168 Journal of Manipulative and Physiological Therapeutics
Volume 17 • Number 3 • March/April, 1994
0161-4754/94/1703-0168 $03.00/0 © 1994 JMPT

A Preliminary Single Case Magnetic Resonance Imaging Investigation into Maxillary Frontal-Parietal Manipulation and Its Short-Term Effect upon the Intercranial Structures of an Adult Human Brain

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ABSTRACT

Objective: To investigate the hypothesis that external cranial manipulation can cause change within the structures of the human brain.

Design: Single subject.

Setting: Private office.

Participant: A 42-yr-old man.

Intervention: MRI scan was administered without manipulative pressure but with the investigator's contacts on the test subjects maxillary palate and frontal/parietal region surrounding the bregma.

Outcomes: Measurements were taken along the superior border of the corpus callosum, the width of the fornix column, the exposed anterior/superior wall of the lateral ventricle posterior to the fornix, the angular surface of the cerebellar central lobule and the posterior surface of the inferior colliculi.

Results: Results from the second MRI (administered during the application of external cranial pressure) demonstrated elimination of a 5-mm peak along the superior border of the corpus callosum and a 4-mm reduction in the width of the fornix column. The exposed anterior/superior wall of the lateral ventricle posterior to the fornix column increased 51 degrees cephalad with manipulative application. The angular surface of the central lobule altered by minus 26 degrees, and the posterior surface of the inferior colliculi varied by minus 7 degrees. The subject experienced no change in his asymptomatic condition as a result of this study.

Conclusion: The present study supports the theory that external cranial manipulation affects the structure of the brain. It also suggests support for the theory regarding suture mobility. (J Manipulative Physiol Ther 1994; 17:168–173).

Key Indexing Terms: Chiropractic Manipulation,Cranium, MRI.

INTRODUCTION

Cranial manipulation began with the investigations of the osteopath Dr. William G. Sutherland in the early 1900s (1). It was Sutherland's hypothesis that the cranial bones functioned independently upon each other and that this mobility was influenced by the alterations of hydrokinetic pressures generated within the cranial vault by cerebrospinal fluid (CSF) and blood. He further theorized that trauma, myofascial tension and stress could cause disruption to the meningeal/osseous relationship. According to his theory, this disruption would affect the environment of the brain and possibly render a significant role in cases of headache, hypertension and various conditions related to brain dysfunction. In addition to this theory, Dr. Sutherland postulated that the specific application of external manipulation to the different bones of the skull would transfer into the dural meningeal system via the sutures. He further believed that the hydrokinetic pressure located within the cranium would constitute a counter force that would influence a change within the meningeal system and thereupon alter the environment of the brain. Under this theory Sutherland (2) hypothesized that the neuronal function of the brain could actually be altered. He spent the better part of his life in pursuit of his theory.

In 1933 Dr. Major DeJarnette (chiropractor, osteopath and founder of Sacro Occipital Technique) began his investigation of cranial analysis and manipulation. Through his theory of departmentalizing analysis of the human condition, Dr. DeJarnette developed the "category system" of analysis and treatment, further enhancing the methodology of cranial manipulation by developing specific manipulative therapeutic approaches according to the idiopathic category of the patient. In 1952, Dr. DeJarnette (3) first published his manipulative cranial technique and thus began one of the first major integrations of cranial therapy into the field of chiropractic. Since that time, cranial manipulation has found both favor and controversy within the chiropractic profession.

A major source of controversy is the question of whether cranial manipulation can actually initiate change within the intercranial environment. Dissection observations with the application of external manipulative force, studies utilizing oscillators with electric capacitative microphones linked to an oscilloscope and FT03C transducers connected to Grass polygraphic equipment have contributed much to our understanding on the subject (4–6). However, the question of the specific effect of cranial manipulation upon the structures of the brain still eludes us.

The purpose of this preliminary investigation is to test the hypothesis that external cranial manipulation can cause observable change within the structures of a living human brain. Confirmation will support the contention for suture mobility. Magnetic resonance imaging (MRI) scanning was selected because it is noninvasive, diagnostically accurate and produces a visual record. Inspection of the intercranial structures before and during the application of cranial manipulative pressure was thus mapped and recorded on film.

