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Case Report

Surgical treatment of frontal sinus fracture sequelae with methyl methacrylate prosthesis

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Abstract: Inappropriate treatment of fractures of the frontal sinus can lead to serious complications. These fractures are often associated with soft tissue injuries and loss of bony structures. This case report shows the use of methyl methacrylate frontal prosthesis to treat a sequel of frontal sinus fracture; surgical options are discusses and one-year follow-up is present to show stability and good cosmetic result.

Keywords: Frontal sinus, frontal fracture, sequel fracture

Introduction

The frontal sinus occupies the junction between the splanchnocranium and the neurocranium, placed between the anterior cranial fossa and the naso-orbito-ethmoid region. Inappropriate treatment of fractures of the frontal sinus can lead to serious complications, principally septic even many years after the accident [1]; other complications are related to recurrent sinusitis, osteomyelitis of the frontal bone, mucocele or mucopyocele, meningitis, encephalitis, brain abscess or thrombosis of the cavernous sinus and may have fatal consequences [2-7].

The incidence of frontal sinus fractures is estimated between 6 and 12% of all craniofacial fractures [3, 6]. However, severe comminuted fractures with involvement of both anterior and posterior walls of the frontal sinus occur in only 0.7-2.1% in cases of craniocerebral trauma [2]. The frontal sinus fracture rapidly assumes a prominent position in the management algorithm of craniofacial trauma, because of the complications of delayed or improper management: persistent cerebrospinal fluid (CSF) leak, mucocele/mucopyocele, encephalitis or brain abscess [8].

It is obvious frontal fractures are associated with high kinetic energy. Thus, they are often associated with soft tissue injuries and loss of bony structures that can lead to severe post-traumatic deformities. Because they are often accompanied by complex trauma to other areas like the brain and body that threaten the life of the patient, the treatment of the facial injuries is often delayed. If treatment is not carried out soon after the injury, facial bone fractures often malunion, soft tissues shrink and contract, and scarring occurs, all of which makes delayed treatment very difficult. Although frontal fracture treatment has evolved greatly since the introduction of computed tomography (CT) for diagnosis, craniofacial techniques, and rigid fixation for treatment, delayed frontal fracture treatment is still one of the most challenging issues for maxillofacial surgeons. The goal of treatment, as with all facial fractures, is to restore both the function and pre injury 3-dimensional (3D) facial contours [9].

Craniofacial skeletal defects remain a significant clinical challenge for the facial reconstructive surgeon. Current approaches use various techniques of autologous tissue grafts and alloplastic implants to augment and replace

Figure 1. Frontal defect related to frontal sinus fracture treated previously.

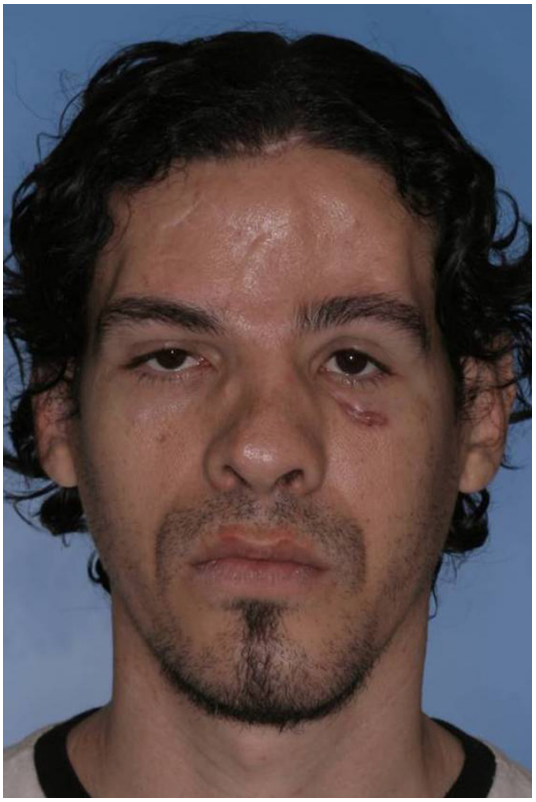

Figure 2. The patient present length inter canthal distance, fistulae in the left inferior rim and mal position of nasal fracture reduction.

deficient sites [10]. The main limitations in the use of autologous grafts have been donor site limits and morbidity and volume maintenance over time. Alloplastic implants have been used to preclude donor site morbidty, shorten operative times, and ensure a predictable volume replacement over time. Yet, alloplastic implants to date have been susceptible to rejection from infectious seeding and chronic inflammation from mobility [11].

