CRANIOPLASTY USING POLYMETHYL METHACRYLATE IMPLANT CONSTRUCTED FROM AN ALGINATE IMPRESSION AND WAX ELIMINATION TECHNIQUE

[*]A.E. ABDULAI, M.I. IDDRISSU[1] AND T.K. DAKURAH[1]
Maxillo-facial and [1]Neurosurgical Units, Department of Surgery, Korle Bu Teaching Hospital, P.O. Box 77, Korle-Bu, Accra, Ghana.

SUMMARY

Design: This is a retrospective review of the record charts.

Setting: A joint study by maxillofacial and neurosurgical units, department of surgery, Korle Bu Teaching Hospital, Accra, Ghana, a tertiary and premier health care centre.

Participants: Seventeen consecutive patients with various cranial defects treated using prefabricated acrylic methyl methacrylate implants.

Interventions: The cranioplasty on all the patients took place at an average of about 12 months after the initial surgery.

Main outcome measures: These included complications during and after surgery. X-ray views of the skull, ranging from true lateral to anterior-posterior, were taken at follow-up and examined to ascertain the stability of the graft by looking out for any adverse bony changes around it or loosening of any of the steel sutures securing it to the skull.

Results: A total of 17 patients (5 males and 12 females) with a mean age of 30.4 years were treated. Follow-up period ranged from 9 months to two years. In all cases the surgical procedure was uneventful and the cosmetic results were good. There was no significant change in the size and shape of the preformed methyl methacrylate implant after autoclaving.

Conclusion: Cranioplasty using prefabricated acrylic methyl methacrylate implants apart from being affordable also ensure shorter operative time and good aesthetic result.

Keywords: Cranioplasty; polymethyl methacrylate (acrylic); wax elimination technique.

INTRODUCTION

Cranioplasty is one of the oldest known neurosurgical procedures, dating from the year 3000 B. C., when the Paracas Indians in Peru performed procedures to correct large cranial defects. Across the centuries, many materials have been used for covering bony defects, including coconut shells, bones from both human and non-human donors, metals including gold, silver, tantalum, and titanium and more recently, biosynthetic materials such as resins and ceramics. Acrylic cranioplasty is frequently used for patients who have a cranial defect after trauma or an infected craniotomy or meningiomas[1, 4]. The aim of this study was to report our surgical experience in cranioplasty using prefabricated acrylic methyl methacrylate implant from an alginate impression and wax elimination technique.

MATERIALS AND METHODS

A retrospective review of the record charts, radiographs and clinical outcome of seventeen consecutive patients with various cranial defects treated using acrylic (methyl methacrylate) implants at the Korle Bu Teaching Hospital, University of Ghana Medical School, Accra, Ghana was performed.

Polymethyl methacrylate implant fabrication produce

The cleanly shaved skull defect of the patients is gently palpated to identify the periphery of the cranial defect. This is carefully demarcated using indelible pencil. A piece of cardboard is trimmed to conform to the periphery of the skull defect and plastered to the skull to demarcate the extension of flow of the alginate impression material. A smooth lightly-mixed alginate impression material is poured onto the skull defect bounded by the band of cardboard. A layer of dental gauze is placed over the alginate just at the time it is about to set, in order to act as a binding unit between the alginate and the cast formed by pouring lightly mixed plaster of Paris over the gauze. The plaster of Paris cast is to provide a rigid support for the alginate

[*] *Author for correspondence*

impression and also to prevent dimensional distortion during the removal of the set alginate material from the patients head.

Dental stone plaster is mixed and poured onto the alginate impression to obtain the positive likeness of the patient's skull. The indelible pencil mark shown on the alginate impression is intensified so that it will show on the stone plaster cast. After setting, the stone plaster is detached from the alginate impression. A wax pattern is then made to the exact dimension and contour of the skull defect image derived from the positive replica of the stone cast. At this stage, the patient is recalled for a "try-in", in order to ensure a proper fit of the wax skull-defect pattern.

The wax pattern is then invested in plaster of Paris, using 2 flask halves in the wax elimination technique[4]. The eliminated wax is replaced with acrylic (mixed methyl methacrylate) in a ratio of 1:3 (liquid: powder) by volume. External pressure (bench press) is exerted on the dental flask containing the plaster mould of the eliminated wax to expel the excess dough. The pressure exerted on the mould is maintained *throughout* the period of polymerization to prevent porosity. A spring clamp is used to maintain the pressure in the bench press. After this, heating, not exceeding 70^{o} C is carried out slowly in water for one hour. At the end of the curing cycle, the hot flask is bench-cooled prior to deflasking of the acrylic mould and then trimmed and polished to perfection ready for implantation.

