Cranioplasty with PMMA Alloplastic Implant using Custom Made Compression Clamp and Flask – An Innovative Approach

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ABSTRACT

Introduction: The primary aim of rehabilitation of the maxillofacial defects is the restoration of the form and function in order to meet the functional and esthetic demands of the patient. The etiology of these defects remain the same namely trauma, secondary to tumour resection, infections or congenital. Maxillofacial defects may be present in the form of ocular, auricular, nasal or cranial defects. Rehabilitation of all these defects is mainly in the form of restoration of appearance and esthetics. The functional rehabilitation is possible only in residual cranial defects wherein the prosthetic implant results in the protection of the underlying structures with maintenance of intracranial pressure along with the restoration of the calvarial contours.

Case report: A young serving soldier was brought to our institute by his relatives with a chief complaint of fractured skull bone. He was a case of EDH (extradural hematoma) for which he was operated at a civil hospital. Decompressive craniectomy was done which resulted in a residual cranial defect of approx 04x05 inches in the fronto-temporo-parietal region. Due to large size of the defect, the case was planned to be taken up for reconstruction of the defect with PMMA alloplastic implant using custom made compression clamp and flask.

Conclusion: There are a wide variety of techniques and materials available for reconstruction of calvarial defects. Due to high cost of these treatment options, they seem less suitable for simple defects. However, with improved simplicity, cost-effectiveness and advantages of PMMA over other alloplastic materials, it remains the material of choice for such reconstructions.

Keywords: Residual Calvarial Defect, PMMA Prosthesis, Cranioplasty, Custom Made Compression Clamp and Flask

INTRODUCTION

Large defects of the cranium result from decompression craniectomies following trauma, ablative tumour resections and bone flap infections. These patients may suffer from a wide spectrum of symptoms varying from headaches to seizures. All these clinical aspects cannot be taken care of by cranioplasty alone.[1] However, the symptoms that can be reliably improved by cranioplasty are protection of the cerebrum and improved cosmetic appearance.[2] The goal of a cranioplasty procedure is to achieve a lifelong, stable, structural reconstruction of the cranium covered by a healthy skin and scalp flap. A wide range of techniques and materials have been advocated in literature. Cranioplasty is carried out to achieve morphological and functional rehabilitation of the cranial vault affected with a severe bony defect resulting from trauma, infection, tumour or cerebral decompression procedure.[3] Whatever the cause, one of the main indications for cranioplasty is the treatment for the so-called ''syndrome of the trephined'' which is characterized by headache, dizziness, irritability, loss of concentration, depression, anxiety, intolerance to noise and vibration. This syndrome is the result of the direct effect of atmospheric pressure onto the scalp and dura which causes closure of the subarachnoid space and reduces the perfusion pressure of the brain; contra-lateral hemiparesis, hemispheric collapse and epilepsy may even occur.[4]

Other relevant indications for cranioplasty are protection, aesthetic reconstruction, epilepsy, neurological disorders and changes in cerebrospinal fluid (CSF) dynamics.[5] Where there has been a morpho-functional alteration with a defect in the cranium, cranioplasty can improve cerebral blood flow and neurological deficits. Maxillofacial prosthetic devices serve an essential role in restoring the physical and psychological well being of patients with missing or disfigured anatomical structures due to trauma, congenital abnormalities or disease such as cancer. The primary role of the prosthetic rehabilitation is to help patients improve their quality of life and restore their self esteem.

Alloplastic materials have the advantage of no donor site morbidity and an abundant supply. For these reasons alloplasts have been popular in the uncomplicated primary cranioplasty. The condition of the recipient bed is an important consideration in cranioplasty. Variables such as previous infection, inadequate soft tissue coverage, and a communicating paranasal sinus are all potentially detrimental to cranioplasty. A dead space can arise in the late restoration of a collapsed cranial vault.

