Primary Repair of Compound Skull Fractures by Replacement of Bone Fragments*

FRED C. KRISs, M.D., JAMES A. TAREN, M.D., AND EDGAR A. KAHN, M.D.
Department of Surgery, Section of Neurosurgery, University of Michigan Medical Center, Ann Arbor, Michigan

EUROSURGEONS are almost unanimous in their agreement with the principle of early debridement of compound skull fractures. However, there are many differences of opinion as to the immediate handling of the bony defect which follows debridement. The classical and accepted method involves total resection of all the contaminated bone and fragments at the fracture site.\(^7\)\(^8\)\(^9\) A second operation for cranioplasty is then performed at a later date.

We believe that primary repair of these bony defects can be achieved by the replacement of bone fragments at the time of the initial debridement. This can be accomplished without danger to the patient. Gross contamination, even in the presence of dural or brain laceration, does not contraindicate bone replacement provided the dura can be sutured.

During a 17-year period at the University of Michigan Medical Center, 79 patients were treated with replacement of free bone fragments as a primary procedure in compound skull fractures. Only two patients became infected, and in only one of them did the bone fragments have to be removed. An excellent cosmetic and functional result with solid skulls was achieved in 75 out of 79 patients. No patient developed osteomyelitis. This report extends that of Carrington, et al.,\(^9\) from this clinic in which 20 cases were reported in 1960.

This technique is not without precedent, since MacEwen\(^6\) in 1888 replaced bone fragments after washing them in bichloride of mercury. Coleman,\(^3\) Lyerly,\(^5\) and Browder\(^1\) also support the idea of early return of bone fragments provided there is no gross contamination of bone and if the dura has not been lacerated. Primary repair of skull defects by acrylic resin has been described by Schorstein\(^11\) and Rietz.\(^9\) Gillingham\(^4\) reported taking free grafts from the outer table of the skull during World War II, but he gave no follow-up.

Our report presents the first long-term documented follow-up on a series of fractures repaired with bone fragments. The following four representative cases illustrate the various problems, techniques, and results.

Case Reports

Case 1. A 10-year-old girl was involved in an automobile accident on December 17, 1958, and sustained a circumscribed compound depressed skull fracture in the left parietal area measuring 5 × 4\(\frac{1}{2}\) cm. She was briefly unconscious, but otherwise neurologically normal. In the operating room a badly comminuted fracture was found with a dural laceration. The cortex was intact. The wound and bone fragments were mechanically debrided, then soaked in aqueous Zephiran. The dural laceration was closed with silk, after cortical inspection, and the bone fragments replaced as a mosaic. The dura was tacked to the pericranium with chromic catgut sutures to add support.

The bone fragments quickly incorporated to form a solid bony skull. Ten years later, February 28, 1968, the fracture could not even be seen (Fig. 1); the patient is perfectly well and is a sophomore in college.

Case 2. A 14-year-old farm boy was thrown from a horse on September 9, 1956, striking his head on a plow blade. He was immediately unconscious and was semicoma
tose upon arrival in the emergency room. Brain was extruding through a 4 cm laceration in the left parietal region, and a rightsided hemiparesis was present. He was taken to the operating room 5 hours after his in-
jury where bone fragments from a 10 × 10 cm depressed fracture were all removed, saved, and soaked in antiseptic solution. Necrotic brain was removed from a cortical laceration, and an 8-cm dural laceration was closed. Several of the large bone fragments were then replaced in the bony defect and held in place with pericranial bridging sutures over them. The scalp was closed with a single layer of wire sutures.

The patient made a rapid recovery with resolution of the hemiparesis. He had several focal seizures involving the right face 5 days postoperatively and another focal seizure 2 years postoperatively when he discontinued his anticonvulsant medicine. For the past 10 years he has been free of seizures. He has otherwise enjoyed perfect health. Now, 12 years after his accident the skull is solid (Fig. 2).

Comment. We feel the single layer scalp closure is important because it avoids foreign body reaction in the galea.

Case 3. A 13-year-old schoolboy was involved in an automobile accident on September 30, 1958, striking his head on the dashboard. A large supraorbital laceration was present, with brain extruding through the laceration. On exploration the supra-orbital ridge was found to be depressed into the frontal lobe as a free fragment through a dural defect which measured 2 × 4 cm (Fig. 3, left). The mucous membrane of the frontal sinus was exenterated, the frontal lobe debrided, and the dural rent closed with a temporalis fascia graft. The supra-orbital ridge was soaked in antiseptic, replaced, and wired for stability (Fig. 3, right). The patient made an excellent recovery and was neurologically normal at discharge. The supra-orbital ridge remained in excellent position 3 years later, and a fine cosmetic result was obtained.

