Papers and abstracts from the Eighteenth National Osteopathic Research Conference*

Michigan State University-College of Osteopathic Medicine

**The Eighteenth National Osteopathic Research Conference was held under the auspices of the Bureau of Research of the American Osteopathic Association on March 15 and 16, 1974, at the University of Chicago Center for Continuing Education. Papers and abstracts by researchers from the Philadelphia College of Osteopathic Medicine appeared in the January 1975 issue of JAOA, from the College of Osteopathic Medicine and Surgery, Des Moines, in the February issue, from Kirksville College of Osteopathic Medicine in the March issue, and from Chicago College of Osteopathic Medicine in the April issue. This JAOA includes papers from Michigan State University-College of Osteopathic Medicine. Research findings from the remaining osteopathic colleges will be published in subsequent issues.*

A preliminary study of cranial bone movement in the squirrel monkey

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The cranial motion concept first advanced by Sutherland[1] is still highly controversial. Palpatory findings in its support are subjective and disputable. The only objective study of cranial motion describes patterns in the human being that are synchronous with both the arterial pulse and the respiratory rates, as well as the presence of a slower idiosyncratic rhythm.[2] However, the presence of tissue between the skull and recording heads suggests the possibility of recording artifacts. The present report describes experiments designed to test the hypothesis that the cranial bones move and possess a slow rhythmic motion pattern, by direct instrumentation of cranial bone displacement in the monkey.

Methods

Adult (> 3 year old), female monkeys, Saimiri sciureus, weighing 500-700 gm., were anesthetized with sodium pentobarbital (20 mg./kg., intraperitoneally). The animal was placed in a supine position and its head was secured in a stereotaxic frame. Lateral immobilization was accomplished by use of two tapered rods inserted into the external auditory meatus. Vertical fixation was by a single flat bar pressing upward against the roof of the mouth and by two hook-like bars pressing downward on the infraorbital ridges. These rods and bars were fixed in position by adjustable clamps, which prevented their being moved during the experiment.

Femoral arterial blood pressure was monitored with a Statham P23AC transducer and Grass 7P polygraph, enabling the determination of mean arterial blood pressure (MBP) and heart rate (f_H). In two animals an external jugular venous cannula was advanced to the heart, allowed the monitoring of central venous pressure (CVP) with a Statham P23V transducer. Cannulas were maintained patent by flushing with a heparinized sodium chloride (NaCl) solution (1,000 units sodium heparin per milliliter 0.9 percent NaCl). Respiration rate (f_R) was monitored either as tracheal pressure changes with the use of a Statham P23V transducer or as thoracic displacement with the use of a Statham FT10C transducer.

A midline scalp incision (4-6 cm.), extending from the frontal to the occipital pole, and lateral scalp incision (<2 cm.) allowed the scalp to be reflected, exposing the skull. A small hole (<0.5 mm. diameter) was drilled in the right parietal bone, 1 cm. posterior and 0.5 cm. lateral to the bregma, into which a small, stainless steel eye screw was threaded perpendicular to the bone surface. Care was taken to maintain dural integrity. A Statham FTO3C transducer, connected to the eye screw with silk suture (no. 00), monitored the frequency of parietal bone movement (f_M) by measuring its displacement (D_B). No attempt was made to quantitate D_B. In one animal, f_M and D_B were simultaneously and bilaterally monitored.

A control recording period (10-20 minutes) revealed the basic motion patterns of f_M, f_H, and f_R and allowed the determination of MBP and CVP. D_B was elicited by applying a light digital force (< 10 gm.) to the skull or spinal column for 3-10 seconds. Failure of the D_B tracing to return to baseline after the force was removed was interpreted as whole skull movement within the stereotaxic apparatus. Force was applied to the skull at the sites and in the directions listed below:

(a) frontal bone at frontal pole, posterior;
(b) occipital bone at occipital pole, anterior;
(c) parietal bone, caudal; and
(d) maxilla, posterior.

A force directed anteriorly was applied separately at the cervical, the thoracic, or the lumbar regions to simulate extension. Their regional flexion was simulated by a grasping of the skin overlying the particular spinal region and a general posterior pull, which did not alter the monkey's body position in the support sling.

Assessment of recording artifacts

The possibility of recording artifacts due to movement of either the entire skull or the stereotaxic apparatus was assessed by the use of a wood block (white pine, 2 inches × 4 inches × 6 inches) secured in the stereotaxic frame by the ear bars and the orbital stabilizers. A wood screw positioned 1.5 cm. posterior to the pivot axis (that is, ear bar plane) was connected to a FTO3C transducer positioned directly above it to monitor board displacement. The polygraph preamplifier sensitivity was set at 0.1 mv./cm. (that is, 10 times that used during experiments) and a 100 gm. weight (that is, >10 times the experimental force) was placed at various sites (3-15 cm.) anterior, posterior, and lateral to the wood screw. A pen deflection (<3 mm.) was recorded when the 100 gm. weight was 15 cm. posterior to the wood screw; however, none was evident at sites <6 cm. away.

