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Encasing the Encephalon: Enhancing Psychosocial Rehabilitation

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ABSTRACT

Cranial defects can be broadly classified as congenital and acquired defects. The occurrence of cranial injuries has increased tremendously and due to awareness amongst the population in concern to aesthetics requiring the skull reconstruction, rehabilitation of these defects has also increased in this modern age. Rehabilitation of these defects with prosthesis only acts as a protective shell but also improves the neurological status of the patient. These cranial defects require surgical correction or repair which is named as Cranioplasty. Its aim not merely lies in aesthetically rehabilitating the defect but mainly providing relief to the psychological problems but also improves the patient's social acceptance and performances. With the evolving trends in leaps and bounds, newer biomedical tools technologies and materials are made available to the surgeons and the Prosthodontists for a better outcome in both aesthetics and functions. This article describes a series of case reports on restoring the defect along with the psychological confidence in the patients. One of the techniques using bone cement in combination with the poly-methyl methacrylate is used, which is the novelty of this case report series. The management team constituted of Prosthodontists and neurosurgeons, thereby improving his neurological status and cosmetics.

Key Words: Cranioplasty, Titanium plates, Cranial reconstruction, Rehabilitation

INTRODUCTION

Cranial defects can occur at any age due to accidental trauma, surgical trauma, congenital malformations, infections, pathological cause, or tumours. Defects that are smaller can be covered by soft tissue and need no hardware to repair the calvarial defect. "It is defined as the repair of a cranial defect" by prosthetic rehabilitation. Repair of cranial defects with such prosthesis provides a shell for the underlying brain tissue along with providing contour of lost cranial structure, relieves pain at the site, minimizes anxiety, and enhances neurological as well as psychosocial rehabilitation. The repair of these defects is achieved with either osteoplastic reconstruction or by substituting it with alloplastic materials like metals, non-metal silicone.¹ The management team in such cases are inclusive of the neurosurgeon and Prosthodontists. These defects also causes psychological trauma to the patients. The patient reports to the doctor with these un-noticed complain associated with the disorder like feeling

of hopelessness, inferiority, abandonment, helplessness, and disability. The operator should develop an empathetic approach towards the patient which will also psychologically rehabilitate them.

Ideal requirements of materials for craniofacial rehabilitation

Considering the newer materials evolving which are used throughout the history to the modern era. The prerequisite to label ideal graft material are listed in the schematic diagram.²

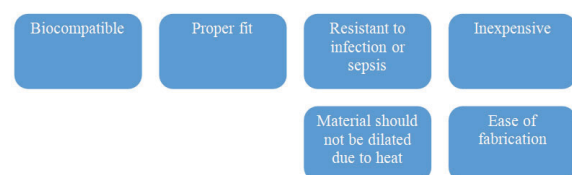


Diagram 1: Ideal properties of cranioplasty materials.

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Materials that are used for rehabilitation:

The materials that are used commonly are depicted in the schematic diagram.

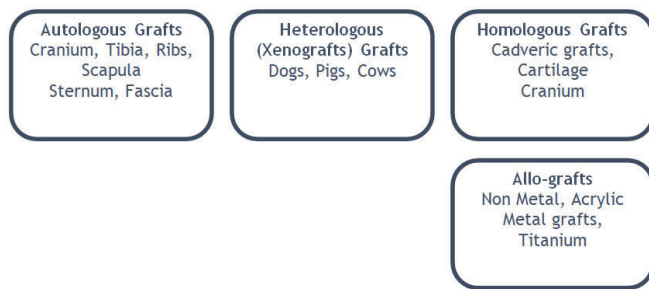


Diagram 2: Explains the materials that can be used for the rehabilitation.

Case reports: The following case series are of the cranial defect due to trauma and are prosthetically rehabilitated using three different techniques namely:

Case 1: Cranial stent of Poly-methyl Methacrylate along with the novel use of bone cement

Case 2: Cranial stent of Hydroxyapatite reinforced Poly-methyl-methacrylate

Case 3: Cranial stent made of Titanium plate.

