Enlarging Skull Fractures: An Experimental Study*

FRANK GOLDSTEIN, M.D., †THOMAS SAKODA, M.D., JOHN J. KEPES, M.D., KENDRICK DAVIDSON, M.D., AND CHARLES E. BRACKETT, M.D.

Departments of Surgery (Section of Neurosurgery), Pathology and Oncology, and Radiology, Kansas University Medical Center, Kansas City, Kansas

Steady enlargement of a skull fracture sometimes follows a head injury, particularly in the first year of life. A review of the literature and discussion of clinical features and problems were presented in 1961 by Lende and Erickson. Other cases subsequently have been reported. Our interest in the problem was stimulated by the case of a 2-year-old girl with a parietal fracture that was apparently enlarging or "growing" 9 months after injury. Surgical exploration exposed a large dural defect; one edge of the defect was 1 to 2 cm behind the bone edge while the other dural margin passed through the fracture line to fuse with pericranium. There were multiple small arachnoidal cysts and old cortical contusions. Dural repair was easily accomplished and the skull defect repaired with split rib grafts.

The following investigation was designed to determine which elements of the clinical syndrome (skull fracture, dural tear, arachnoidal tear, brain and pial tear, or ventricular communication) were essential to the production of an enlarging fracture.

Materials and Methods

Twenty-eight dogs aged 4 weeks (unweaned) to 8 weeks (weaned) were used. Each animal was anesthetized with intraperitoneal Nembutal. A midline vertex scalp incision and bilateral rectilinear osteoplastic parietal bone flaps were made using a dental disc 1 mm in thickness (Fig. 1). The bone flaps were hinged on the temporalis muscle. Additional procedures on meninges or brain were carried out in the region underlying either the anterior or the posterior limb of the craniotomy on each side. The other three limbs of each flap served as controls. There were five experimental operative groups with 10 craniotomies in each group, except for Group 2 which had 15.

The operative procedure varied according to group. In the first four groups, a dural incision was made after craniotomy, and the pericranium was sutured to the dural edge with the formation of a "pouch." Additional procedures were done as follows:

- Group 1. The dura was incised, but care was taken to maintain the arachnoid intact (Fig. 2 A).
- Group 2. The arachnoid was torn, and cerebrospinal fluid was allowed to enter the pouch (Fig. 2 B).
- Group 3. The pia was opened, and brain was damaged to a depth of 4 mm (Fig. 2 C).
- Group 4. One lateral ventricle was opened, and cerebrospinal fluid was permitted to escape (Fig. 2 D).
- Group 5. The dura and arachnoid were

![Fig. 1. Diagram of bilateral rectilinear osteoplastic parietal bone flaps.](image-url)
opened so that one edge of the dura was recessed behind the linear craniotomy and the other edge was brought through the craniotomy line and attached to the pericranium without pouch formation (Fig. 2 E).

In all groups, the bone flaps were sutured into normal position. Immediately after operation, x-rays of the skull were taken (Fig. 3). Later, x-rays were taken at suitable intervals to determine if, in fact, an expanding craniotomy line ("growing fracture") occurred in the experimental limb as compared to the normal healing process which was expected in the control limbs. The animals were sacrificed when x-rays revealed that bone healing had occurred or an enlarging craniotomy line had developed. A cranial cap that included pericranium, bone, meninges, and brain was removed en bloc. The specimen was fixed in 10% formalin, and x-rays of the cranial cap were taken. After decalcification, longitudinal sections of the experimental and control sites were made. Histological sections were stained with Hematoxylin-cosin, van Gieson, and Gomori's trichrome stains.

Results

Results are summarized in Table 1. For all groups, sections from craniotomy lines with no underlying damage in meninges or brain (used as controls in this experiment) showed various stages of normal healing depending on the time of sacrifice of the animal. First, a fibrous callus formed be-

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Fig. 2. Operative methods. (a) The dura was incised but care was taken to maintain the arachnoid intact. (b) The arachnoid was torn, and cerebrospinal fluid was allowed to enter into the pouch. (c) The pia and brain were damaged to a depth of 4 mm. (d) The lateral ventricular was opened and ventricular fluid permitted to escape. (e) The dura and arachnoid were opened so that one edge of the dura was recessed behind the linear craniotomy and the other edge was brought through the fracture site and attached to the pericranium without pouch formation.