MATERIALS AND METHODS

A 42-yr-old asymptomatic male subject, 167 cm and weighing 63.5 kg with no prior history of cranial surgery or neurological disorders, was chosen for the study. The study was performed in compliance with the Helsinki Declaration of 1975. The subject was informed of the potential risks and benefits prior to the study and gave his informed consent to participate. A low-field MRI was chosen for its cost effectiveness and easy access to the subject's cranium. A vital element of this magnet's design is its high absolute field homogeneity which surpasses that of the conventional superconducting magnets. Rothschild et al. (7) note that at this field strength, the T1 for soft tissue is considerably shorter and the radio frequency (RF) power deposition and chemical shift artifacts are decreased. Motion and flow artifacts are also reduced. Sagittal MR image investigations were performed using a First Generation Toshiba Access Imaging System operating at .064T (Toshiba American Medical Systems, 280 Utah Avenue, So. San Francisco, CA 94080). Data were acquired with a 192 × 256 matrix and two-dimensional Fourier transformation. The subject was positioned comfortably in a standard Toshiba head coil (THC). Slice thickness was 10 mm, and a single slice was acquired. Scans were performed with one number of excitation (1 NEX). An echo time (TE) of 30 msec was used. The repetition time (TR) was 150 msec, and the total scan times were 0.29 min.

Two investigators were implemented in the study. Investigator "A" gained access to the subject's parietal/frontal region through the cephalad opening in the THC. A general contact involving the four metacarpal phalangeal joint regions of the investigator's left hand was made. Investigator "B" gained access through the caudal opening of the THC to contact the center of the subject's hard palate with his right thumb. Two midsagittal scans were performed. Scan 1 was performed with the investigator's contacts in position. The contacts were light and absent of pressure application. Upon completion of the first scan, the investigators were instructed to apply firm pressure through the contacts toward the opposing contact point. Pressure application was then maintained during the entire duration of the second scan (Figure 1).

Measurements were acquired through the aid of the MRI computer grid which overlays the anatomically correct grid image of the MRI film. The grid overlay on the magnification (MAG) 3.50 images divides the images into three units of measurement. The largest unit is divided into 5 square centimeters. The midrange unit is 1 square centimeter, and the smallest unit of measurement is divided into 2-mm increments overlaying the square centimeter grid. The images set at MAG 1.60 were divided into square decimeters, 2 square centimeters and 1 square centimeter(s). To measure structures, a single-ply straight edge paper sheet was placed on the photographic film image and aligned to two prominent points related to the structure in question. A compass needle was utilized to puncture the outer edge of the paper adjoining the two points of interest. The puncture points along the paper edge were then aligned to the film grid for dimensional evaluation. Although the MRI grid is considered anatomically correct and measurements are taken from two dominant structural points within the brain, a ±1 mm standard error of mean is considered with each measurement.

RESULTS

In the first scan (performed without pressure application but with the investigator's hands in contact

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Paper submitted March 18, 1993; revised May 24, 1993.

Source of grant, Sacro Occipital Research Society International.

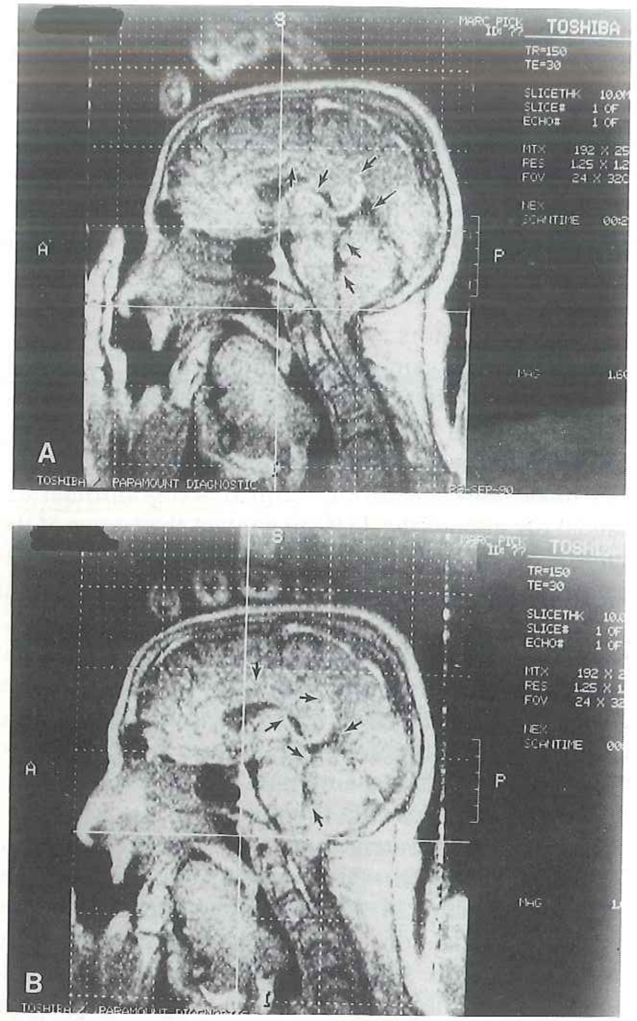

Figure 1. Midsagittal MRI performed at magnification 1.60; the *arrows* depict areas of investigational focus. *A*. First MRI scan performed with the investigator's contacts positioned but without the application of cranial manipulative force. *B*. Second MRI scan performed during the investigator's application of firm manipulative pressure toward the opposing contact point.