CASE REPORT

A 32 yrs old serving soldier was referred to our institute from Ahmedabad for the management of residual calvarial defect in the left fronto-temporo-parietal region. History revealed the patient had sustained a severe head injury

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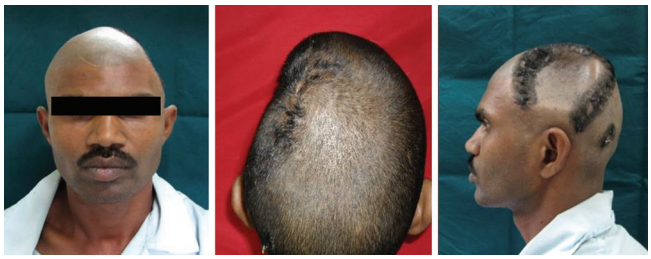

Figure-1: (a) Pretreatment (Frontal view); (b) Pretreatment (Posterior view); (c) Pretreatment (Profile view depicting ovoid shape of the defect approx 4x5 inches)

Figure-2: (a) Custom made compression clamp; (b) Custom made flask

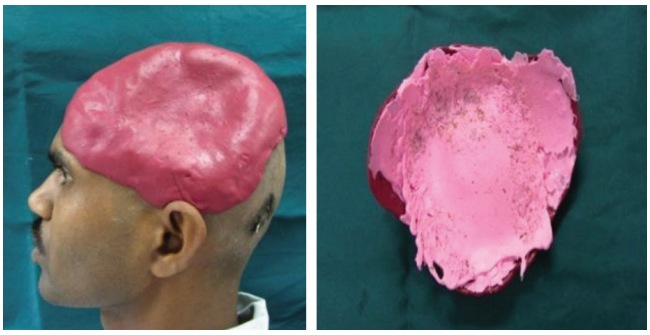

Figure-3: (a) Custom tray with impression compound; (b) Impression with polyvinylsiloxane impression material

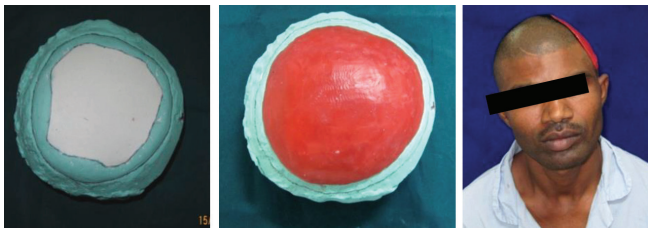

Figure-4: (a) Defect area blocked out with plaster; (b) Wax pattern using molten wax technique; (c) Wax pattern trial

with extradural hematoma and underwent a neurosurgical procedure with craniectomy of the fronto-temporo-parietal region. On systemic examination, the patient was conscious and well oriented in time, space and person. The pupils were bilaterally normal and reactive. There was no neurological deficit. The cardiovascular system and respiration were within normal limits. Local examination revealed a large calvarial defect on the left fronto-temporo-parietal region

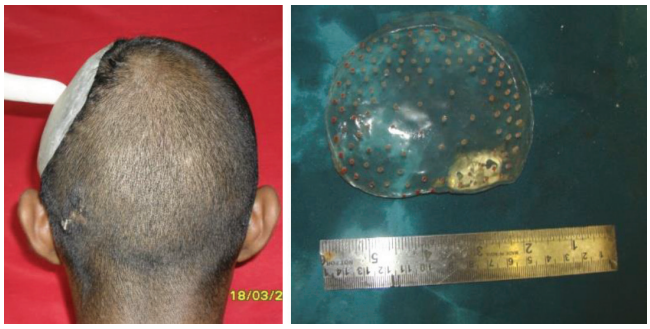

Figure-5: (a) PMMA prosthesis trial; (b) PMMA prosthesis with perforations

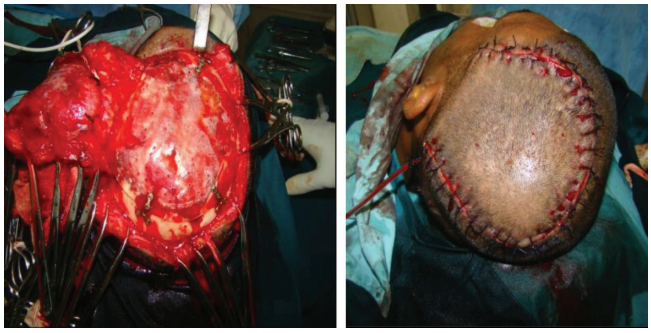

Figure-6: (a) Prosthesis fixation with Ti miniplates and screws; (b) Surgical site sutured in layers

