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Methyl Methacrylate Cranioplasty

13 Years Experience with 417 Patients

By

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With 4 Figures

Summary

The use of methyl methacrylate for cranioplastic repair in 417 patients over a 13 year period has been presented. Its advantages have been noted as well as the indications and the operative technique. Infection has occurred in less than one percent, and half of these cases (2) were due to surgical errors.

Operations for repair of cranial defects have been performed for many years, and a good historical account is given by Reeves[3]. Many different materials have been used which have included bone (autogenous, homogenous, and heterogenous), metal (aluminum, gold, silver, lead, vitallium, ticonium, tantalum, and stainless steel), and alloplastics (celluloid and acrylic resins). The use of many of these substances has been discontinued, but acrylic resin, tantalum and bone are ones that have remained popular and are in current use by neurosurgeons and plastic surgeons.

Bone and tantalum cranioplasties were being performed by the Neurosurgical Service at Walter Reed General Hospital until 1957 when the acrylic resin, methyl methacrylate, was evaluated. Methyl methacrylate is known by various trade names as lucite, vitacrylic, plexiglass or crystallite.

Since our preliminary evaluation with methyl methacrylate, we have continued to use it as the material of choice, to the virtual exclusion of all others. 417 patients have had insertion of methyl methacrylate prostheses from 1957 through 1969.

Pre-operative Evaluation and Operative Procedure

Prior to surgery, complete x-ray examination of the skull is performed, and where the defect includes an air sinus region, special attempts are made to try and determine the presence of any air in the sinus which would preclude the performance of the cranioplasty, but indicate the need for a further exenterative procedure. Evidence of osteomyelitis is a contraindication to cranioplasty.

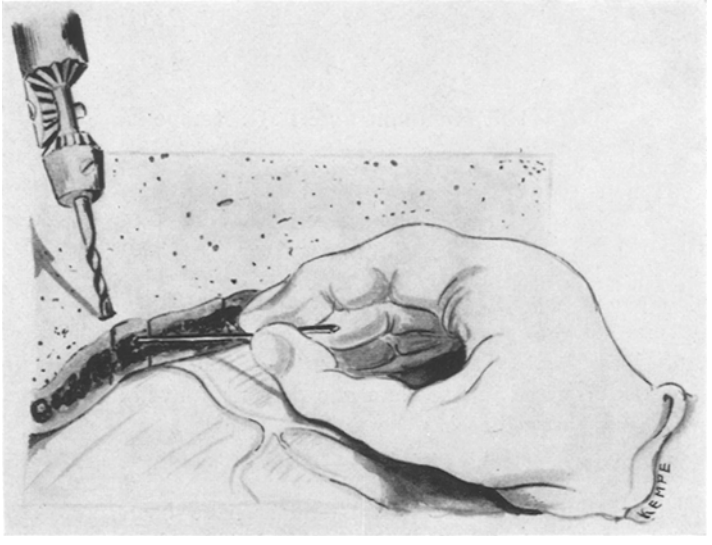

Fig. 1. Technique of drilling wire hole in skull to prevent dural dissection.

The head is completely shaved the day prior to surgery so that the scalp and its scars can be totally evaluated and a decision made regarding the best type of incision. A well-healed linear scar overlying the defect may be utilized, if it is not anterior to the hairline. When the scar is stellate, irregular or thin, it is advisable to avoid reusing this scar for the incision, but to plan a scalp flap about the defect to insure adequate blood supply and uneventful healing. If the scar is anterior to the hairline, a concealed coronal scalp incision is planned.

An examination is also made for the presence of retained sutures or a protruding suture from the galeal layer. These are removed and local cleansing procedures performed until the area is unquestionably free of potential contamination, then cranioplasty is re-scheduled.

The thoroughly evaluated patient is then anesthetized, usually under general endotracheal anesthesia, and positioned such that when

possible, the plane of the skull defect is parallel with the horizontal. This makes the molding of the methyl methacrylate to the defect much more easily performed.

