Reconstruction of Frontal Bone Using Specific Implant Polyether-Ether-Ketone

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Abstract: Defects on the craniofacial complex may result in aesthetic defects, functional damage, and psychologic consequences. Previously, surgeons showed no interest in reconstructing the operated area, but in the treatment of the problem, leaving bone contour is a secondary issue. Nowadays, area reconstruction with post-reestablishment of contour and local shape has become one of the surgeon’s priorities.

The use of alloplastic implants with specific digital design has been stated to be an effective technique on the treatment of craniofacial defects, reducing the need for manipulation in the intraoperative period and decreasing surgery time. Polyether ether ketone (PEEK) is a potential candidate because it is a linear polyaromatic semicrystalline polymer that combines strength, stiffness, durability, and resistance. Polyether ether ketone biocompatibility has been supported in literature, and subsequent medical applications of the material have been observed.

The aim of this study was to describe a case of frontal bone defect reconstruction in which the PEEK was used as polymer material in a specific implant for the Synthes (PEEK-PSI) patient.

Key Words: Frontal bone, Specific implant, Trauma

(CLINICAL STUDY

D)efects on the craniofacial complex may result in aesthetic defects, functional damage and psychologic consequences.1 Previously surgeons showed no interest in reconstructing the operated area, but in the treatment of the problem, leaving bone contour as a secondary issue. Nowadays area reconstruction with post-reestablishment of contour and local shape has become one of the surgeon’s priorities.2 Formerly, several materials such as silver and gold were used for the reconstruction of cranial bones.3 More recently, materials such as autogenous bone graft, metal and non metal bone substitutes have been reported in the reconstruction of craniofacial bone defects.1-3 However, craniofacial reconstruction techniques might present unexpected issues related to aesthetics and biocompatibility as a result of problems associated with chemical and mechanical properties as well as difficulties in manipulation and molding of prosthesis in the intraoperative period.1

The use of alloplastic implants with specific digital design have been stated to be an effective technique on the treatment of craniofacial defects, reducing the need for manipulation in the intraoperative period and decreasing surgery time.1 Polyether ether ketone (PEEK) is a potential candidate due to the fact that it is a linear polyaromatic semicrystalline polymer which combines strength, stiffness, durability, and resistance.3 PEEK biocompatibility has been supported in literature, and subsequent medical applications of the material have been observed.1-3

The aim of this study is to describe a case of frontal bone defect reconstruction in which the PEEK was used as polymer material in a specific implant for the PEEK-PSI (Synthes, Jacksonville, FL) patient.

CLINICAL REPORT

A male patient, 47 years old, victim of assault, diagnosed with traumatic brain injury with comminuted fracture of frontal bone and meninges exposure, was initially seen by the neurosurgical team who performed a frontal sinus cranialization treatment.

Two years after the first intervention, the patient sought help from the oral and maxillofacial traumatology and surgery team with an aesthetic complaint involving the upper third of the face. At the extrabuccal physical test, a facial asymmetry was observed due to depression on the frontal bone area (Figs. 1A, B). The patient did not present pain or functional complaints. Imaging tests (computed tomography [CT] scans) showed the absence of the entire anterior wall region of the frontal sinus and part of the bilateral supraorbital margin (Figs. 1C, D) explaining the apparent aesthetic defect. The making of PEEK-PSI was suggested as treatment to restore the volume and anatomic contour of the area.

The patient underwent surgery with general anesthesia. The access chosen was coronal with subperiosteal dislocation until the exposure of the entire fractured area (Figs. 2A, B), which presented a difficult dislocation healing process, expected by the team. The PEEK part was tested (Fig. 2C), and it adapted to the bone defect margins, restoring the local anatomic contour. The part was then fixed in previously studied areas in the implant as well as in the bone structure (Fig. 2D) with titanium plates and screws of the 1.3-mm system from Synthes (4 plates with 6 holes each in double “Y”). After tissue repositioning and suturing, the aesthetic contour was immediately restored.