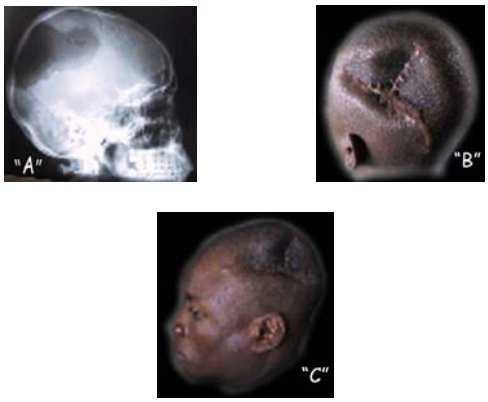

Figure 1 Radiographic images and photographs obtained in a 27-year man with a large cranial defect following trauma: preoperative plain radiograph (A) showing large cranial defect in the parietal region; preoperative photograph (B) & (C) showing the cranial defect in the parietal region.

Surgical Procedure:
We start intravenous administration of antibiotics at the time of skin incision, and the previous scar excised or incised. The skin flap is turned carefully to avoid damage to the dura underlying the skull defect. Holes are drilled into the plastic graft to effect drainage and to encourage ingrowths of tissue through them to help anchor the graft. The freed bone edge is saucerized with bone rongeurs, thus forming a beveled surface onto which the plastic graft rests, thereby preventing slippage inward into the defect. The graft plate is secured with soft stainless steel wire or other appropriate suture material. Rough edges are filed smooth. The pericranium and galea are approximated for snug adherence. A drain is placed over the graft material, and left in place for as long as it is functional, along with compressive turban dressing. Postoperatively, antibiotics are continued for at least five days. The follow-up period ranges from one to two years.

Though acrylic is radiolucent, depending on the site of the cranioplasty, various plain x-ray views of the skull, ranging from true lateral to anteroposterior, taken at follow-up periods were examined to ascertain the stability of the graft by looking out for any adverse bony changes around it or loosening of any of the steel sutures securing it to the skull. The cranioplasty on all the patients took place at an average of about 12 months after the initial surgery.

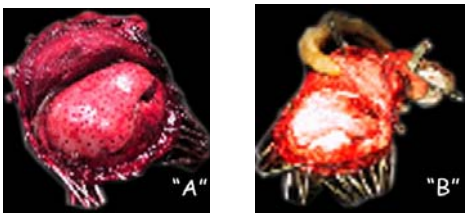

Figure 2 Intraoperative photographs (A) & (B) showing insertion of the methyl methacrylate implant.

RESULTS

The age and sex distribution of all the patients the 17 patients are shown in Table 1. There were twelve males and five females giving a male-female ratio of 2:1. The mean age of the study sample was 30.4 years. Table 2 shows the indications for the cranioplasty ; 10 patients were treated for traumatic disorders (contaminated compound depressed skull fracture), 3 patients with bone tumours, out of which two had osteoma and one transitional cell meningioma that destroyed almost the whole of the frontal bone on one side. The re-

maining 4 patients were treated for bone infection (osteomyelitis). Follow-up evaluation of the cases ranged from 9 months to two years. Methyl methacrylate implants were used for the repair of all the skull defects. In all the cases the surgical procedure was uneventful and without post-operative complications. There was no significant or noticeable change in the size and shape of the preformed methyl methacrylate implant after autoclaving and the cosmetic results were good.

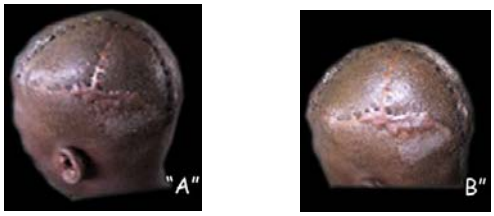

Figure 3 Postoperative photographs (A) & (B) obtained 3 days after surgery.

