Cranial Reconstruction: Cosmetic and Function with use of PEEK and Collagen Matrix, Case Report

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Abstract

The reconstruction of the cranial vault represents a challenge for the surgical team when facing a patient with extensive bone defect. In recent years, computer designed techniques based on tomographic data makes it possible to manufacture alloplastic implants preoperatively. This allows us to perform a cranioplasty in less time, and provides excellent cosmetic results. We present a case of a 19-year old man that had a successful left fronto-parietal-temporal reconstruction using a prefabricated Polyetheretherketone (PEEK) implant and collagen matrix graft.

Keywords: PEEK; Prostheses and implants; Reconstructive surgical procedures; Collagen matrix

Introduction

The reconstruction of the cranial vault represents a challenge for the surgical team that is faced with a case of extensive bone loss. The choice of material is complicated by the multiple options available and the different characteristics of each. The size of the defect, history of infection, the age of the patient and other factors that influence the decision of the reconstruction method should be taken into account. In recent years, the application of computer designed techniques based on tomographic images makes it possible to manufacture alloplastic implants preoperatively, which allows surgery to be performed in less time, reduces the need for trans-operative adjustments and offers excellent cosmetic results. Polyether Ether Ketone polymer (PEEK) has characteristics that make it safe and very close to the ideal implant when used in patients who have completed the stage of skull growth.

Traditional methods of repairing the dura after incidental durotomy involve tedious attempts at primary hermetic suture with a failure rate of 5% to 10%. The dura mater lesion occurs after trauma or may be a secondary excision due to tumor resection [1]. In some cases, it is necessary to place a dura mater substitute, which is a graft composed of pure type 1 collagen, extracted from the Achilles tendons of cattle. This collagen matrix provides a scaffold for the invasion of host fibroblasts, promotes fibrin clot, and is completely reabsorbed as the wound heals [2].

In this article, we report the case of a reconstruction of the left fronto-parieto-temporal region with a prefabricated Polyether Ether Ketone (PEEK) implant and dura mater replacement.

Case Presentation

A 19-year-old man with a history of blunt facial skull trauma, due to direct aggression, received surgical treatment in a different hospital with a decompressed craniotomy for subdural hematoma and one month later cranioplasty with titanium mesh in the left fronto-parieto-temporal region. A year later, he came to our team for evaluation for presenting a cranial vault deformity and exposure of the titanium mesh. The asymmetry is evident on physical examination due to depression in the left hemicranium (Figure 1). Three-dimensional computed tomography is performed where the deformity of the titanium mesh fracture is corroborated (Figure 2). The proposed management was the removal of the fractured and deformed mesh and reconstruction with a prefabricated polyether ketone implant (PEEK-OPTIMA™ LT (Synthes –CH 4436 Oberdorf, Switzerland). Prior surgical authorization by informed consent, the tomographic data was sent to the supplier for the manufacture of the prosthesis with a specific computerized design for the characteristics of the skull.
When we receive the sterile alloplastic material, the surgical intervention is performed under general anesthesia, tracking through the previous craniotomy incisions and dissecting temporal parieto flap to expose the totality of the titanium mesh. Once the screws that fixed the mesh on the periphery were removed, a careful dissection was performed to separate it from the dura, which in some areas was very thin or non-existent (Figure 3). Hard bovine collagen matrix compound (DuraGen®) covered the entire defect and then we placed the prefabricated PEEK implant which showed a slight millimetric discrepancy to the defect, so we needed to remodel the implant with high speed milling drill reducing 1 mm of the upper and anterior edge. Once the perfect fit was achieved, the fixation was made with 2.0 titanium plates and self-drilling 5 mm 2.0 screws (Figure 4). The prosthesis is partially covered with pericranial flap and finally with the previously dissected fasciocutaneous flap. A suction drain of 1/8 inch was placed which was then removed on the 4th day; as well this tomographic control was performed in the immediate postoperative period evidencing proper placement of the prosthesis (Figure 5).