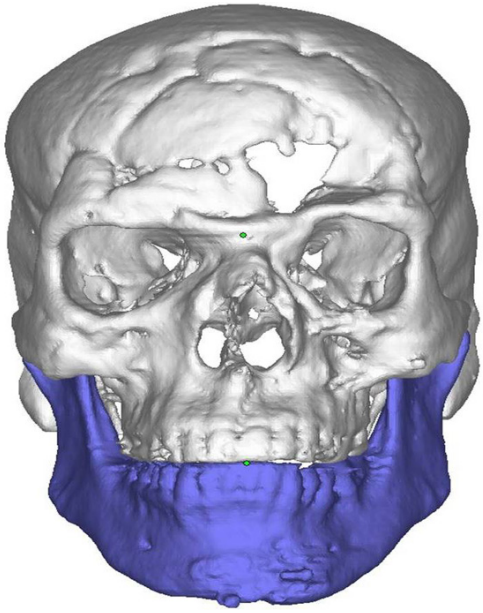

Figure 3. TC reconstruction showing the anterior and posterior frontal wall destruction, nasal bone defect and left orbital defect.

Calcium phosphate and hydroxyapatite cement have been used for bone replacement. The advantage of this system in craniofacial reconstruction is the ability to accurately contour and shape complex skull structure. In addition, since bone mineral is formed under physiologic conditions, it enhances the ability for implant osseointegration [12].

Full-thickness calvarial vault defects may be repaired with autologous bone or alloplastic materials, such as methyl methacrylate, hydroxyapatite, titanium, or porous polyethylene [13-16]. Partial thickness defects or skull surface contour irregularities are particularly well suited to methyl methacrylate reconstruction because the inner bone is present and the dura mater is not exposed to the exothermic polymerization reaction. Second, monomeric methyl methacrylate is liquid so that it easily fills shallow defects. Third, once polymerized, methyl methacrylate can be contoured and tapered to match the surrounding native bone [17].

Despite its many advantages, methyl methacrylate has smooth surface characteristics that prevent tissue ingrowth and adhesion [18-20]. The aim of this case report is show the surgical treatment to correct frontal and NOE fracture sequels.

Figure 4. Biomodel showing the same situation of TC reconstruction. This model was used to construct the frontal prosthesis.

Figure 5. Frontal prosthesis installed in the frontal area with titanium plate in the lateral area; the prosthesis was perforated in different point to prevent complications related to fluid into de prosthesis.

Case report

Patient M. A. S., 25 years old, masculine, was victim of motorcycle accident with average trauma in superior, medium and inferior thirds of face. The patient was treated previously and eleven months after first surgery was evaluated at Division of Oral and Maxillofacial Surgery, Piracicaba Dental School. The initial diagnostic was frontal, LeFort II, Naso-orbito-ethmoidal and mandibular fractures treated with severe frontal deformity (**Figure 1**), increase of the

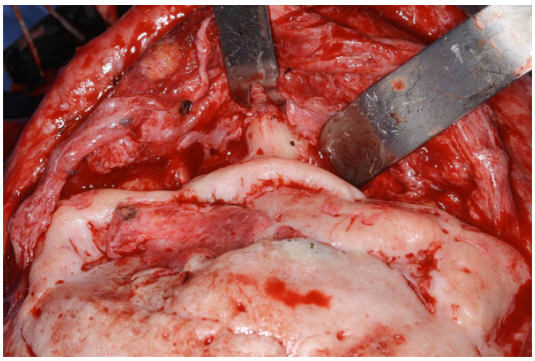

Figure 6. Coronal approach showing the bone consolidation and the expose of dura mater.

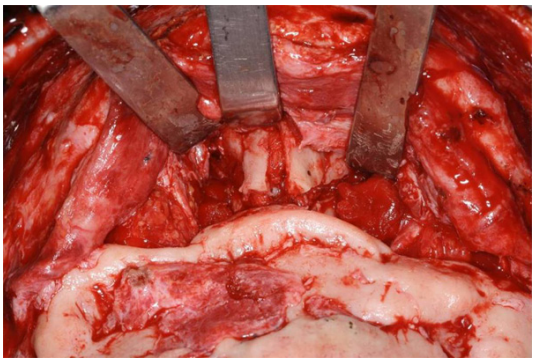

Figure 7. Osteotomies in the NOE area to modify the mal position of nasal bone.

