THE ONE-STAGE METHOD OF CRANIoplasty
WITH A FOLLOW-UP STUDY

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(Received for publication May 6, 1957)

Acrylic derivatives were employed early by odontologists for making various types of dental appliances, as well as by orthopedists.\textsuperscript{5,16} Zander, in 1940, was the first to perform a cranioplasty with methyl-methacrylate (Lucite), and around the same time Kleinschmidt,\textsuperscript{11} in experiments on rabbits, demonstrated its nonirritative character. Other pioneers are Gurdjian \textit{et al.},\textsuperscript{5} Kerr,\textsuperscript{10} Kahn,\textsuperscript{9} Krüger,\textsuperscript{12} Small and Graham,\textsuperscript{15} Schorstein,\textsuperscript{14} and Woolf and Walker.\textsuperscript{20} In recent years, further investigations have been reported which favor the use of plastics.\textsuperscript{4,14,16,19} The method, however, has one drawback: it is based on the principle of impression and therefore necessitates a two-stage procedure.

THE ONE-STAGE METHOD

In 1948 the British authors Oliver and Blaine\textsuperscript{13} reported 3 cases in which they had shaped the plastic and allowed it to harden \textit{in situ}. They had an observation time of 1 year and the results were successful. In 1951 Woring er\textit{et al.},\textsuperscript{22} presented 15 cases and described the method in greater detail. Woring er has since been its chief advocate and, while visiting the Mayo Clinic, prompted Dodge and Craig to adopt it. The latter authors presented, in 1953, a preliminary report of their experience on the basis of animal experiments and 7 successful cases.\textsuperscript{8} Since 1952 the method seems to have been used consistently by Spence,\textsuperscript{17} though he has not described the number and character of his cases. Following a visit by Woring er to Stockholm, the procedure has been standard at our departments since January, 1953, and up to January, 1957, 51 cranioplasties had been performed. Of these cases, 46 have now been followed up and form the basis of the present investigation.

\textit{Principle.} The chemical basis of acrylic plastics\textsuperscript{1} is that the molecules of methyl esters of methacrylic acid (monomer) possess the ability of additive polymerization, i.e., of uniting in long chains on dissociation of the double bond C=\textendash C.

If the monomer (liquid) is mixed with its polymer (powder), a plastic paste results that can be shaped as required. For the earlier acrylic plates this mixture was placed in a mold and a countermold was applied. The two

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CRANIOPLASTY WITH ACRYLIC PLASTIC

were then compressed by heavy clamps and placed in a water bath at approximately 70°C, for 1 hour. Not until then had the polymerization terminated, leaving the prosthesis ready for use. The solution to the problem, making a one-stage procedure possible, was reached by adding certain substances, producing a redox complex, which eliminated the need for heating and compression and brought about autopolymerization that terminated within 8–10 minutes. With this rapid method, heat evolves with a temperature of between 70 and 80°C.

_Bacteriologic Studies and Animal Experiments_. Woringer has shown that the liquid (monomer) not only is sterile but also has a bacteriostatic action, tending to inhibit cultures of staphylococci, coliform bacteria and streptococci. The powder (polymer) can be used direct from the manufacturer’s package, for it is satisfactorily sterilized by addition of the liquid. Important, therefore, is to mix the substances adequately, so that the mixture will be sterile.\(^3,12,13,21,22\)

Blaine, in a series of animal experiments, found only a minimal fibrous tissue reaction to the implant. A similar result was obtained by Hoffmann\(^7\) as well as by Dodge and Craig in experiments on dogs. Woringer compared the tissue reactions from tantalum and from acrylic implants and found them to be equally slight.

**OPERATIVE TECHNIQUE**

Following exposure of the cranial defect all tissue is removed from edges of the bone, so as to permit accurate fitting of the prosthesis. The dura mater, if injured, is sutured; minor dural defects are repaired with muscle grafts and major ones with polyethylene film. In order to protect the dura mater and adjacent tissue from the heat produced at polymerization, a covering of cotton strips moistened in saline is applied. This also ensures that the prosthesis will not rest directly on the dura mater, thus leaving a space for expansion of the brain. The powder is poured direct from its container into a sterile dish in an amount commensurate with the size of the defect. The liquid is then stirred in, care being taken to ensure that all powder is incorporated in the mixture; this is important both for sterility of the plastic and for homogeneity of the finished prosthesis.

The resulting paste is initially somewhat viscose, but this phenomenon disappears after a minute or so, leaving a highly cohesive and homogeneous sheet, moldable to any shape. It can be thinned out by stretching, and conversely it can be thickened by folding. This facilitates shaping of the plastic in the defect and exact duplication of the anatomy. When the paste begins to harden, cold salt solution is poured over it, and after a further minute or so the prosthesis is removed, now retaining its shape yet still having a consistency enabling it to be trimmed with shears. Once having hardened, the prosthesis is firm, difficult to break, and has a slight degree of elasticity which prevents distortion from bending. The final trimming can now be done with a rongeur, and a few holes are drilled for fixation with stainless steel wire.

Adaptation of the prosthesis to the defect has consistently been done according to the inlay principle; only in a few cases has a layer of adequate thickness overlapped the margins of the bone by about 5–10 mm., somewhat like a lid. Some