The entire scalp is sterilly prepared and draped for total scalp exposure of the planned incision and any extensions that may become necessary. If the incision is made through old scar that overlies the skull defect, special attention is needed to avoid incising the underlying

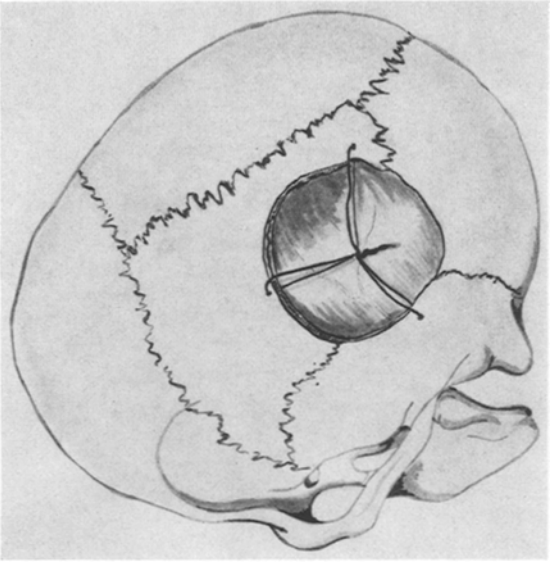

Fig. 2. Crossed and knotted fixation wires prior to application of methyl methacrylate.

dura. Scalp hemostasis is secured with scalp clamps only if the incision is made through normal scalp, but if made through a previous incision or scar then clamps should be used only on the galea or galeal scar.

Careful undermining of the scalp is performed particularly over the defect to avoid penetrating either the dura or the adherent scalp. As much scar tissue as possible should be left attached to the undersurface of the scalp to maintain maximal scalp thickness where this will overlie the prosthesis.

Total exposure of the cranial defect is achieved to include reflection of any overlying muscle. A circumferential incision is then made through the pericranium around the defect, and the inner edges are dissected from the external table of the skull and carried down over the edge of the bone until dura is exposed. The remaining epidural tissue is

then dissected towards the center and discarded. This then allows for a prosthesis to be prepared which will have maximum thickness corresponding to the surrounding bone.

Different methods for anchoring the prosthesis in place have been utilized and all were basically acceptable but one method has been preferred. Because of the possibility of an epidural hematoma forming in what will be a closed and externally rigid space, and its formation

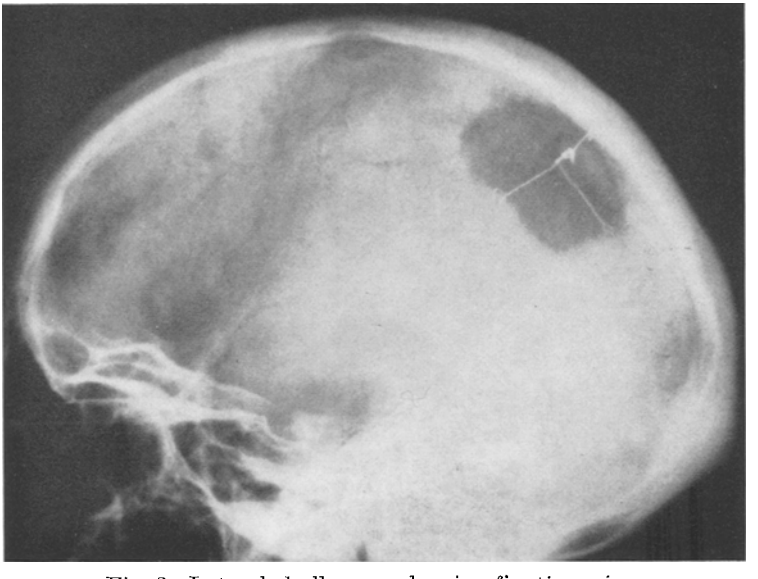

Fig. 3. Lateral skull x-ray showing fixation wires.

enhanced due to increased vascularity in healing scar tissue, it is inadvisable to dissect between the skull and the dura which necessitates lysis of adhering epidural scar tissue. Therefore, we do not advise the molding of an inner ledge of acrylic to lie between the skull and dura.

Drill holes are made about the cranial defect so that anchoring wires can be inserted. These drill holes are most conveniently made with an air drill. Again, so as not to dissect dura from under the bone, the drill hole is made by first drilling into the diploic space from the vertical surface of the exposed edge of bone to a depth of approximately 5–8 mm. A straight needle is then inserted into this hole and the drill placed on the external table of the skull and angled towards the inserted end of the needle which then moves when touched by the drill point (Fig. 1). This maneuver is not practical when dealing with extremely thin bone

such as the temporal squama. One must also avoid drilling a hole into or through an air sinus.