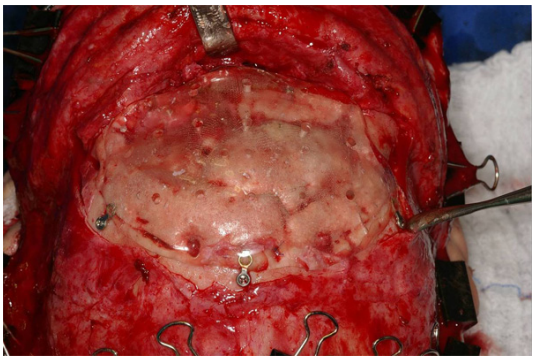

Figure 8. Frontal prosthesis in position with 5 mm screw for fixation.

intercanthal distance and deviation and asymmetry of nose. In left infra-orbital region and mandible was observed fistulae probably associated with internal rigid fixation failure used in the first procedure (**Figure 2**). It denied reduction of the visual accuracy and dyplopia. To the physical examination it had step in the infra-orbital rim, step into zygomatic-maxillary area, deformity in frontal region. The tomographic images demonstrated the facials fractures sequels (**Figure 3**).

The treatment plan included confection of prototype (**Figure 4**) to reproduces every facial defect and analyses of surgical treatment. NOE osteotomies was performed and a frontal prosthesis of methyl methacrylate was choose to correct the frontal deformities (**Figure 5**); the prosthesis was associated with titanium plates for the fixation during the surgical procedure.

Under general anesthesia, coronal, subtarsal and intra-oral approaches were performed for access the frontal and NOE regions and zygomatic area. The coronal approach was very careful realized because the defect in left part of anterior wall of anterior fossa cranium, which expose of dura mater (**Figure 6**). Every materials used in first procedure were removed after approaches.

Due to bone consolidation, they had been necessary osteotomies for NOE repositioning, including the nasal process of frontal (**Figure 7**), laterals walls of nasal cavity, and nasal septum. After these osteotomies, was necessary realize bilateral canthopexy. Consequently, the frontal prosthesis was installed and fixed with titanium screws 2.0 mm system (**Figure 8**). This prosthesis was perforated in various regions, to minimize risks of increase of intracranial pression by fluid into the prosthesis. The nasal bone was not fixed and an external dispositive was installed associated to anterior nasal gauze.

Immediate postoperative complications were not observed. One year follow up, the cosmetic and functional result are satisfactory (**Figure 9**).

Discussion

Frontal sinus and frontofacial skeletal reconstruction remains challenging because of the significant aesthetic and functional consequences of such defects. Defects are commonly encountered as a result of traumatic injury, elective neurologic-transfacial surgical approaches, and correction of congenital deformities. Most surgeons prefer autogenous bone mainly from split cranial bone to alloplastic material. For most of them it is a truly stable permanent bone, with no potential problems for the future. Autologous bone remains the standard for comparison of alloplastic techniques [20, 21]. Autologous graft, when successful, provides for excellent outcomes; however this technique is related to donor site limits and complications, the need for fixation hardware, and difficulties in contouring [17]. Due the large frontal defect the amount of autologous bone graft will be so much. So, the first option was used the pre-fabricated prosthesis.

Demineralized allograft bone showed an option [22] however does have the risk of immunological reactions and it is not being widely used [23]. Others authors prefer an alloplastic reconstruction for cranioplasty in some situation [24]. Furthermore, the ideal alloplastic material is inert or biocompatible, cheap, easily available, easy to use, stable long term, low risk of infection yet is easy to remove at any stage if removal is indicated. Methyl methacrylate has enjoyed considerable popularity as an alloplast for cranial defects. In a study of a similar population of anterior frontal-cranial defects, found that acrylic, although useful, had a 50% infection rate when in contact with the paranasal sinus mucosa.

Recently, more biocompatible alloplastic alternatives have been proposed, in particular hydroxyapatite cement [24]. However, some authors reported a worrying problem with hydroxyapatite, which was frequently due to particulation, with an inflammatory immunological reaction occurring some months at least after implantation and resulting in extrusion of the material or requiring its removal. Methyl metacrylate should still be considered as a good option when autogenous bone is not available. Unlike others alloplastic, methylmethacrylate possesses good tension and compression stress resistance, is very cheap [25] and easy to contour, does not undergo resorption, and will not interfere with computed tomography

