Cranioplasty of Hemispherical Defects Using Calcium Phosphate Cements Along with Titanium Mesh: Our Experience

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Abstract

Introduction Cranial defects may arise due to trauma, infection, surgical ablation or errors in development. Restoration of such defects is important for esthetics, function and morale of the patient. Several materials are available. Each has its advantages and disadvantages. Search is on for an ideal material. Autogenous grafts remain the gold standard in reconstruction of such defects. However, the morbidity associated with their harvest, additional time required, the need for a second surgical site and the limited supply has led to the search for newer substitutes. Although many materials are available today including biologic and non biologic substitutes, there is still no consensus about the best material. In this article we describe our use of calcium phosphate cements for reconstruction of hemispherical cranial defects.

Materials and Methods Cases requiring reconstruction of hemispherical cranial defects (more than 15 cm in any dimension) were selected for study. After exposing the defect under GA, titanium mesh was adapted to the defect for support. Then the calcium phosphate cement was prepared and injected on the mesh to establish good contour. The alloplastic insert in each patient was evaluated for: (a) Immediate post-operative complications (b) Restoration of contour and soft tissue support (c) New bone formation ascertained on HRCT at the end of 2 years. Patients were examined on postoperative first week, at 3 and at 6 months.

High resolution computed tomography scans were taken at 2 years postop. There were two female and three male patients.

Results There were no complications in the post operative period. The general condition of the patients improved post operatively. Even though the cements maintained their contour at 2 years, there were no signs of bone formation within the cement.

Conclusion Calcium phosphate cement is a good bone substitute for use in cranioplasty. In defects requiring mechanical strength, it should be supported by a titanium mesh. It retains the contour but is not replaced by bone even after 2 years.

Keywords Decompressive craniectomy · Cranioplasty · Calcium phosphate cements · Reconstruction

Introduction

Bone defects in the craniofacial region may arise from surgical ablation, infection, traumatic avulsion or developmental abnormalities. There are several materials available for restoration of these defects like autogenous free bone grafts, vascularised bone grafts, pedicled grafts, allografts, xenografts and alloplasts [1–5]. Autogenous grafts remain the gold standard in reconstruction of such defects. However, the morbidity associated with their harvest, additional time required, the need for a second surgical site and the limited supply has led to the search for newer substitutes [6]. The ideal restorative material should be biocompatible, ideally osteoinductive, osteoconductive, readily available, easily adaptable to the site in terms of size and shape, biodegradable and replaceable by host bone [7, 8]. Several allografts are available but they produce

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unpredictable results. They also carry the risk of transmission of infection. Xenografts include bovine or porcine bone and coral.

Advances in the field of biomaterials and the limitations in the use of auto and allografts have led to the development of a wide range of alloplastic materials [9]. Alloplasts are synthetic bone substitutes that are readily available in different types, sizes and quantities and shapes and do not require additional surgery or time. The different types of alloplasts available are hydroxyapatite, calcium phosphate, calcium sulphate and bioglass.

Calcium sulphate and calcium phosphate compounds are attractive alternatives to autografts because of their excellent biocompatibility, handling characteristics, porosity, rate of dissolution, chemical and physical resemblance to bone mineral and potentially unlimited supply at a modest cost [10–13]. Calcium phosphate cements are one of the most widely used bone substitute [13, 14]. In this study, a clinical and radiological evaluation of the use of calcium phosphate cements in restoration of cranial defects was carried out.

Materials and Methods

Cases requiring reconstruction of hemispherical cranial defects (more than 15 cm in any dimension) were selected for study (Figs. 1, 2). Preoperatively Inj Cefotaxime 1 g was given intravenously. After exposing the defect under GA, titanium mesh was adapted to the defect for support (Figs. 3, 4). Then the calcium phosphate cement was prepared and injected on to the mesh to establish good contour (Figs. 5, 6). The alloplastic insert in each patient was evaluated for:

- Immediate post-operative complications.
- Restoration of contour and soft tissue support.
- New bone formation ascertained on HRCT at the end of 2 years.

Fig. 1 Calcium phosphate cement powder and liquid

Fig. 2 Preoperative frontal photo showing the defect

Fig. 3 Intraoperative photo showing the defect

Patients were examined on postoperative first week, at 3, 6 months and 2 years. High resolution computed tomography scans were taken at 2 years. There were two female patients and three male patients. Age group ranged from 18 to 55 years (Table 1). Decompressive craniectomy was carried out for traumatic head injury in four cases and due

Fig. 4 Intraop photo showing titanium mesh adapted to the defect

Fig. 5 Placement of cement

to cerebral infarct in one case. Cranioplasty was carried out 1–2 years after the decompressive craniectomy.