Wire is then inserted through this angled drill tract. We prefer a doubled strand of 30 gauge stainless steel wire, but other non-absorbable material could be used. An advantage to wire, besides its tensile strength, is the radiographic evidence of its presence (which at times has been

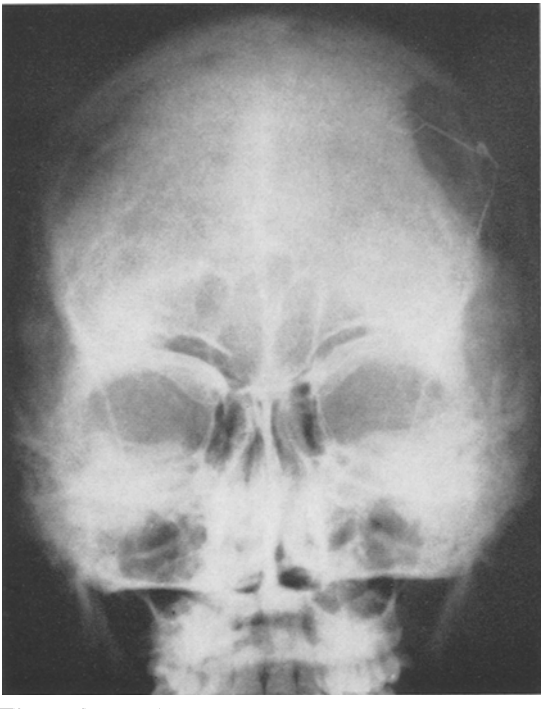

Fig. 4. Frontal skull x-ray showing fixation wires.

valuable in indirectly helping to show a patient or another physician that indeed a prosthetic was in place since by x-ray methyl methacrylate is radiolucent). Also if a wire was to break, the loss in continuity of the loop would be visible by x-ray.

Three fixation wires, not in a straight line, will hold the prosthetic firmly in place, as with a routine bone flap.

Our preferred method of wire fixation is that of continuing the wire from hole to hole across the defect or having them meet in the middle and knotting them there (Fig. 2). This provides a type of anchoring meshwork and possibly some additional strengthening upon embedding the wires within the methyl methacrylate (remotely similar to reen-

forced concrete). Its radiographic appearance is even more dramatic (Figs. 3 and 4). When this method is employed, at least three drill holes are usually placed and a radial meshwork is produced. Using this method for fixation also eliminates the need for drilling holes in the prosthetic itself, since it is firmly anchored by the wires that it enmeshes.

The site of the cranial defect now having been totally prepared, and hemostasis secured, attention is directed to the forming of the prosthetic plate.

No prior external molding, measurements or preparations are required. The methyl methacrylate comes prepared as a sterile liquid and a powder in separate glass containers*. Although the contents of the containers are sterile, we prefer to also sterilize the containers so that they may be handled by the surgeon at the operating table.

An appropriate volume of the liquid monomer and the powdered polymer are mixed in a 1 : 1 ratio in a suitable sterile container, and when a thickened consistency is attained such that the material can be poured into the defect and mold itself, it is applied directly into the defect. The advantage of having the defect area parallel with the horizontal is now apparent.

A quantity is instilled to completely enmesh the crossing wires and reach the outer surface of the surrounding bone. Material that flows over the edges is either pushed back towards the defect or removed with a moistened tongue blade or metal spatula. As the acrylic begins to harden and is of dough-like consistency, it is easily contoured on its convexity and edges. Supraorbital ridges, glabella and zygomatic arch contours are thus easily molded and formed.

With hardening, which begins about 3–4 minutes after mixing, one can appreciate the heat of the exothermic reaction. The hardening prosthesis is then continually irrigated with isotonic room-temperature saline for another 3–5 minutes until totally hard and cool. Tapping on the hardened prosthesis with a metal spatula causes a clear high-toned ringing note.

Any areas of unwanted overlap, ridges or rough edges can be easily ronguered, filed or ground down to desired smoothness and contour.

If the technique of embedding of the wires is not performed, then the prosthetic plate is marked for its drill holes, removed and drilled. The wires are then inserted, twisted to tightness, cut, and the free ends bent so that they enter a drill hole and are buried.

