CRANIOPLASTY WITH ACRYLIC PLATES

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The purpose of this presentation is to record the authors' experiences
in 70 cases of skull defect repaired by acrylic plates made at the time
of the operation by means of an impression technic.

Any method of repairing cranial defects should achieve a satisfactory
cosmetic result while minimizing difficulty of the procedure, and any mate-
rial used should be of sufficient strength to assure permanency of repair while
achieving satisfactory cosmetic results, and such a material should produce a
minimum of foreign body reaction in the tissues. Since the advent of World
War II, because of the increased incidence of cranial defects, neurosurgeons
of this and other countries have searched for a material that would meet
these specifications. Fulcher¹ advocated the use of tantalum plates and
described their successful application in patients. Since that time, the
material has been extensively employed, both in military and civilian
practice.

Our work was started at Fitzsimmons General Hospital, Denver,
Colorado, by Major Joseph M. Cameron, M.C., A.U.S., and the technic has
been modified and improved by the authors at Fitzsimmons General Hospital
and at Newton D. Baker General Hospital, Martinsburg, West Virginia.
Much credit must be given to the dental departments of both hospitals for
their close cooperation.

The material chosen for study was a plastic, methyl methacrylate, the
polymer of methyl alpha acrylic acid esters, commonly known as acrylic.
The properties of the acrylic resins have been studied extensively and are
well known.⁵,⁶ Gurdjian, Webster and Brown reported the use of an acrylic
plate in one case,² and Kerr mentions seven cases in which he employed
acrylic plates in England.³ Experimentally, the material has been employed
as observation windows in the craniums of monkeys by Shelden, Pudenz,
et al.⁷ Early tissue studies with methyl methacrylate indicate that there is
practically no tissue reaction to the substance in experimental animals.⁴,⁸

A technic was evolved which effected satisfactory cosmetic results (Figs.
1 and 2) and the material has produced a minimum of foreign body reaction
in the tissue. Based on a series of 70 cases, we have concluded that acrylic
may be safely used for the repair of cranial defects.

When the work was started, it was necessary, because of technical dif-
ficulties, to perform the cranioplasty in two stages, usually on successive
days, and to employ a general anaesthetic. Recognizing that valid objec-

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tions would be raised to any procedure that required reopening a wound that had been sutured 24 hours previously, we succeeded in perfecting the technic so that the cranioplasty may be performed in a single procedure. In addition, we no longer employ a general anaesthetic, but resort to procaine

Fig. 1. Front and side views demonstrating the defect in the frontal region, involving the nasal process (preoperative).

Fig. 2. Front and side views of same patient 2 weeks postoperative.
infiltration of the scalp surrounding the defect and a moderate amount of preoperative medication.

TECHNIC

When the patient is admitted to the hospital, a general physical and neurological examination is performed. Laboratory procedures include electroencephalography to determine abnormalities, particularly in the area of the defect. Following the operative procedure, the neurological examination and electroencephalography are repeated to determine any change in the status of the patient. There have been no variations between the preoperative and postoperative electroencephalograms in our patients. Variations in neurological status will be discussed later.

The patient is placed on the operating table after moderately heavy preoperative medication. The scalp is shaved widely around the defect and the field prepared with green soap and water, followed by alcohol. The line of the intended incision is then infiltrated with procaine 2 per cent, and then the drapes are applied. The incision is usually so placed as to remove as widely as feasible the old scar, although occasionally it may be advisable to prepare a fresh scalp flap. This is particularly true when dealing with large defects. The scalp edges are undercut between galea aponeurotica and periosteum around the edges of the defect and the incision is held open by means of self-retaining retractors.

In most cases, the problem that now confronts the operator is a layer of dense scar tissue which is closely adherent to the edges of the defect and which usually forms a thick false covering on top of the dura mater. Frequently we have noticed that whenever an area of dura mater had been sacrificed at a previous operation, the brain would be densely scarred and adherent to the galea aponeurotica. In order to obtain an accurate impression, the scar tissue must be assiduously dissected free from the edges of the defect (Fig. 3). The removal of scar tissue from the surface of dura mater or brain is probably advantageous from a neurological standpoint and is necessary in order to gauge the proper thickness of the plate on the impression material.

