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Biomaterials Used in the Prosthetics of Facial Fractures

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Abstract: *The etiology of maxillofacial injuries is represented by car accidents, human aggression, and work-related trauma. Trauma to the maxillofacial area requires a complex treatment that involves functional and aesthetic rehabilitation. To restore the functionality of the damaged areas, a correct surgical technique is necessary along with the use of the ideal prostheses for a better reconstruction. Along with the development and improvement of facial fractures osteosynthesis techniques, an attempt was made to identify the right material to complete these surgical methods. We analyze in this paperwork the benefits of polyetheretherketone-based materials in the prosthetics of different facial fractures in comparison with other materials like titanium.*

Keywords: *polyetheretherketone, titanium, maxillofacial osteosynthesis*

1. Introduction

A complete history of biomaterials has not yet been written, but their multi-millenary development can Biomedical alloys became essential parts of modern medical applications [1].

Facial fractures are difficult to manage. It is necessary to identify the ideal material for the reduction of fracture to be harmonious with the most favorable aesthetic and functional results.

Trauma injuries of the face are commonly encountered in emergency medicine. More than half of patients with these injuries have multiple traumas that require coordinated management between emergency physicians and surgical specialists in oral and maxillofacial surgery, otolaryngology, plastic surgery, ophthalmology, and trauma surgery [2]. Important sensory systems are contained within the face (e.g., vision, auditory, somatic sensation, gustatory, olfaction, and vestibular system) and also, vital structures, of the head and neck are intimately associated (airway, blood vessels, nerves, and digestive tracts. From the anatomical point of view, the face is made up of vertical and horizontal buttresses where the bone is thicker to increase the resistance forces of this bone structure. Reduction and fixation of these key areas are the basis of maxillofacial rehabilitation [2]. Fracture fixation surgery, like minimally invasive plate osteosynthesis, shifted in the direction of saving more tissue and toward smaller dissection. The plating technique started to be used for different bones, however, a broader clinical adoption must be considered after refined conclusions.

Osteosynthesis with miniplates and screws is a technique that brings a series of advantages both to the surgical treatment of fractures and to the functional and physiognomic rehabilitation of the patient. This technique achieves rapid primary healing of the fracture site, and effective stabilization of the bone fragments, eliminating the need for immobilization and thus reducing the patient's discomfort. Also, thanks to the direct visual control, the technique allows a precise anatomical reduction of the fracture.

Along with the development and improvement of facial fracture reconstruction techniques, an attempt was made to identify the right material to complete these surgical methods.

A lot of opportunities and challenges there are in the creation and characterization of biomedical alloys. Features of these materials have been designed to be in contact with blood, as replacements for soft and hard tissues [3].

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However, they cannot satisfy the increasing requirements for large-scale production owing to the degradation of metals. Physical surface modification could be an effective way to enhance their bio functionality [1].

Continuous research and development of the polymer industry with applications in all medical fields have their ground in the importance of these biomaterials in the health domain [4].

The most used biomaterials in bone prosthetics are by far titanium, polyetheretherketone (PEEK), and a new representative with multiple potentials - BioHPP. Titanium is frequently used in facial implantation based on its durability, low weight, and biocompatibility which offers it good osseo-integration. As part of the polyetheretherketone family of polymers, polyetheretherketone is a very efficient bioinert material, which makes it proper for implantation in the human body. Compared to a titanium-based material used to restore joints, polyetheretherketone is more elastic and mirrors the human bone. Research conducted in this area proved the benefits of BioHPP polymer when used for prosthetic restoration on implant abutments [5].

The most commonly used materials for the fabrication of conventional prostheses are currently metal alloys titanium. Currently, high-performance polymer biomaterials tend to improve framework properties and potentially reduce the cost of prostheses [6].

In the current study, we investigate the use of polyetheretherketone materials in the prosthetics of different facial fractures in comparison with other materials like titanium.