Thorough irrigation is again performed to wash out any free chips of methacrylate, hemostasis is re-secured and the scalp is closed in

* Cranioplastic Kit. Codman and Shurtleff, Inc., Boston, Massachusetts.

2 layers with non-absorbable suture material. Drainage is not performed. Post-operative antibiotics are not routinely administered.

The average operating time is about one hour, and a custom made, form fitting, harder than bone, translucent, cosmetically pleasing, permanently protective cranial prosthetic has been inserted.

Discussion

The indications and timing for cranioplasty have remained quite rigid at Walter Reed General Hospital. The defect needs to be larger than a routine trephine opening (unless in a cosmetically visible location,

Table 1. *Indications for Methyl Methacrylate Cranioplasty*

Compound Wounds	349
Craniectomies Performed for Benign Tumors	29
Replacement for Symptomatic or Complicated Metal Implants	15
Replacement for Absorbing or Cosmetically Disfiguring Bone Implants	11
Previously Removed Infected Craniotomy Bone Flaps	6
Craniectomy for Cerebral Decompression	3
Replacement of Resorbing Craniotomy Bone Flaps	3
Leptomeningeal Cyst	1
Total	417

i.e. forehead), lacks complete covering by thick, protective, overlying muscle masses (temporal or suboccipital muscles), and full thickness scalp covers the area of the cranial defect.

Any cranial defect that occurred as the result of a compounding wound, or where the operative site was infected, is not considered for cranioplastic repair until at least one year has elapsed since compounding or last evidence of wound infection. This has been strictly adhered to and there has been no cause to regret this delay. Also, if in attempting to perform the cranioplasty it is noticed that an air sinus (usually the frontal sinus) has not been totally exenterated, and mucosa is present which would be contiguous to the prosthesis, sinus exenteration is completed and cranioplasty not again attempted prior to a year following exenteration. In 2 cases where this policy was not followed (1958 and 1968) both patients developed cellulitis and one an osteomyelitis, both requiring removal of their prostheses.

It has also been our policy not to perform immediate cranioplasty for benign cerebral tumor removals where the bone flap is discarded (i.e. meningiomas), but to wait several weeks prior to performing the cranioplasty. This has allowed a temporary decompression site as well as demonstrating that a wound infection has not developed fol-

lowing a lengthy operative procedure. Small elective craniectomies for osteomas, eosinophilic granulomas or other excisional biopsies of the cranium have had primary cranioplasties performed without complication.

In Table 1 are noted the indications for which methyl methacrylate cranioplasty was performed. The predominant number were due to compound injuries of the skull (349 cases). Another significant group required removal of previous cranioplasties performed with metal or bone (26 cases).

Headaches, poorly contoured or sprung metallic plates, scalp erosions, bone implant resorption and metallic clicking noises were some

Table 2. *Complications Following Methyl Methacrylate Cranioplasty*

Infection	4	
Contiguous to Non-exenterated Frontal Sinus		2
Wound Infection, unexplained		2
Post-operative Epidural Hematoma	1	
Scalp Erosion (due to rough edge)	1	
Loose Plate Requiring Rewiring	1	
Total	7	

of the indications necessitating removal and replacement with methyl methacrylate.

Of the 417 methyl methacrylate cranioplasties performed, there were 7 early or late complications requiring removal or revision (Table 2). Four cases became infected, including the 2 noted above that were due to insertion next to non-exenterated frontal sinuses. The other 2 infections were unexplained except as wound contaminations. All 4 required removal and 3 have had later successful cranioplasties performed.

One of the other complicated cases developed an acute arterial epidural hematoma which dissected from the operative site. This was successfully evacuated and repeat cranioplasty performed 2 months later. In this case the dura had been dissected from under the bone edge.

No cases in the follow-up group from 6 months to 13 years have experienced fracturing of the methyl methacrylate plate and no case has had increased regional head pain or headache upon exposure to heat or sun. Many military patients have returned to full, un-restricted active duty and have engaged in parachuting, flying, Special Forces Training, contact sports and combat.

Interpretation of later performed neuro-radiologic diagnostic procedures is unimpaired since methyl methacrylate is radiolucent.

There have been no incidents where contiguous tissue damage occurred, recognizable clinically, and in fact it is this same methyl methacrylate in a more rapid polymerizing mixture that has been used for over 13 years to encase cerebral aneurysms[1, 2].

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