Case 1

A 12 year old female patient with a history of past trauma from road accident involving multiple bone fractures inclusive of the cranium. The patient was given a referral to the Department of Prosthodontia for fabrication of the cranial prosthesis with chief complaint of the postoperative calvarial defect. The defect involved the parts of the right frontal, parietal, and temporal bone. The size of the defect measured 16 cm ×9 cm ×6 cm. (Figure 1). Radiographic evaluation was done using CT scan (case 1 Figure-2).



Figure 1: A Patient photographs frontal and superior view of Defect area before reconstruction.



Figure 2: Radiographic evaluation: CT scan images of the patient

The procedure for fabrication of cranial prosthesis was carried out under two phases namely, prosthetic phase and surgical phase. The phases involving steps and materials used are illustrated in Table 1. The patient was examined in the department of prosthodontics after one week of surgery and there was a remarkable improvement in the contour of the skull. The patient was extremely satisfied with the relief from psychological trauma, severe headache, and the excellent cosmetics obtained. The patient was reviewed after 4 months and the patient has been leading a normal social life. (Figure 1A).

Case 2

A 32 year old male patient with a history of trauma due to road accident and was operated for multiple bone fractures inclusive of the cranium. The patient was referred to the Department of Prosthodontia for the fabrication of the cranial prosthesis with chief complaint of the postoperative calvarial defect. The defect involved the parts of the right frontal, parietal, and temporal bone. The size of the defect was 16cm ×8 cm ×7 cm (case 2- Figure 5-A). The procedure for fabrication of cranial prosthesis was carried out under two phases namely, prosthetic phase and surgical phase. The phases involving steps and materials used are illustrated in Table 1. The contours on the defect site were evaluated postoperatively and after a 7-day follow-up. The patient was evaluated 6 months postoperatively with no complications. (Case 2 Figure 6-D)

Case 3

A 25 year old male patient came to the prosthetics department with the chief complaint of bony disfigurement in frontal or the forehead region. The patient had history of trauma to frontal bone fracture due to road traffic accident 6 months back and was operated for the same which led to the post-operative defect. Examination revealed mushroom-shaped defect which measures about 7cm X 9.5cm including frontal bone detected (case 3 Figure 7-A). Radiographic investiga-

tions were carried out and computed tomography scans for the fabrication were sent for the 3-D printing of the titanium plate. The prosthetic and the surgical phases were explained well in Table 1. The patient was recalled for the follow-up. (Case 3 Figure 7-B). Aesthetics of the patients were rehabili-

tated and the patient. This rehabilitation brings about visible changes that is aesthetics as well as invisible changes such as boosting of the self-confidence of the patient and social acceptance.

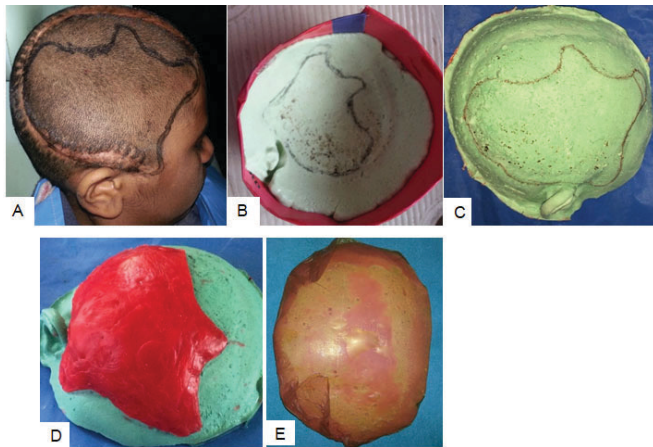


Figure 3: Prosthetic phase -A: Outline the defect using indelible pencil by palpating the bony edges B: Impression making using irreversible hydrocolloid, C: working cast fabricated from Type III gypsum product. D: wax pattern fabrication using modelling wax, E: heat cured PMMA cranial prosthesis.