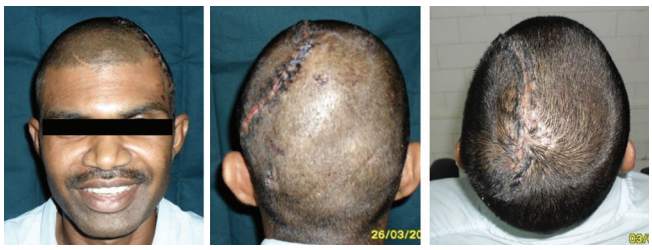

Figure-7: (a) Post-operative (Frontal view showing restored calvarial contour); (b) Post-operative (Posterior view); (c) Post-operative (Superior view showing healthy suture line)

with no associated neurologic deficit (Fig 1a). The defect was roughly ovoid in shape with a size of 4'x5' in maximum dimension (Fig 1b, 1c).

Management

The case was planned to be taken up for rehabilitation of the residual cranial defect by cranioplasty and reconstruction with an alloplastic implant made of high strength PMMA (Polymethylmethacrylate) under GA utilising a multidisciplinary team approach comprising of Prosthodontist along with Oral and Craniomaxillofacial Surgeon. The management consisted of 2 phases: Prosthetic and Surgical phase.

Prosthetic phase: Fabrication procedure for the PMMA cranial prosthesis with custom made compression clamp and flask

(a) Fabrication of custom made compression clamp and flask

As the defect was extensively large to be restored using autogenous graft or titanium mesh, it was planned to be reconstructed with high strength polymethylmethacrylate

(PMMA) cranial prosthesis. A specialized custom made compression clamp and flask were designed and fabricated to accommodate the size of the large cranial plate. [Figure 2a, 2b). The flask was square in shape with self interlocking device for complete closure and ease of deflasking. The height of the clamp was about two and half feet and size of the flask was 10x 10 inches. They were made of wrought iron and weighs about 10kg.

(b) Fabrication of PMMA cranial prosthesis

A custom tray was fabricated using medium fusing impression compound. The perforations were made for retention [Figure 3a]. The impression was made with polyvinyl siloxane impression material [Figure 3b]. Margins of the defect are then palpated, traced with an indelible pencil, and transferred in the impression. The model was poured with type 3 dental stone. The defect area was blocked out using dental plaster [Figure 4a]. The wax pattern was made using molten modelling wax [Figure 4b]. It was then polished and tried onto the patient's cranial defect area [Figure 4c]. The modifications in the contour were done using the contralateral side as the guide. The wax pattern was then invested in the flask using dental stone. Dewaxing was carried out. The PMMA polymer and monomer were mixed in the ratio of 3:1 and packed in the dough stage. The flash was removed. The flask was then closed and compressed in the clamp under pressure. Bench curing was done. The acrylisation was carried out in the acryliser using the long curing cycle. It was acrylised at a temperature of 73 degree celcius for six hrs and a terminal boil for 01 hr. this was done to minimize the residual monomer content in the prosthesis. The flask was removed and deflasking was done after bench cooling. The prosthesis was polished to achieve transparency. It was again tried over the defect so as to minimize the operating time. It was kept about 10 mm overextended so as to flush the margins with the bevel at the craniotomy site. It was kept in water for 02 days to further facilitate removal of residual monomer content. It was then kept in 2% glutaraldehyde solution for 24 hrs for disinfection. Perforations were made 10 to 15 mm apart over the implant's surface with a round bur and countersunk with a flame-shaped acrylic [Figure 5a, 5b]. The perforations aid in preventing the accumulation of fluid beneath the implant after its placement, allow the inward growth of fibrous connective tissue to improve its stabilization and provide a means to secure the implant.