Comment. We feel this type of fracture involving a supra-orbital ridge is especially suitable for replacement of the free fragment. The cosmetic defect resulting from loss of the supra-orbital ridge is especially noticeable. Cranioplastie repair, even with acrylic, is difficult and often imperfect. Rib autogenous grafts tend to reabsorb.
The next case represents one of the two infections in our total series of 79 cases. It will be seen that no serious complications supervened, no bone had to be removed, and the end result was excellent.

Case 4. On June 5, 1967, a 15-month-old boy crawled under a neighbor’s car; the automobile was unknowingly backed out of the driveway and over the head of the infant. A tangential crush injury was sustained, splitting open the scalp widely in the parietal occipital area. The child was in shock when brought to the emergency ward due to massive blood loss from the scalp. Rapid transfusion saved his life, and he was taken to the operating room where an extensive comminuted skull fracture was found involving essentially the whole posterior one-half of the skull. Cerebellum, right lateral sinus, and sagittal sinus could be seen through the dura, which, fortunately, was intact. Dirt and gravel from the driveway had to be picked out of the wound. Multiple pieces of skull were extracted, mechanically cleaned, and soaked in Betadine.* The wound was vigorously debrided and irrigated with Betadine.

*Betadine (chemical name-povidone-iodine), the Purdue Frederick Company, Yonkers, New York.

The large bone fragments were then replaced in the bony defect in a mosaic pattern and wired together (Fig. 4). The wound was closed in one layer and the patient did remarkably well; recovery was complete. Six weeks following the repair, a small pustule appeared in the occipital scalp. This was opened, granulation tissue curetted, and the wound packed open for 10 days. It was then closed with sutures. No bone had to be removed. Examination 6 months postoperatively revealed good incorporation of bone fragments and a solid calvarium (Fig. 5).

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**Fig. 3.** Case 3. *Left:* Photograph of preoperative x-ray film of skull showing depressed and rotated supra-orbital ridge. *Right:* Supra-orbital ridge replaced as a free fragment and wired for stability with excellent cosmetic result.

**Fig. 4.** Case 4. Operative photograph showing extent of scalp laceration and debrided wound with multiple bone fragments replaced and wired in position.
Comment. To have excised and discarded all contaminated bone in such a massive fracture would have left the infant with only one-half his skull and the prospect of an extremely difficult cranioplasty in the future. He suffered no serious sequelae from the infection, no bone fragments were lost, and osteomyelitis did not result.

Discussion

Advantages. We believe that primary repair of compound skull fractures can be achieved by the replacement of bone fragments. Regardless of the contamination or lacerations of the dura or brain, replacement can be accomplished safely and successfully provided the wound can be treated within 24 hours and the dura closed primarily. Antibiotics are, of course, used. We feel this series with one 17-year follow-up has proved the efficacy of such treatment.

The skull defects resulting from resection of bone are both unsightly and dangerous. In children (66% of our series), the defects are more difficult to repair than in adults. Prostheses are apt to loosen or fracture as the child grows. There is also a tendency to procrastinate and hope that bone regeneration will occur. It has been our experience that even clean defects more than 1 inch in diameter will rarely regenerate. This procedure repairs the bony defect without the need and risk of a second operation for cranioplasty.

Complications. We have had two infections. In one, the bone fragments had to be removed and an acrylic cranioplasty performed 1 year later. The other (Case 4, Figs. 4 and 5) did not lose any bone fragments. In neither case was the complication serious or life-threatening. Three patients (including the one infected case) needed acrylic cranioplasty because of inadequate bone replacement. Each of the other 75 patients has been carefully re-examined from 1 to 17 years postoperatively. All wounds healed primarily without pulsatile defect, the skull has remained solid, and no complications have occurred.

The incidence of posttraumatic epilepsy was 11% in the 35 cases with laceration of the dura or brain.

Summary

We have reported a long-term follow-up of 79 patients with compound skull fractures who were treated by immediate replacement of the original bone fragments. In 75 there was an excellent cosmetic result and a solid skull. Many cases have been followed for more than 10 years and one for 17 years. There have been only two instances of infection following the procedure. We have described four representative cases from the series and have given our reasons for believing that this form of treatment is preferable to classic debridement with or without a second operation to install a prosthesis. Only three cases later required cranioplasty.

Fig. 5. Case 4. Top: Photograph of skull x-ray film 1 week postoperatively showing multiple bone fragments wired into place in mosaic pattern and extending over entire parietal-occipital-suboccipital area. Bottom: Appearance of skull x-ray 6 months after debridement with no evidence of osteomyelitis and beginning incorporation of fragments.
References