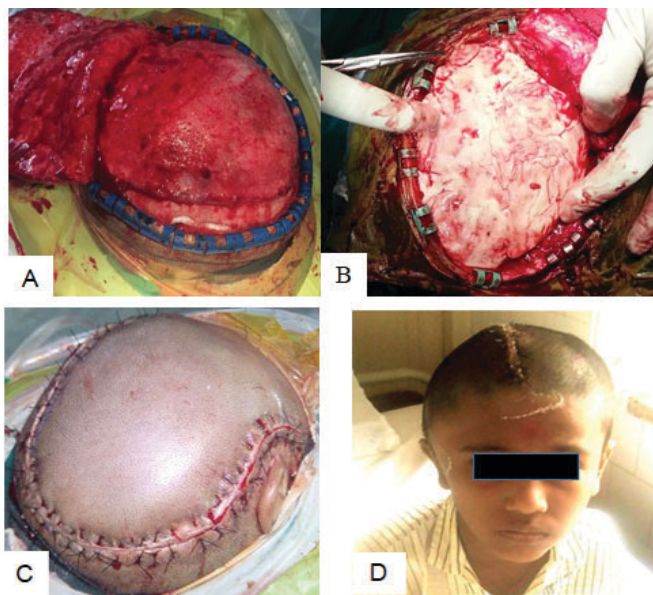


Figure 4: Surgical phase :A- flaps of the cranium are raised ;B -grafting of bone cement onto the prosthesis in layer not beyond 5mm;C closure confirmed; D-Esthetic evaluation of contours post operative of the patient after followup of 7 days.

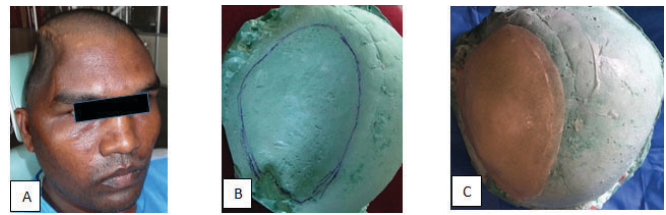


Figure 5: Prosthetic phase: A-pre op defect in frontal view, B- Working cast fabricated after impression making C- fabrication of hydroxyapatite reinforced heat cured PMMA.

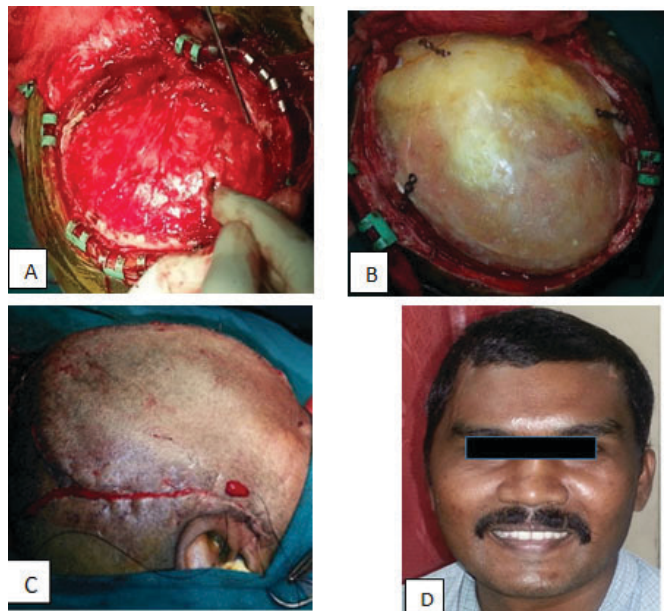


Figure 6: Surgical phase: A Exposure of the defect; B placement and fixation of the hydroxyapatite reinforced PMMA cranial prosthesis ;C- closure confirmed D- post op on follow up.

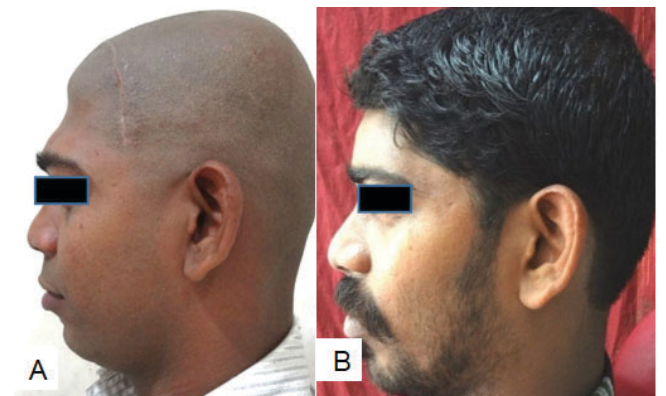


Figure 7: A-Pre-operative photograph showing mushroom shaped defect in frontal region,B-defect post-rehabilitation photograph.