Forces (500-1,000 gm.) applied to or removed from either the legs of the stereotaxic apparatus or the support sling did not cause pen deflections. However, application of a 0.5 gm. weight to the displacement pick-up head resulted in a full-scale pen deflection (that is, > 100 mm.), which returned to baseline upon removal of the weight. Pushing or pulling the stereotaxic apparatus across the table by its legs resulted in pen deflections of 3-8 mm., which did not return to baseline. It was concluded that during the experiments with monkeys a tracing of D_B that deviated from the baseline with the application of a small force (<10 gm.) and returned to it upon removal of that force was the result of parietal bone displacement.

Results

A tracing of the patterns reflecting f_M, f_H, and f_R is shown in Figure 1. An f_M, corresponding to f_R, was recorded superimposed upon a second f_M (range 5-7 · $min.^{-1}$, which did not correspond with either f_R or f_H. Mean control values (± S.E.) for MBP, f_H, and f_R (Table 1) do not differ from previously reported data.[3,4] In the two animals in which CVP (range 1-4 cm. H_2O) was monitored, f_R and f_H were reflected as pressure changes; however, changes corresponding to f_M were not observed.

Forces applied to the skull at various sites usually resulted in reversible D_B (Fig. 2). Downward D_B was evident when pressure was applied to either the frontal or the

TABLE 1. PHYSIOLOGIC DATA OBTAINED IN SIX ANESTHETIZED SQUIRREL MONKEYS. (ALL VALUES ARE MEANS ± S.E.)

MBP* (mm. Hg)	f_H† ($min.^{-1}$)	f_R‡ ($min.^{-1}$)
94 ± 14	244 ± 17	49 ± 3

* MBP — mean blood pressure
† f_H — heart rate
‡ f_R — respiratory rate

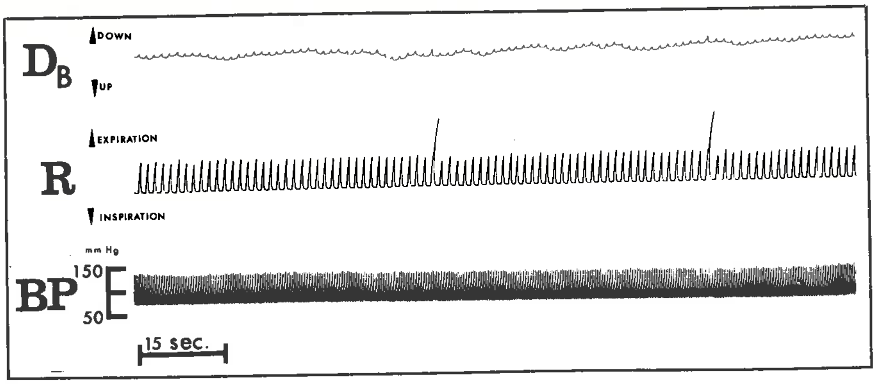

Fig. 1. *Record of parietal bone displacement (DB), respiration (R), and arterial blood pressure (BP) in the squirrel monkey.*

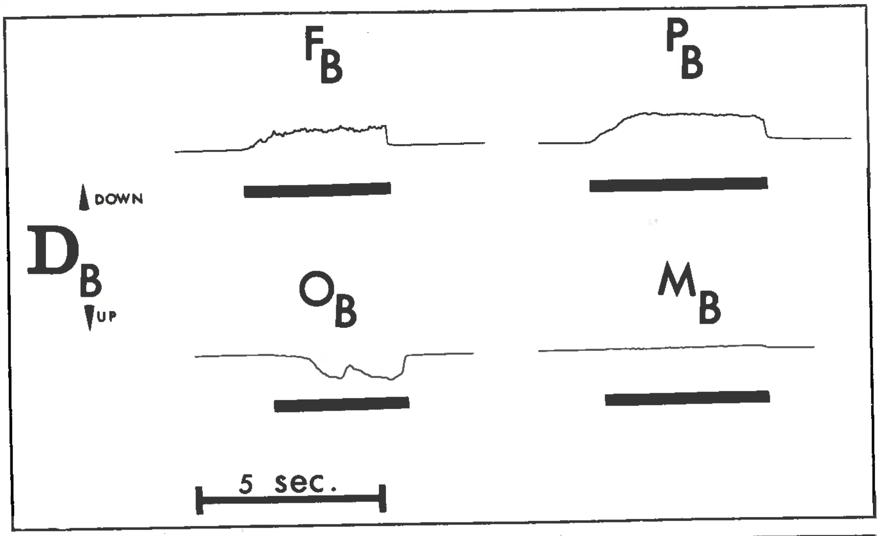

Fig. 2. *Records of parietal bone displacement (DB) during application of a light force, interval indicated by the horizontal bar, to the frontal (FB), parietal (PB), occipital (OB), and maxillary (MB) bones of the skull. The preamplifier was attenuated to remove the respiratory effects on the recorded DB.*