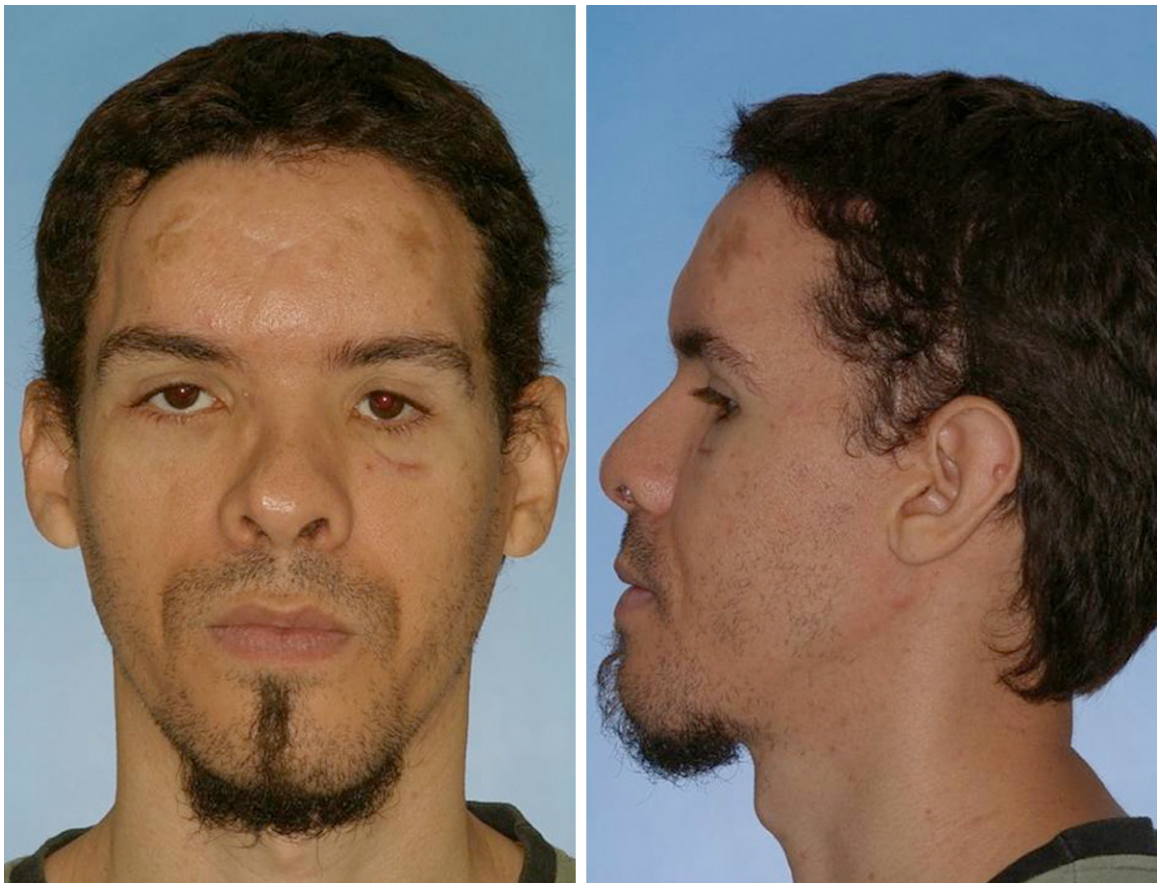

Figure 9. One-year follow-up showing stability of prosthesis. The patient present good position of nasal bone with symmetry of the area and the left canthal area still maintains the increased distance; the lateral view showing adequately formation of frontal area.

(CT) or magnetic resonance imaging (MRI) [20]. Because of that features we choice the methyl methacrylate to recontour the frontal region on the present case.

Despite its favorable characteristics, methyl methacrylate has a higher infection rate than autologous bone. Methyl methacrylate cannot be used when a paranasal sinus or the nasal cavity is exposed in the surgical field [20]. The patient in this instance presented sinking of every anterior frontal wall, without sinus exposition.

While autologous bone and a variety of alloplastic materials may be used for full-thickness calvarial defects, methyl methacrylate is particularly useful for partial thickness defects or skull surface contour deformities. Since the dura mater is not exposed to the exothermic polymerization reaction, the monomeric methyl methacrylate is safe and easy to manipulate.

In non-reinforcing techniques, such as a mortice and tenon configuration in the native bony perimeter have been designed to improve the tensile strength of methyl methacrylate constructs, these techniques do not improve the fracture properties [26]. In presented case, the increase in width provides enough resistance to the prosthesis.

Various techniques were used to fixes the prosthesis of methyl methacrylate how wires, plates, and mesh. Someone authors prefer wires, because are significantly less expensive than plates or mesh. We used plates and screws and the results were satisfactory, no resulting in unaesthetic appearance.

Recent studies on cranioplasty have described the use of pre-fabricated PMMA implants for full-thickness calvarial defects [27]. These custom PMMA designs reduce operative time as well as eliminating the intra-operative polymer-

ization process that may cause thermal injury to the dura. In contrast to inlay cranioplasty, however, a prefabricated prosthesis construct for onlay use is not cost-effective.

Prosthesis of methylmethacrylate is one of alloplastic materials of choice to repair thickness calvarial defects and surface contour deformities in adults. The technique is simple, rapid, safe, effective, and cost-efficient.

Disclosure of conflict of interest

The authors declare that they have no competing financial interests.

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