When the defect has been cleared of scar tissue and hemostatis obtained, an approximation of the outer contour of the skull in the region of the defect is obtained by placing a sterilized piece of dental base plate in the wound. Previous to this the base plate is heated in a pan of hot water until pliable. After carefully molding on the skull to the desired contour, it is removed from the incision and hardened by placing it in cold sterile water for a few seconds. The base plate must be larger than the defect, since it is to serve as an impression tray and since it determines the outer contour of the completed acrylic plate. Two retention holes are punched in the center of the tray. This is easily accomplished by using a heated blunt instrument. A layer of impression material is now spread on the inner surface of the impression tray. The material we have found most advantageous is a previously prepared mixture of beeswax and vaseline. This mixture consists of \( \frac{3}{4} \) beeswax and \( \frac{1}{4} \) vaseline. It may be either boiled or autoclaved to insure sterility. The impression material is firm when cool and must be softened by molding in the operator's hands. The layer of impression material which is spread on the inner surface of the tray is of sufficient thickness to obtain an accurate measurement of the depth of the bone edges. The material is pressed firmly to the inner surface of the tray, allowing some of the material to extrude through the retention holes.

An impression of the bone defect edges is now taken by reinserting the tray with its inner coating of wax into the wound and pressing down firmly (Fig. 4). The tray is then removed and the impression inspected for defects. If the operator is satisfied that the impression is satisfactory, it is placed in a pan of cold water for hardening and sent to the dental laboratory. The retractor is removed from the incision and a sterile dressing is applied to the wound, without disturbing the drapes.
In the dental laboratory, the impression and its tray are embedded in ordinary dental stone, using the lower half of a Pryor injector flask. The stone is allowed to harden and then is coated with silax. The upper half of the flask is now filled with dental stone and the halves are placed together. The lid of the flask is placed in position and the pressure plunger adjusted to the estimated top of the tray. After 5 minutes, the pressure plunger is removed and the halves of the flask are separated. The wax impression material is boiled out and the tray removed. The impression matrix is now lined with light tinfoil and packed with acrylic resin in sufficient quantity to insure a packing pressure and to allow for about 20 per cent shrinkage. The top of the injector flask and pressure plunger are reinserted and the plunger screw is adjusted until the indicator is ¼ inch above the housing. The material is cured for an average of

35 minutes by placing the flask in boiling water. During the curing process, the plunger screw will require several readjustments. After the heating process has been completed, the flask is allowed to cool for 10 minutes, after which the parts of the flask are separated and the acrylic plate is removed for polishing. In the polishing process we have found it desirable to leave a small overhanging ledge which will impinge on the outer table of the skull and prevent the plate from sinking into the defect. Several small drill holes are placed around the circumference of the plate, diagonally at the base of the overhanging ledge, to facilitate wiring the plate into position in the defect. Two large drill holes are placed in the center of the acrylic plate to insure drainage after the plate has been inserted (Fig. 5). Sterilization of the completed plate is accomplished by placing it in Bard-Parker solution for 15 minutes. The entire procedure for completing the plate requires, on the average, 1½ hours.

When the plate has been returned to the operating room, the dressing is removed from the wound and the incision edges are again infiltrated with procaine 2 per cent. The retractors
are replaced and the plate is inserted. It should fit snugly without rocking. Small through-and-through drill holes are placed around the circumference of the bone defect and threaded with .009 mm. steel wire. Usually 4 opposing holes are sufficient to hold the plate firmly in place. These holes should correspond closely to their counterparts in the acrylic plate. The inner end of each wire is next threaded through one of the small holes previously placed around the circumference of the acrylic plate and the wires are tied tightly with a square knot. The ends are cut short and the knots are buried in the drill holes, either of the plate or of the bone (Fig. 6).