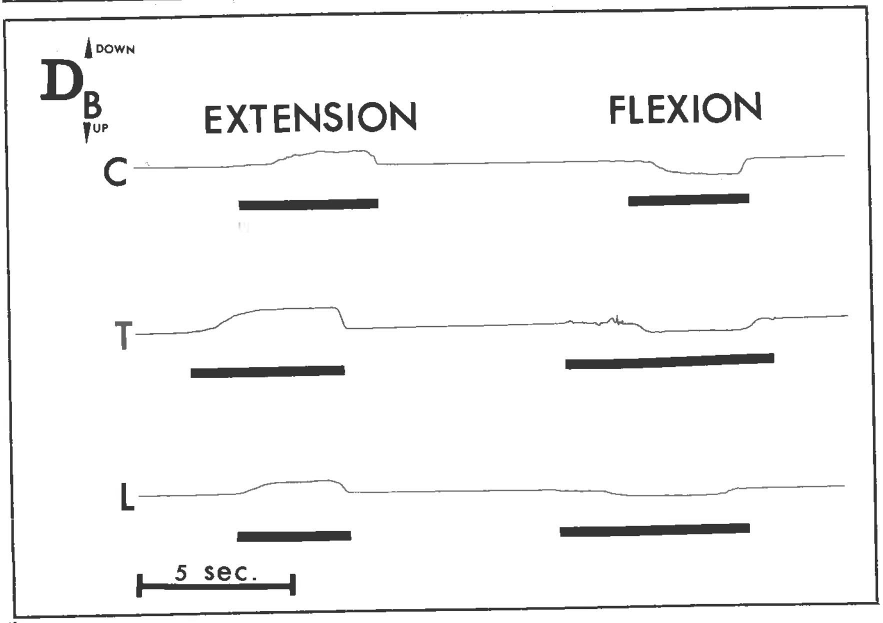

Fig. 3. *Records of parietal bone displacement (DB) during spinal flexion and extension of the cervical (C), thoracic (T), and lumbar (L) segments. The horizontal bar indicates the time interval of flexion or extension. The preamplifier was attenuated to remove the respiratory effects on the recorded DB.*

parietal bones; upward DB was evident when the force was exerted on the occipital bone. Forces applied to the maxilla did not produce DB, a result implying that the skull was adequately immobilized.

Simulation of spinal column extension in the cervical, thoracic, or lumbar regions resulted in downward DB, whereas their flexion resulted in upward DB (Fig. 3).

Discussion

This report describes a cyclic cranial bone displacement pattern of 5-7 cycles · min.$^{-1}$, which could not be attributed to either respiration or heart rate (Fig. 1), in the anesthetized adult monkey. A cranial motion pattern of 7-12 cycles · min.$^{-1}$ has been palpated[5-7] and recorded with an oscillograph[2] in human beings. Similar cranial motion

continued on page **869**/138

patterns have been palpated in the dog.[7]

Cranial motion has been attributed in part to forces associated with other processes (that is, respiratory movement) and transmitted up the vertebral column via its ligamentous attachments.[1] Figure 1 shows cranial bone displacements associated with respiration in support of that concept. Structural anomalies in the adult human skull, defined and described roentgenographically, show a correlation with sacral base lesions,[5] suggesting strain transmission via the connections of the vertebral column with the cranium. Our data (Fig. 3), which show that spinal flexions and extensions resulted in cranial bone displacement, support that hypothesis.

Summary

This report describes experiments designed to test the hypothesis that the cranial bones in the adult monkey move. Parietal bone displacement patterns were recorded. One corresponded to the respiratory frequency; another of 5-7 cycles · min.$^{-1}$ corresponded to neither heart rate nor changes in central venous pressure. Reversible displacement of the parietal bone was induced by the direct application of force to the cranium, by spinal flexion, and by spinal extension. A possible etiology for parietal bone displacement is discussed.

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Cranial bone mobility

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The cranial bone mobility concept originated with observations by Sutherland[1] while he was a student of osteopathy at Kirksville in 1899. His studies on human skulls involving mobility at the sutures were accorded little acceptance until 1940, when the Academy of Applied Osteopathy offered its support. Then, in 1947, the Osteopathic Cranial Association was formed; in 1960, it became the Cranial Academy, an official affiliate of the AAO. The purposes of the Cranial Academy were to teach the techniques and to investigate the mechanisms of cranial manipulative therapy.[2]

Cranial bone articulations in the dissected skull suggest their mobility,[1,3,4] a generally accepted concept in the child and adolescent. However, many claim that adult cranial bone sutures are so completely ossified and the component bones are fused to such an extent that any movements of the individual bones relative to each other is a physical impossibility.[5-7]

The question of suture closure and ossification is discussed in most textbooks of anatomy. According to Gray[5] the time of suture closure varies considerably, with the final activity in old age. A point seldom discussed is what actually constitutes suture closure. Is it a complete ossification process, or are the interdigitated bone edges tied together by connective tissue?

The thirty-fifth British edition of "Gray's Anatomy"[8] shows a schematic representation of the general structure of the suture. The discussion of suture development presents numerous details which are not covered in most textbooks. One statement of particular interest is as follows:

> Sutural fusion does not even commence until the late twenties, proceeding slowly thereafter; yet it is clearly necessary that sutures should cease to function as mobile joints as rapidly as possible after birth.

It is difficult to rationalize why it is "clearly necessary" that the sutures cease to function as mobile joints. There is no