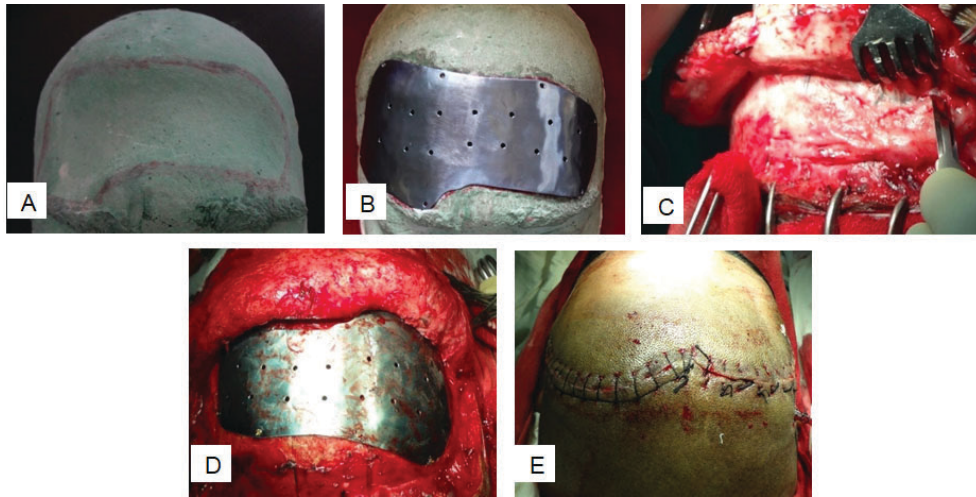


Figure 8: Illustration of surgical and prosthetic phase A-stone model showing frontal defect delineated, B-Titanium plate fabricated by 3-D printing verified on stone model, C-defect area exposed, D- titanium plate prosthesis in place intra-operatively, E-confirmation of closure.

Table 1: A: illustration of the case and the defect region involved; B: The prosthetic phase describes the step-wise fabrication of the prosthesis; C enlists the material used for the fabrication and along with the prosthesis; D describes the surgical phase and the prosthesis fixation

Cases & Defect area	Prosthetic Phase	Material used for Prosthesis	Surgical Phase
Case 1: Right Temporo- parietal region(Figure 1A)	1. Defect is delineated and Impressions recorded using irreversible hydrocolloid	Heat cured Poly-methyl methacrylate(PMMA) in conjunction with Bone cement layer	The defect was delineated Flaps are raised (case 1 Figure 4-A)
Case 2: Right Temporo-parietal region (case 2 Figure 5-A)	(case 1 Figure 3-A,B) 2. working cast fabrication (case1-Figure 3-C) (case2 Figure 5-B) 3. wax pattern try-in (case1 Figure 3-D) (case2 Figure 5-C) 4. fabrication of the heat cure cranial prosthesis (case1 Figure 3-E)	Hydroxyapatite reinforced heat cured Poly-methyl methacrylate	(case 2Figure 6-A) 2. The fit of the prosthesis was verified intra-operatively 3. Antibiotic laden irrigation. 4. Stabilisation and fixation of the cranial PMMA prosthesis (case1 Figure 4-B) (case2 Figure 6-B) 5. Confirmed closure of the defect. (case1Figure 4-C) (case2 Figure 6-C) 6. Recall and follow up (case1Figure 4-D) (case2 Figure 6-D)
Case 3: Frontal region (case 3 Figure 7-A)	1. Impressions recorded using irreversible hydrocolloid. 2. working cast fabrication (case 3 Figure 8-A) 3. The computed tomography scans of the defect for fabrication of prosthesis	3-D Printed custom made titanium plate with perforations	CT scans of the patient recorded. 2. Cranial prosthesis of titanium after verification on working cast(case3 Figure 8-B) 3. Titanium plate stabilised and fixed. (Case3 Figure 8-D) 4. Confirmed closure of the defect (case 3 Figure 8-E) 5. Post-op & follow up(case3 Figure 7-B)