In the postoperative period, the patient presented with transient bradylalia, which yielded after 10 days. At six months after surgery, the patient has a satisfactory clinical evolution and excellent aesthetic result, having recovered the proper contour of the cranial vault (Figure 6).

**Discussion**

The existence of large cranial defects with a total thickness represents a challenge for the surgeon because of its complexity. Factors such as previous surgeries, local infection and osteonecrosis should be taken into account to select the best method of reconstruction [3].

Different techniques and materials have been used in cranial reconstruction. The choice of material to be implanted is controversial, and will depend on the size of the defect and the conditions of the receiving area [4].

Advances in tissue engineering and computer-assisted techniques...
offer a promising future for anatomical reconstruction with autologous bone. However in the same way, since the last century there has been many methods and materials tried to find the ideal bone substitute. The most commonly used alloplastic materials in cranioplasties include titanium meshes, ceramics, methyl methacrylate, porous polyethylene (Medpor), hydroxyapatite cements, and HTR-PMI (polymethylmethacrilate - polyhydroxyethyl - calcium hydroxide coated) [5]. Each material has its advantages as well as disadvantages and the search for the ideal substitute continues. Since 1998, PEEK (Polyether Ether Ketone) polymer has been available for medical use, which belongs to a family of linear aromatic polymers called polyarylether ketones, and which has been used successfully in the aerospace, electrical and automotive industry for more than 20 years [6,7].

Polyether ether ketone implants have physical characteristics that make them superior when compared to other materials. They are resistant to heat and ionizing radiation, which allows them to be sterilized multiple times with steam or gamma rays. Its inert nature prevents chemical reactions and therefore the release of cytotoxic substances, also they are not allergic. The degree of elasticity can be adjusted to match the adjacent bone by adding carbon fibers to its structure. They are radiolucent and non-magnetic, so they do not produce artifacts in the tomography or magnetic resonance imaging, facilitating postoperative monitoring [7].

In recent years, the use of prefabricated alloplastic implants based on preoperative computed tomography images has gained popularity, mainly in the reconstruction of relatively large cranial defects. The advantages of these computer-designed implants include reduced operative time; reduced need for trans-operative adjustments, perfect anatomical adjustment to the recipient site and excellent aesthetic results [7,8]. Another benefit is resistance, restitution of the reconstructed skull contour and the restoration of symmetry, a very noticeable situation when the defect is located in the frontal region [9].

Three requirements of critical importance are a bed with adequate vascularity, a stable and sufficient skin cover, and no local infection [9].

On this occasion, in the case of the 19-year-old boy who underwent reconstruction of the left fronto-parieto-temporal region with a PEEK implant designed and manufactured by computer preoperatively based on tomographic studies is presented. We attribute the slight discrepancy of the implant-defect to bone growth that may have occurred in the periphery from the time the tomographic study was performed until the time of surgery (2 months). Therefore, a recommendation would be that the imaging study, from which the data to manufacture the prosthesis is extracted, is carried out as close as possible to the moment planned for the operation. Implant remodeling was performed without major setbacks and did not take more than 5 minutes. Other authors have also reported the remodeling of PEEK implants without problems or significant increase in operative time [7]. On the other hand, due to the defects that were found when removing the previous plaque, it was also necessary to place a hard substitute, with a collagen matrix that helps us provide a scaffold for fibroblast invasion, promote fibrin clot, and is completely reabsorbed as the wound heals [2]. The interaction between the dura substitute and the PEEK implant was excellent, finding no seromas or infections of the reconstructed area in the reported patient.

There is a slight subsidence in the left temporal region due to muscular atrophy; we plan to remodel this in the future with fatty grafts. We consider that the reconstruction method chosen in the case of our patient allowed us to achieve the objectives of providing an adequate protective cover for intracranial structures in addition to excellent cosmetic results, using a safe material and reducing the operative time compared to techniques that require grafting or modify the reconstruction material considerably.

References