the main and control group, according to the localization of the osteosynthesis zones

<table>
<thead>
<tr>
<th>Group</th>
<th>Osteosynthesis localization</th>
<th>Number of patients</th>
<th>Number of osteosynthesis zones</th>
<th>Number of fixation devices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zygomatic complex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>jugal bridge</td>
<td>49</td>
<td>62</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Zygomatico-frontal suture</td>
<td>62</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Zygomatico-gingival crest</td>
<td>10</td>
<td>26</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Upper jaw</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Naso-frontal buttress</td>
<td>12</td>
<td>26</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>chin</td>
<td>3</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Lower jaw</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>branch and angle</td>
<td>9</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Total (%)</td>
<td>77</td>
<td>76</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28.2%</td>
<td>27.9%</td>
<td>21.2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>58</td>
<td>38</td>
<td>13.9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21.2%</td>
<td>13.9%</td>
<td>1.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>38</td>
<td>5</td>
<td>1.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13.9%</td>
<td>1.8%</td>
<td>7%</td>
</tr>
</tbody>
</table>

International Journal of Medical Dentistry
Unilateral fractures (including the intraoperational ones, in cases of chronic or incorrectly consolidated fractures) have been diagnosed in 173 patients, and bilateral ones – in 42 patients. The patients with multiple comminuted fractures have not been included in the study, since most surgeons do not recommend polymer resorptive fixation devices in such cases.

The surgical treatment was preceded by clinical, instrumental and laboratory diagnosis; the patients were prepared for surgeries according to the classical algorithm.

The following conditions were considered for surgical intervention: inefficiency of bone fragments closed reposition and impossibility of assuring their stability in a correct position in the postoperative period.

The surgical treatment of the fractures included the procedure of open reposition and fixation of fragments, supported by an antibacterial, anti-inflammatory and symptomatic therapy. The surgical treatment of facial cranium deformations included the realization of osteotomy in the loci specified in the operative intervention planning stage, relocation of the osteotomized bone fragments in a suitable position and their reliable fixation by means of osteosynthesis bone plates and screws.

The operative treatment was planned in accordance with the protocols proposed by the European Association for Cranio-Maxillo-Facial Surgery. The choice of the fixation devices was determined by the clinico-roentgenologic situation, anatomical characteristics of the bone surfaces and biomechanical loads affecting fractures (osteotomies) areas; adjustments were preformed during the surgery.

The bone fragments were fixed in the correct position by means of osteosynthesis fixators of various types. In the main group of patients, the osteosynthesis procedure was performed with biodegradable polymer fixators, namely polyurethane plates and screws (EPU–GAP–LEV) made from the material proposed by us, as well as polylactic osteosynthesis plates manufactured by KLS Martin, Germany. In the control group, all procedures were performed with titanium plates and screws.

Success of the operative treatment was assessed by postoperative wound healing, exactness of the affected bone anatomical shape recovery (according to radiographic data), absence of inflammatory complications or patients’ complaints, level of personal patient satisfaction, as well as occlusion status, disturbed functions recovery and aesthetic parameters.

Clinical and radiographic studies (including CT scan) represented the main control methods of the status of bone tissues in the operative intervention areas and general assessment of the obtained results; based on these methods, the efficiency of the operative treatment could be estimated.

3. RESULTS AND DISCUSSIONS

In the main group of patients with zygomatic complex fractures in the zygomatico-frontal suture area, the polymer osteosynthesis method was applied in 100% of cases (76 patients), in the zygomatico-gingival crest area – in 23 patients, in the area of the maxillary sinus front wall – in 3 patients. For the treatment of 47 patients, the use of biodegradable polymer plates was inappropriate due to the presence of bone tissue defects in the zygomatico-gingival crest area, so that a permanent “artificial” buttress was created in this zone and only a metal bone osteosynthesis plate could have performed the necessary function in such conditions.