The patient remains in postoperative monitoring, and there are no signals of infection in the PEEK-PSI. Eighteen months after the surgical intervention, it is possible to notice the maintenance of

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anatomic contour and aesthetics of the area (Figs. 3A, B). Also, CT scan showed the adaptation of the piece in bone structures (Figs. 3C, D).

Processing Method of PEEK-PSI

Preoperative digitalized three-dimensional tomography was obtained from axial and coronal images with the following parameters: 512 × 512-pixel matrix, 1.0-mm cut thickness, 1.0-mm rotation, 1.0-mm reconstructed increment slice, high resolution, 0-degree inclination. Images were sent to manufacturer (Synthes Maxillofacial). The software was used to convert and manipulate CT data to create a skull model and an anatomically correct implant using a fast prototyping machine. Skull and implant models were sent to the surgeon for revision and approval. After approval, the manufacturer sent definitive nonsterile models, which were then sterilized in autoclave before its use in hospital.

DISCUSSION

The incidence of fractures on the frontal bone ranges from 2% to 15% in relation to all other facial bone fractures. Because of such low incidence, treatment for this type of fracture is still a controversial issue.5 Therefore, the surgeon must know the physiology and anatomy related to the bone and frontal sinus for adequate diagnosis, classification, and treatment.6

The objective of surgical treatments of frontal bone fractures is, besides preventing infection of intracranial components, to restore the front anatomic contour.6 Reconstruction of anatomy, aesthetics, and skull functional contour, especially in severe defects or those involving the front-orbital region, is still a difficult and challenging procedure for craniofacial surgeons.1 Numerous types of autogenous and alloplastic materials can be used in the maxillofacial reconstruction. The most common ones are autogenous bone grafts, tissue free grafts, methyl methacrylate, different types of bone cements, and porous polyethylene.5 However, such different types of materials present significant disadvantages. Autogenous bone and tissue free grafts show local resorption and morbidity of the donor area.3,5 Porous polyethylene and methyl methacrylate may cause foreign body reaction, increasing the risks of rejection and infection.3,5 Bone cements are difficult to handle because of their need for preparation and sculpture during surgery, increasing surgery time, and may present poor aesthetic results.5

Alloplastic implants with digital design have revolutionized the concept of complex cranioplasty and have become a reliable alternative.7 These premanufactured biomaterials obtained from CT scans are increasingly filling craniofacial surgeons with enthusiasm.3 Literature reports on the use of PEEK-PSI in the reconstruction of maxillofacial defects are limited.5 Nevertheless, recent studies report the successful use of this material in the craniofacial area.1,3,5 Polyether ether ketone is an aromatic polymer in ether and ketone linkages, resistant to high temperatures and radiation, besides presenting strength, stiffness, durability, and natural resistance.8 For these reasons, PEEK has been used in aircrafts, automobiles, and in the electrical industry for more than 20 years.3,5,8,9

Recent studies have demonstrated that PEEK shows biocompatibility and is indicated for fracture fixation and osteotomies, as well as in the reconstruction of maxillofacial bone defects.3,5,8,10 Because of the fact that the PEEK polymer maintains structural stability at temperatures greater than 300°C,9 pieces made of this material can be sterilized in moist or dry heat without dimensional alterations, which makes it easier to handle.

Other inherent features of PEEK-PSI favor its use in maxillofacial reconstructions. Such features are strength and stiffness similar to the cortical bone, which provides higher stability and anatomic adaptation, especially in areas where there has been resection of tumor lesions. It also presents radiolucency, thus decreasing artifact production in imaging scans, and can be produced in a single or multiple pieces with conventional fixation, and PEEK-PSI may be subject to changes made with tools, which are commonly
used by surgeons, providing greater reliability in handling and re-
duction of surgery time. 9

To conclude, the use of PEEK-PSI was successful and showed
good aesthetic and functional results. Its use is a safe alternative for
the reconstruction of craniofacial bone defects.

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