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2. Materials and methods

Polyetheretherketone (PEEK) is a thermoplastic resin employed in the field of industry and medicine for several years. This semi-crystalline high performance composite offers a unique combination of outstanding physical properties, stability at high temperatures and excellent resistance to chemical damage. These are some of the reasons that allow the use of PEEK as a framework material for plates prosthesis, removable dental prosthesis, tooth-implant-supported and implant-supported bridges [7].

A retrospective review of patients hospitalized and treated in the Oral and Maxillo-Facial Surgery Clinic of Craiova had been made.

2.1. Study inclusion criteria

Inclusion criteria were considered to be patients hospitalized and treated in the Oral and Maxillo-Facial Surgery department of Craiova hospital for 3 years starting the year 2012. The patient sustained maxillary fractures, either isolated or in combination with other facial injuries. We had a total of 765 subjects. We made 3 groups of distinct patients. The first one was composed of 176 patients with fractures at both levels of the middle face and the level of the lower face. The other group was made up of 329 patients with lower facial fractures and the last one was represented by 260 patients with middle facial fractures.

2.2. Study exclusion criteria

The most important exclusion criterion had been the time of the study. We used in our study only the patients hospitalized and treated in the Oral and Maxillo-Facial Surgery department of Craiova hospital for a strict period. We also excluded in our study patients with craniofacial malformations, patients with

absolute contraindications for surgical procedures such as active malignant tumors, and immuno-compromised patients.

3. Results and discussions

For a better evaluation of the cases, we have drawn up a "trauma patient file" in which we had noted data on the etiology of the trauma, the age, gender, the patient's environment, the period from the accident to hospitalization, the topography of the lesion, the type of surgical intervention performed, the method of approach (exo-oral or endo-oral), the evolution, the medicinal treatment administered.

In our research, we grouped patients according to different criteria: age, patients' environment, and gender.

The current clinical statistical study set that the frequency of middle-floor fractures between gender is higher in males (73%) than in females (27%). Furthermore, there is an important difference regarding the patients' environment. It had been observed that in the rural environment (58%) the frequency is higher compared to the urban environment (42%). We determined two major ways of producing fractures of the middle level of the face: by aggression or by accident. The greater share had been represented by the fractures caused by aggression (69%) despite the fractures caused by accidents (31%). An equally important modulating factor of facial fractures is represented by the age of the patients. We set six groups of ages as follows: age between 20-30 years, age between 30-40 years, another group between 40-50 years, 50-60 years, 60-70 years, and the group between 70-80 years. We observed an increased number of fractures in patients aged between 30-40 years (15.23%) and between 20-30 years (13.20%).

Furthermore, the clinical statistical study was carried out based on a batch of 200 patients following the previously described aspects. According to age groups, mandibular fractures predominate in the 20–30-year-old group (58 patients) and occur less often in those over 60 years (13 patients) and between 0-10 years (8 affected patients). The frequency of mandible fractures depending on their cause is dominated by human aggression and road accidents which represent 50%, respectively 37.5% of the total cases. Out of the total of 200 patients with mandible fractures, 170 were male and only 30 were females.

Osteosynthesis plates were chosen for each participant according to the particularities of the fracture. We used titanium plates in a proportion of 95% and polyetheretherketone plates (5%) for the stabilization of the bone fragments. For a 46-year-old patient who presents with comminuted fractures of the right malar bone, a victim of human aggression, osteosynthesis plates were placed, evaluated for the correct location, and fixed to the bone (Figure 1). The surgical approach was mixed (bi-coronary and endo-oral).

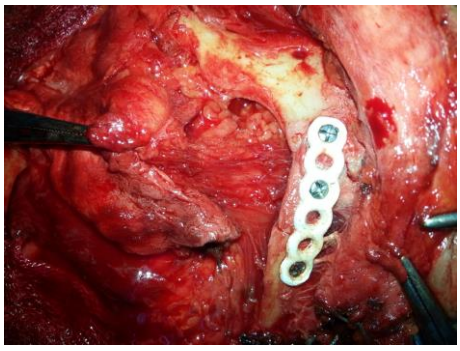

Figure 1. Application of polyetheretherketone plates

Due to the elasticity of the polyetheretherketone osteosynthesis plate, it does not need to be shaped. The plate achieves an effective containment of the fractured fragments (Figure 2).