All human studies have been approved by the hospital ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. All persons gave their informed consent prior to their inclusion in the study.

Results

There were no post operative complications in our cases. All cases showed excellent contour and function (Figs. 7, 8). The

Fig. 6 Sculpting of the cement for contour

Table 1 Site of placement of bone substitute

S. no.	Location	Sex	Age (years)
1.	Frontal bone defect	F	55
2.	Frontopareital occipital region	M	17
3.	Frontopareital occipital region	M	36
4.	Frontopareital occipital region	M	45
5.	Frontopareital occipital region	F	33

Fig. 7 Postoperative photo 2 years post op

general condition of the patients improved after the surgery. Some patients showed remarkable improvement in their neurological status. Even though the cement maintained the

Fig. 8 CT scan 2 years postop showing excellent contour and osseointegration

contour, even after 2 years it was not replaced by bone. However, there was good osseointegration with the marginal bone.

Discussion

Bone defects in the craniofacial region may arise from surgical ablation, traumatic avulsion or developmental abnormalities. There are several materials available for restoration of these defects like autogenous free bone grafts, vascularised bone grafts, pedicled grafts, allografts, xenografts and alloplasts [15–19]. Autogenous grafts remain the gold standard in reconstruction of such defects. However, the morbidity associated with their harvest, additional time required, the need for a second surgical site and the limited supply has led to the search for newer substitutes [6]. Alloplasts are now being increasingly used for cranial reconstruction because of its several advantages [20, 21]. The most popular materials used for cranioplasty today are methylmethacrylate and titanium mesh. Methyl methacrylate is not strong enough for restoration of large sized defects. Titanium mesh when used in large defects cannot give ideal contour. To overcome this disadvantage of titanium mesh, we used injectable calcium phosphate

cements over the titanium mesh to achieve good contour. The injectable calcium phosphate cement used in our study sets in 5 min and gives adequate working time to contour the cement to achieve optimum aesthetics. There was no case in which the cement was avoided.

Cranioplasty is often associated with a complication rate of 10–22.5 % [22–25]. Most of their complications were in cases involving frontal sinus and patients who had undergone irradiation. Another reason cited by the authors is the placement of implants immediately beneath a temporal or bicoronal incision. In our cases we placed our incisions on sound existing bone forgoing the existing scar thus avoiding complications. Verret undertook biopsies of 14 cases requiring secondary reconstructive procedures or surgery for recurrent neoplasm and found evidence of osseous ingrowth into the cement matrix but none of the specimens showed replacement by host bone even after 6 years. In our cases also the cement was not replaced by bone but all cases showed good osseointegration. Zins et al. [26] had a complication rate of 15 % in a series of 121 patients. They had a higher rate of complication when these cements were used in defects >25 cm². Micro fragmentation was seen in few cases reported by Baker et al. [27] and Losee et al. [28] when these cements were used alone which was not seen in our cases. Baker et al. used carbonated calcium phosphate cement in 16 patients and had one case of infection and two cases with cement micro fragmentation. In the series reported by Mathur et al. [29] intraoperative failures occurred in four cases while 17 % of their cases developed infection. Titanium mesh was used in five patients for cranioplasty as well as orbital reconstruction. All the cases of infection had exposure to the nasal or oral cavity. In the study by Gomez et al. [30] they found one case of wound dehiscence with infection out of five cases treated for secondary craniofacial deformities. In a study of all cranioplasty cases undertaken at AIIMS, New Delhi from Jan 2008 to Apr 2010, they found 22.5 % complications out of 114 cases [25]. They routinely used autologous calvarial bone stored in the abdomen for cranioplasty and the mean duration between decompressive craniectomy and cranioplasty was 207.6 days [25]. In our cases there were no cases of infection at the operated site. Even though there was no substitution by host bone, the cement retained contour and showed excellent osseointegration.

Conclusion

Calcium phosphate cement is a very useful material for reconstruction of craniofacial defects because of its excellent osseointegration capabilities and ease of handling. However an adequate soft tissue cover is mandatory. A larger sample study with a long term follow up is required

to assess the bioresorbability and osteoinductive potential of the bone substitute. Since they do not have bone regeneration properties, use of growth factors along with these cements may give better results.

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