**DISCUSSION**

Our series of 70 cases was compiled between June 1943 and January 1945. There were 7 infections, the first 4 of which occurred in the first 11 cases. Two of these infections occurred in cases of supposedly healed osteomyelitis of the skull. One of these healed without interference with the plate. The other required a removal of the plate because of persistent draining sinuses. This plate had been in position for 10 months and at the time of removal was essentially unchanged in appearance. One frank wound infection occurred in an uncomplicated case, but healed without interference with the
plate. The other infection was in a case of brain tumor receiving X-ray therapy. This plate was removed to facilitate disposition of the patient. In our recent cases there have been 3 slight wound infections, all of which were probably due to a necrosis in a thin scar. Each of these infections has healed without interference with the plate. From these results we have concluded that the tissues tolerate acrylic extremely well.

There have been few postoperative complications besides the infections mentioned, which could be related to either the procedure or the material used. One patient had his first convulsion 6 weeks following cranioplasty. This convulsion occurred approximately 16 weeks following the patient's injury and could conceivably be attributed to this. On a phenobarbital regime, there have been no further attacks. Two patients had mild postoperative headaches which were not incapacitating. The only other complication occurred in a patient who had had a severe head injury and at the time of his cranioplasty was suffering from post-traumatic symptoms. These were exacerbated for 48 hours. The great majority of our patients have tolerated the material very well.

As has been mentioned previously, when this work was first started, it was necessary to perform the procedure in two stages. This was mainly because of organizational difficulties. With close cooperation of both dental and operating room personnel, the procedure is now being routinely performed in one stage. This has been true for the last 43 consecutive cases. It has been noticed that the patients tolerate the procedure well and most of them are allowed out of bed within a few hours after return from surgery. In most cases a subgaleal collection of fluid develops during the first 48 hours postoperative. Simple aspiration and pressure dressings control this complication readily.

There is a tendency for methyl methacrylate to absorb water. We feel that this may be advantageous. In the first place, the amount absorbed is small, averaging .45 per cent. In addition, the statement has been made that water absorption of the acrylics increases their toughness and flexibility. Our first operations were done two years ago and we have noticed no complications that could be attributed to a change in the consistency of the acrylic plate and have concluded from our follow-up studies that permanent repair has been obtained. We feel that the material is satisfactory for the repair of skull defects because it is readily accessible and the plate can be made by any competent dental technician. Furthermore, the completed plate is the result of a direct impression of the defect and conforms to the defect. We also contend that there is a minimum of operative trauma. It has not been necessary, for instance, to smooth bone edges with a rongeur in order to acquire accurate fitting of the plate. This procedure would be disadvantageous when dealing with traumatic cases in which the wound was potentially infected. We suggest that the time limit between the debridement of a compound skull fracture and the insertion of an acrylic plate may be reduced. In our uncomplicated traumatic cases the average time
between injury and insertion of the acrylic plate has been 4 months. The longest time was 12 months, and the shortest time 9 days.

SUMMARY

The requirements of an ideal material for the repair of cranial defects are pointed out. A technic is described for the preparation and insertion of acrylic plates in cranial defects and the advantages of this material are discussed. Employing acrylic plates in a series of 70 cases, we have demonstrated, clinically, that there is a minimal foreign body reaction to the material and that an excellent cosmetic result can be obtained. In addition, we have perfected the technic so that the plate may be inserted at a single operative procedure with only moderate discomfort to the patient, and have decreased the operating time to within a reasonable limit. Postoperative complications are discussed and the conclusion is drawn that no permanent changes have occurred that could be related to either the material used or the method employed.

CONCLUSIONS

Methyl methacrylate is a satisfactory material for the repair of cranial defects. It is sufficiently strong to assure permanency of repair and the material produces a minimum of foreign body reaction in the tissues. Excellent cosmetic results may be obtained by an impression technic.

We have concluded that the only contraindication to the use of acrylic plates for repairing cranial defects is the history of recent infection in the area of defect. It is true that this is a contraindication to the repair of cranial defects with any material available at the present time.

No permanent postoperative complications have occurred that could be related to either methyl methacrylate or to the method described for inserting the acrylic plate.

REFERENCES

8. Walker, A. E. Personal communication.