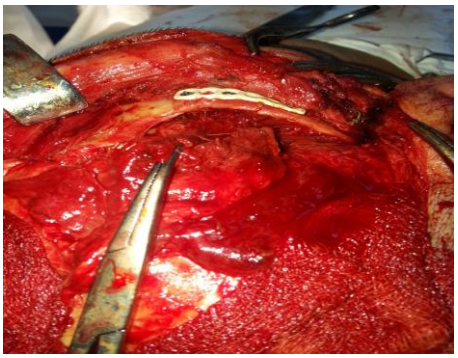

Figure 2. The elasticity of the polyetheretherketone plates

In this case, we decided to use titanium plates and polyetheretherketone plates to compare the results (Figure 3).

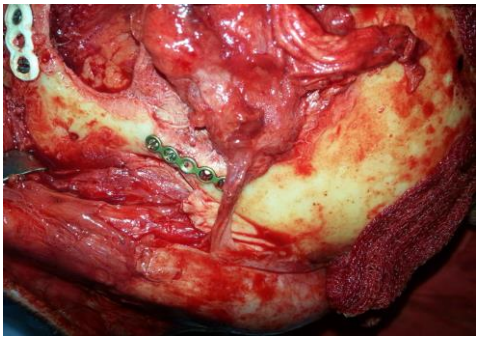

Figure 3. Titanium and polyetheretherketone plates

The locations of the implants were designed to be fitted on the free edges of the fractured bone. The final thickness of the polyetheretherketone plates was reduced after finishing and polishing. The size of the titanium plates was not changed.

Mandibular and maxillary fractures are frequently encountered by the OMF surgeons. Accurate anatomical bone reduction cannot be guaranteed although a lot of techniques and prosthetic devices have been reported for the treatment of fractures. Open reduction internal fixation is the method to obtain almost perfect anatomical reduction, especially in fractures with severely displaced bone segments. In our study we used custom-made polyetheretherketone and titanium miniplates for osteosynthesis to determinate the differences between those materials.

We experienced better results with polyetheretherketone miniplates both because it allows a better customization on the surface of the anatomical defect and because of the better visibility of the fracture edges. It's been beneficially applied as an implant material in various medical fields since the 1990s thanks to its high stability, good biocompatibility, low density, insolubility, excellent fatigue properties, high toughness, corrosion and aging resistance, ease of processing, and color stability [8].

The time spent intraoperatively to fix the bone fracture with the two different types of osteosynthesis plates does not show significant differences, although the polyetheretherketone custom-made implants were by far easier to integrate.

In our study, patients treated with custom-made polyetheretherketone plates did not encounter different local complications than the other group where we used titanium plates.

Polyetheretherketone plates were studied for orthopedic surgery, but there are few studies from facial trauma surgery. Thanks to its bone-like elasticity, polyetheretherketone may be a viable different material. Due to its high flexibility polyetheretherketone decreases stresses at the bone–screw interface. There are studies comparing titanium and PEEK plates that lead to the hypothesis that the elasticity of PEEK fixation may decrease the risk of screw pullout/push [9].

4. Conclusions

Cases treated with the osteosynthesis technique (mini plates and screws) had a favorable evolution, without local complications. Following the surgical intervention, patients were able to resume their daily activities after a short period of hospitalization, without affecting speech, physical appearance, and a normal, non-restrictive diet, thus producing a rapid psycho-social recovery.

Late complications, such as delayed consolidations, pseudarthrosis, mandibular constrictions, occlusion disorders, or vicious consolidations, were not observed in the treated cases. The advantages of polyetheretherketone plates are the wide possibility of customization depending on the patient, as well as the elasticity comparable to human bone. The titanium alloys used to manufacture the mini plates and screws are biocompatible, easily accepted by the human body, and also compatible with MRI investigations or metal detectors in airports.

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