Table 1 Age and Sex Distribution of the 17 Patients

Age	Male	Female	Total	Percentage
10-19	2	2	4	23.5
20-29	4	2	6	35.3
30-39	2	0	2	11.8
40-49	2	1	3	17.6
50-59	2	0	2	11.8
Total	**12**	**5**	**17**	**100**

Male: Female Ratio = 2: 1
Mean Age = 30.4 years

Table 2 Indication for Cranioplasty

Indication	Number of cases	Percentage
Contaminated Compound Depressed Skull Fracture	10	58.8
Osteoma	2	11.8
Transitional Cell Meningioma	1	5.9
Bone Infection (Osteomyelitis)	4	23.5
Total	**17**	**100**

DISCUSSION

The role of an implant within the body is to replace, augment, or in some manner assist the function of missing or inadequate tissue. Many materials have been used as implants for cranial defects, and their role in cranioplasty have been mainly to replace the missing bone part and improve aesthesis of the affected area. Although autogenous bone grafts are the materials of choice for cranioplasties, acquisition of such bone grafts usually requires another incision and discomfort. Bone flaps removed from the cranium of the patient or bone obtained from a bone bank stand the risk of getting resorbed after implantation.[3, 4] Bone obtained from bone banks also carries the risk of transmitting diseases[3] such as Creutzfeld-Jacob diseases, and often results in only fair cosmetic outcome. Obtaining good cosmetic result is often challenging. Struts with titanium mesh or miniplates have been suggested for use to improve the cosmetic results, but this technique is more costly[9, 10]

Of the several materials used in cranioplasty, methyl methacrylate and titanium have remained today as viable alternatives for cranial implants[1, 2] Titanium is, however, expensive, difficult to prefabricate, and hardly affordable by many patients in our environment. Self or cold-curing methacrylate can be used directly to fabricate a plastic implant at the time of surgery. This material, most frequently used in Japan, can cause exothermic reactions, which may damage surrounding tissues and lead to massive subgaleal exudative fluid and infection[56]. This threat of thermonecrosis of tissue exposed to the exothermic curing of methyl methacrylate at the implant site can be eliminated by fabricating a custom acrylic plate, using the wax elimination technique, pre-surgically.

This was the method employed for all the cases of cranioplasty in this study. Other different methods have been described to prefabricate methyl methacrylate plates for cranioplasty[3-6]. For instance, Maniscalco et al[4] used alginate poured directly into the patient's cranial defect, with the alginate confined by a cardboard and gummed tape retainer. None of these techniques need the original bone flap, but they are complex and require skilled personnel to adapt the mould for exact fitting.

Prefabricating acrylic methylmethacrylate plate as employed here has several advantages. These include complete polymerization resulting in non permeability to body fluids, shortening of operative time, and giving assurance to improved physical properties such as compressive, impact and sheer strength. The technology involved is simple and easily accessible. We used simple impression material commonly employed in dentistry to mould acrylic to the shape that will fit the patient's skull defect and this technique, apart from being affordable, also ensures shorter operative time and good aesthetic result.

ACKOWLEDGEMENT

We are indebted to Mr Biney of the Maxillo-Facial Unit of the Korle Bu Teaching Hospital for his invaluable technical assistance in preparing the implants. We also wish to acknowledge Miss Nelly Affram for her secretarial support.

REFERENCES

1. The use of bone graft alloplastic materials in cranioplasty. *Clin Orthop* 1991; 268: 270-278.

2. Titanium mesh and acrylic cranioplasty. *Neurosurgery* 1989; 25: 351-355.

3. Cooper PR, Scheter B, Rubin RC, Willie RL. A preformed methyl methacrylate cranioplasty. *Surg Neurol* 1971; 8: 219-221.

4. Jordan RD, White JT, Schapper N. A technique for cranioplasty prosthesis fabrication. *J Prostet Dent* 1978; 40: 230-233.

5. Maniscalo J E, Garcia-Bengochea F. Cranioplasty: A method of prefabricating alloplastic plates. *Surg Neurol* 1974; 2: 339-341.

6. Van Gool AV. Preformed polymethyl methacrylate cranioplasties: Report of 45 cases. *J Maxillofac Surg* 10: 255-257.

7. Genest AS. Cranioplasty made easier. *Surg Neurol* 10: 255-257.

8. Vanalocha V, Saiz-Sapena N, Garcia Cassola C, de Alave E. Cranioplasty with autogenous autoclaved calvarial bone flap in the cases of tumourial invasion. *Acta Neurochir (Wien)* 1997; 139: 970-976.

9. Blum KS, Schneider SJ, Rosethal AD. Methyl metacrylate cranioplasty in children: Long term results. *Pediatr Neurosurg* 26: 33-35.

10. Pochon JP, Klot J. Cranioplasty for acquired skull defects in children: A comparison between autologous materials and methyl methacrylate. *Euro J Pedriatr Surg* 1991; 1: 199-201.