DISCUSSION

Cranial decompression is the most accepted treatment for an increase in intracranial pressure caused by traumatic injuries, cerebral infarcts or haemorrhage, tumours, etc. Apart from aesthetics, restoration of these defects stabilizes hemodynamic functions, neurological, and psychosocial status of the patient. A wide variety of rehabilitating materials are available with metal base or non-metal namely, resin-based, ceramics, and other noble metals. Some of these metals are biocompatible and are not corrosion resistant with high thermal conductivity. Metals also produce scattering when radio-investigations like CT, MRI are done out of all the materials available titanium and PMMA (poly methyl methacrylate) are used preferably.²

PMMA is a polymerized ester of acrylic acid. Methyl methacrylate was first used as a cranioplasty material by Zander in 1940. Direct application of the auto-polymerizing acrylic resin over the defect area would cause complications due to exothermic polymerization reaction and hence prefabricated prosthesis are desirable. Preferably heat-cured resins should be used resulting in a stronger prosthesis. The aesthetic results are better as compared with other materials in the context of contour effect. PMMA is contraindicated in cases with cranial infections and in the age group of patients less than 3yrs. PMMA provides excellent cosmetic results. This PMMA when combined or reinforced with other bone simulating materials helps in Osseo-conduction thus enhancing reconstruction better. Hydroxyapatite reinforcement (case 2) and bone cement layer application (case 3) were used in the cases discussed above. **Hydroxyapatites** are the natural compounds of calcium and phosphates present in the human body in teeth and bones. By the sintering process, these compounds can be produced artificially. These artificial hydroxyapatites are commercially available in various modes like 2 paste system, powder-liquid form, granules or preformed buttons and plates. Overcoming the disadvantage of PMMA, hydroxyapatites show no exothermic polymerization reaction and can be used intra-operatively on the defect site after prosthesis stabilization and fixation. Whereas the most noticeable disadvantage is that the materials break off easily. Can be used in combination with titanium mesh or plates for more Osseo-integrative results increasing its durability³ **Bone cements** is available in two-component system namely powder consisting of Pre-polymerized forms and liquid which compromises monomer, inhibitors, and stabilizers. When mixed in proportions the viscosity changes from a luting or liquid to a rubbery dough and can be molded and applied onto the prosthesis intra-operatively onto the plastic /prosthesis- bone junction. The material hardens after the setting time and has to be manipulated quickly. The exothermic reaction takes place and heat dissipates therefore to minimize the effect the bone cement layer should not be

exceeding more than 5mm. these synthetic compounds can be reabsorbed and replaced by human bone.⁴

Titanium on the other hand is relatively radiolucent, non-ferromagnetic, and non-paramagnetic. On a comparative note, titanium possesses a very low rate of corrosion, low density, and modulus of elasticity equal to that of bone.² The titanium plate was fabricated using the digital 3D printing technique and was then verified onto the stone model. After the verification, it was disinfected and stored in 2% glutaraldehyde solution for about 24 hours and was then used intra-operatively. The perforations present in the prosthesis helped the process of elimination of the inflammatory exudates also providing blood supply to the overlying flap tissues mainly the scalp. The polished dorsal surface of the metallic prosthesis allows proper fit and acceptable.

CONCLUSION

With the upcoming trends in modern dentistry, it has also led to developments in the field of regeneration or 'tissue engineering' involving the molecular biology concepts and techniques comprising the stem cell implantation followed by desired differentiation in relation to function. Bone morphogenic proteins of the transforming-growth factor- β -family, and various polypeptide growth factors, play a central role in fracture healing.⁵ Fundamentals of aesthetic components are maxillofacial structures and need reconstruction if a defect is present by any of the methods mentioned.⁶ The aim of surgical treatment is to restore the functionality of the brain tissue, repair, correction of the bony discrepancy and thus restoring back the form, function and aesthetics in the maxillofacial complex.⁷ Such defects lead to social embarrassment and affect quality of life. Also, assessment of quality of life plays pivotal role in determining the feelings and perception of patient for effective communication between the health care professional and patients and thus our goal of the empathetic approach can be fulfilled.

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