Surgical phase: A hemicoronal incision was placed along the previously existing scar line for craniotomy. No dural tear was encountered. The margin of the calvarial defect was defined.The custom made PMMA cranial plate was adjusted by trimming and adapted to fit in the calvarial defect. Contours were verified and fixation was done using 3x04 holed titanium miniplates and screws [Figure 6a]. Surgical site was debrided and closed in layers [Figure 6b]. Hemostasis was achieved and closed circuit surgical drain was placed. Postoperative recovery was uneventful. Post op result shows satisfactory restoration of calvarial contours with healthy suture line [Figure 7a, 7b, 7c].

DISCUSSION

Cranial defects may result from trauma, disease and congenital malformations. Cranial defects can also result due to the loss of bone flap from prior neurosurgical intervention such as evacuation of traumatic intracranial hematoma. Trauma to the cranium and fronto-orbito-temporal region can result in devastating defects. Repair of cranial defects is indicated to protect underlying brain tissue, provide pain relief at the defect site, improve cosmesis, and minimize patient anxiety.[6]

The objective of a cranioplasty is to obtain a durable and stable reconstruction of the cranium, covered with a good skin layer. Cranioplasty is accomplished either with osteoplastic reconstruction or restoration with alloplastic implants Today, the materials most commonly used fall into four groups: autografts, allografts, xenografts and alloplastic materials.

The choice of graft generally autogenous bone, in particular split calvarial grafts. The main contraindications for its use are excessive extent of the defect, advanced age of the patient, previous failures of cranial reconstructions. Moreover, when using autogenous bone, other disadvantages must be taken into consideration such as the donor-site morbidity, the risk of post-operative infection and resorption of the graft with the loss of its physical properties.

While xenografts may present immunological risks, allografts may be responsible for the transmission of infections such as hepatitis B, hepatitis C or human immunodeficiency virus (HIV).

As a result, alloplastic materials are chosen more often. Presently, the most commonly used materials include, titanium mesh, methylmethacrylate, polyethylene sheets, and hydroxyapatite cements. One of the main advantages of using alloplastic materials is that it is possible to prefabricate the prosthesis preoperatively, thus, reducing operation time and complexity, and improving the final result.Independently of the type of material used,

In the last decade, modern plastic materials have largely replaced metal. With a complex range of possibilities, the ideal synthetic material should be bio-compatible, inert, non-thermal conducting, radio-transparent, nonmagnetic, lightweight, rigid, simple to prepare, easily applicable and inexpensive. Polymethylmethacrylate (PMMA) is one of the inert materials which best meets most of these requirements.[7]

Acrylic resins are the alloplastic materials of choice for the delayed cranioplasty of a sizable defect. Acrylic implants are dimensionally stable, chemically inert, radiolucent, nonconductive, inexpensive, and can be easily placed and modified.

PMMA is commonly used because of its remarkable plasticity and long term stability. Moreover, it does not interfere with radiography or electroencephalograms, nor radiotherapy. PMMA is also very cheap and easily available. Overtime, PMMA has been shown to be well tolerated

without presenting biological side effects like foreign-body reactions.[8]

Fabricating cranial implants before surgery using molds and heat-polymerized methyl methacrylate avoids exposing tissue to residual monomer or the heat of polymerization. Heat-polymerized resin is 50% stronger than autopolymerizing resin and contains less than 0.4% residual monomer following a 1-hour terminal boil. Preformed implants simplify the restoration of complex cranial defects, reduce the surgical time necessary for implant placement, and decrease the risk of contamination that can occur when large implants are shaped intraoperatively. Preformed implant surfaces can also be polished, which can further reduce the risk of inflammatory tissue reactions.[9,10]

Some disadvantages need mentioning, however. It is not incorporated into or vascularized by adjacent bone; it may be subject to infection.

CONCLUSION

The reconstruction of large calvarial and other maxillofacial defects always pose a challenge for Surgeon and Prosthodontist. An innovative and novel technique based on scientific knowledge and ethics proved to be rewarding as shown in our case and the same can be further utilised in fabrication of other maxillofacial prostheses.

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