REPAIR OF CRANIAL DEFECTS WITH TANTALUM

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Autogenous bone transplant repair of cranial defects is not completely satisfactory. It entails an extended or separate operative procedure to secure bone, the size and contour of which leaves something to be desired. A "crows-nest" appearance may result from a multiple fragment repair and there is some question of the survival of the bone fragments as osseous tissue. An ideal substitute material has yet to be discovered. Such a substance should be readily available, easily worked, preferably workable when cold, strong enough to withstand ordinary trauma, and above all, inert in tissue.

Until 1936, when Venable, Stuck and Beach found that vitallium caused no tissue reaction, a satisfactory substitute for bone was unavailable. In the search for an inert metal, Burch (1938) obtained tantalum and, for the first time, used it in surgery. Burch and Carney's observations on the inertia of tantalum in tissues were reported in 1942. Burke (1940) reported that no reaction was produced by tantalum wire in soft tissue.

The adaptability of tantalum to neurosurgery was demonstrated by Pudenz (1942). He proved that brain substance and meninges of cats tolerated the metal extremely well and that the skull plate replacements were efficient. Fulcher (1943) reported a case in which he repaired a frontal skull defect with tantalum sheet metal. Neither Craig nor Spurling have reported their considerable experiences with tantalum in several applications in the field of neurosurgery.

Some information regarding tantalum will explain its suitability for use in surgery, and particularly in cranioplasty. It is an element; a heavy metal with a density of 16.6 (about twice that of steel). It reacts only to strong alkalis, hydrofluoric acid, and concentrated or fuming sulfuric acid at ordinary temperatures. It is virtually non-magnetic and is very high in the EMF Series. These attributes obviate the "storage-battery effect" frequently found in alloys when placed in tissues. Its chemical inertia obviates reactions to body fluids.

Tantalum is workable when cold but cannot be cast. Strength and thermal conductivity are approximately that of steel. The coefficient of expansion of tantalum is 50 per cent that of steel, 40 per cent that of copper and 30 per cent that of silver. Its workability makes it "adaptable to the situation" in contrast to stock or specially cast metal replacements. In the range of body temperature, changes in size of the metal are insignificant.

* Tantalum is produced by the Fansteel Metallurgical Corporation, North Chicago, Illinois.
† While the present article was in press the use of tantalum wire and foil in peripheral nerve surgery was reported by Lt. Col. R. G. Spurling (J. Neurosurg., 1944, 1: 133-148).
Tantalum sheet metal (.015 and .02 inches thick) has been used to repair skull defects at Brooke General Hospital, Fort Sam Houston, Texas, since September, 1942. It has been found that tantalum is easy to use, very adaptable to situations met at the operating table and it has been demonstrated that its reaction in tissue is minimal. No reaction was observed in one tantalum cranioplasty revised after six days, or to segments of tantalum foil after being in place over cortical lacerations so long as 54 days.

Two methods of cranioplasty with tantalum have been used at Brooke General Hospital. One is a two-stage operation, the other a one-stage procedure. In the former, the bed for the plate is prepared by mortising the periphery of the bone defect. A shelf is made in the outer table by chisel, or burr, 2 to 3 mm. beyond the limit of the defect. An impression of the defect, and details of the margin of bone, is obtained with ordinary dental impression compound. A wax model is made duplicating the contour of the portion of the skull to be replaced. From this positive, a die and counter die are made of either calcar, or zinc and lead to swage the metal to conform to size, shape and contour of the missing bone. At secondary operation, the plate is merely placed into the previously prepared bed and fixed in position.

The more frequent, and highly satisfactory method, is a one-stage procedure. The bed is prepared as described above. The approximate size segment of tantalum is molded by bending and shaping, or more frequently by “beating” to contour. Then the exact outline is cut with heavy scissors to conform to the outline of the mortised defect. By this method, done at primary operation, it has been possible in several of the cases to omit the precaution of fixing the plate into position.

If the outline has been cut accurately to size and shape, after the contour has been formed, one border of the plate is engaged into the shoulder of the mortise and by slight bending, and forcing the opposite border into its corresponding shoulder, the plate will fit so well when it has flattened out as a result of its inherent spring, that it will lock itself into position. This is not so difficult as it would seem in description.

Other methods exist or may occur to the surgeon. Moulage, or other type of impression, can be made of the cranial defect before operation. Contour and approximate size and shape of the replacement can thus be formed pre-operatively. This planned type of replacement is advantageous, especially in the frontal regions of the skull where bilateral exact symmetry is most important.

Fixation of the tantalum replacement may be accomplished by wire suture passing through the edge of the plate and through the adjacent bone. In several instances, we used small triangular trimmings of the tantalum sheet, utilizing the principle of glazier’s points. These points are driven into the diploic space about the margin of the defect in the same manner that a glazier immobilizes a glass window pane before applying putty about its border. We believe that, with rare exceptions, all replacements should be fixed and the “glazier point” method has mechanical advantages over fixation with wire.