As far as fractures of the upper jaw of different time durations are concerned, 34 patients have been observed. Among them, 19 suffered from the Le Fort I, II upper jaw fractures, 14 patients – from local upper jaw fracture in the naso-frontal buttress area, 1 patient – from Le Fort III post-traumatic midface deformation. The main group included 12 patients, the control group – 22 patients. In the main group of patients, the polymer osteosynthesis method was applied in all cases in nasofrontal buttress and zygomatico-frontal suture areas, and in the zygomatico-gingival crest area – in 8 patients.

Until recently, most surgeons would have preferred metal titanium fixators for the fixation of lower jaw bone fragments during the osteosynthesis procedure, namely titanium mini plates and screws, since the lower jaw is the part of the facial cranium capable of sustaining
SURGICAL TREATMENT OF PATIENTS SUFFERING FROM FRACTURES AND DEFORMATIONS OF THE FACIAL CRANIUM BONES, BY VARIOUS FIXATION OSTEOSYNTHESIS DEVICES

considerable stresses in the process of mastication. Nevertheless, our clinical experience shows that the use of such fixation devices during the surgical treatment of the lower jaw fractures can be quite effective in some cases. Such devices can be used in the treatment of the lower jaw branch in zones experiencing mainly stretching/compressing loads. The process requires an individual approach for deciding on the suitability of bioresorptive fixators placement in the articular process cervix area and in the notch area; in so doing, the concrete clinical situation data should be taken into account. In the body and chin region, characterized by complex anatomical surface topography, where the bending and twisting loads dominate, the bioresorptive plates should be used with caution and only in combination with jaw splintage or an additional metal plate. In so doing, the use of such fixation devices in the external oblique line area for treating the biomechanically conducive transverse fractures of the mandibular angle appeared as effective and biomechanically justified. This area mostly sustains the stretching deformations and, due to the complex topography of the fracture and to the presence of compression forces acting along the lower jaw edge, the stress affecting the fixation device is considerably reduced, a significant part being taken directly by the bone tissue in the fracture area. In this case, the plate operates as a support. Obviously, in the post-operative period, patient’s masticatory loads should be limited until a bony union is formed in the fracture area, although an early jaw mobilization is also possible in such cases. 24 patients with mandibular fractures that required surgical treatment were observed: 12 of them constituted the main group and other 12 – the control group. 9 polymer osteosynthesis procedures have been performed in the mandibular branch area (EPU–GAP–LEV), 3 – in the chin area (1 with the use of the EPU–GAP–LEV resorptive fixators, 1 – with the use of osteosynthesis polylactic fixators produced by KLS Martin, Germany). In the post-operative period, all patients have been assigned a standard anti-inflammation therapy course.

It should be noted that, in the main group of patients, good treatment results for the zygomatic complex and maxillary fractures have been obtained in 100% of cases (both in the patients with polyurethane plates and screws and in those with polylactic osteosynthesis fixators). The signs of post-operative edema should disappear 4-5 days after the surgical intervention, that is, approximately 1 day earlier than in the control group. No mobility of the bone fragments was registered upon palpation along the early post-operative period. One patient has developed hematoma infection in the osteosynthesis zone 3 days after the surgery. Nevertheless, due to a prompt draining, antiseptic dressing of the bone wound and correction of the antibiotic therapy, the generally positive course of bone tissue regeneration in this patient had not been affected. Consolidation of bone fragments occurred properly, without further complications.

As far as the mandibular fracture treatment is concerned, one should observe that polymer osteosynthesis in the branch area has been 100% effective in all patients of this subgroup; the same procedure, performed in the chin area, has failed to show positive outcome in 1 case, due to relocation of the bone fragments having occurred in the postoperative period, as caused by the biomechanical loads affecting the zone, as well as by the elasticity and insufficient firmness of the fixation device.

In the process of radiographic control of bone fragments positioning in patients, performed after the polymer osteosynthesis procedure (within 4-7 and 30 days after surgery), evidence was found on the correct positioning of the bone fragments.

The radiographic control of bone tissue density performed 6 months after polymer osteosynthesis evidenced restoration of the radiological (mineral) density of the bone reclaim in 41 patients.

In the control group of patients, good results were obtained in 97.5% of cases. The signs of post-operative edema would disappear on day 5-6. No mobility of bone fragments was registered upon palpation along the early postoperative period. In the process of radiographic control of bone fragments positioning in patients, performed after polymer osteosynthesis (within 4-7 and 30 days after surgery), evidence was found on the correct positioning of bone fragments. No pyoinflammatory complications
occurred in the early postoperative period. However, in the osteosynthesis area of 3 patients, an inflammatory infiltrate appeared 1.5-2 months after surgery. Inflammation became chronic; the plates have been removed 2 months after the surgery. Radiographic control of bone tissue density performed 6 months after the surgery showed an almost complete mineralization of the bone reclaims in 16 of the patients; nevertheless, the indices of bone tissue density were somewhat higher in the main group, compared to the control one.

Clinical example of the bioactive bioresorptive polyurethane plates use in relocated zygomatic bone fractures

Patient S., 30 year-old, has been admitted to the maxillofacial department with a traumatic fracture of the right zygomatic bone, 5 days after trauma (Fig. 1).

![Fig. 1. 3D CT scan of patient S., upon hospitalization](image)

After a meticulous planning, surgery has been performed, namely, reposition and polymer osteosynthesis (EPU–GAP–LEV) of the right zygomatic bone.

Surgery protocol. Under general anaesthesia, through supraorbital and intraoral approaches, the zones of the fracture lines have been skeletonized in the areas of the zygomatico-frontal suture and zygomatico-gingival crest. Refracture of the right zygomatic bone has been performed. Bone reclaim has been removed from the fracture zone in the zygomatico-frontal junction area. The edges of the zygomatic bone have been fixed by a resorptive bone plate and screws (EPU–GAP–LEV) (Fig. 2).

![Fig. 2. Patient S. Diagnosis: Traumatic fracture of the right zygomatic bone. Stages of surgery: a) approaching the fracture line in the zygomaticofrontal suture area; b) performing polymer osteosynthesis with a resorptive bone plate and EPU–GAP–LEV screws](image)
Such a fixation has been sufficient for assuring bone fragments stability. All wounds have been sutured. The first 2 days after surgery were normal. On day 3, the amount of infiltrate in the surgical intervention zone increased and signs of suppurative inflammation appeared. Bone wounds content has been drained, the wounds were dressed with antiseptic solutions and the antibiotic therapy has been corrected. Within 2 days, inflammation has been arrested. Radiographic control has shown a correct positioning of the right zygomatic bone. 7 days after surgery, the patient has been discharged, to continue his treatment in the outpatient department.

For the next 6 months, the patient has been checked monthly. No complaints and no inflammation signs have been ever detected. Patient’s face was symmetrical and proportional.

3D CT control images taken 6 months later showed a complete anatomical restoration of the affected zone (Fig. 3); CT indices of bone reclaim density in the osteosynthesis zone were equivalent to those of the symmetrical zone (Fig. 4). In the orbital cavity external edge area, the implanted polyurethane bone plate with screws could not be palpated. No foreign body reaction was registered in the patient over the whole observation period; there were no complaints.

Fig. 3. 3D CT scan of patient S., 6 months after surgery – reposition, polymer osteosynthesis of the right zygomatic bone

Fig. 4. CT scan of patient S. Comparative analysis of bone tissue density indices in the polymer osteosynthesis zone and in the symmetrically unaffected area
4. CONCLUSIONS

The positive results of our own clinical studies observed in early and distant terms after polymer osteosynthesis procedure performance testify the effectiveness and promising nature of the resorptive (including EPU–GAP–LEV) polymer mini plates use in the surgical treatment of facial cranium fractures and deformations.

Due to a correct treatment planning and to a biomechanically substantiated use of plates, almost all (98%) patients with polymer fixation devices have been fully rehabilitated. The use of the (EPU–GAP–LEV) plates proposed by the authors helps prevent several complications in the post-operative period, reduces the probability of pyoinflammatory complications and avoids a second operation for fixation device removal.

References