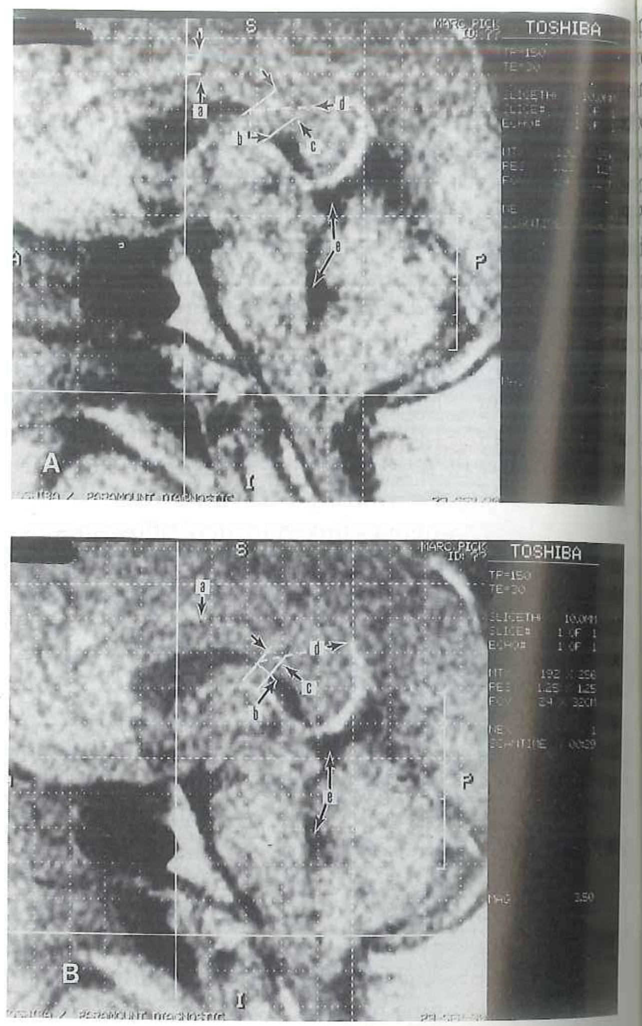

Figure 2. Midsagittal comparative measurements of the brain's internal structures taken from images developed at magnification of 3.50. *A*. MRI performed without application of cranial manipulative force: (*a*) A 5-mm peak is present along the callosal sulcus of the corpus callosum, midway between the genu and the splenium; (*b*) exposed lateral ventricle (posterior to the fornix) is positioned 8 mm caudal to the posterior apex of the ALVO creating a visible cephalad to posterior/caudal step; (*c*) the fornix column's width (between the two lateral ventricle openings) measures 8 mm; (*d*) The superior aspect of the great cerebral vein appears flexed toward the fornix column and measures 28 mm from the posterior apex of the ALVO; (*e*) The superior cistern and fourth ventricle appear enlarged and magnetically translucent, hinting CSF engorgement. *B*. MRI performed during application of cranial manipulative force: (*a*) the callosal sulcus surface of the corpus callosum appears as a continuous arch absent of noticeable peak(s); (*b*) exposed lateral ventricle (posterior to the fornix column) has elevated to create a continuous visible arc with the posterior apex of the ALVO; (*c*) the fornix column's width (between the two lateral ventricle openings) measures 4 mm; (*d*) The superior aspect of the great cerebral vein appears extended away from the fornix column but still measures 28 mm from the posterior apex of the ALVO; (*e*) The superior cistern and fourth ventricle appear condensed and congested with artifacts, suggesting decreased CSF volume compared to Figure 2*A*.

posture), the callosal sulcus surface of the corpus callosum exhibited a 5-mm cephalad peak midway between the commissure fibers of the genu and the splenium (Figure 2*A*). In the second scan (performed during pressure application), the 5 mm peak is absent (Figure 2*B*).

The right lateral ventricle is exposed anterior and posterior to the column of the fornix. In the first scan, the ventricular opening posterior to the fornix is 8 mm caudal to the posterior apex of the anterior/lateral ventricular opening (ALVO). The posture between the two ventricular openings appears as an anterior to posterior caudal step (Figure 2*A*). The MRI from the second scan confirms the posterior lateral ventricular

pening (PLVO) has elevated to create a visible change om the caudal step in the first scan to a continuous rch in the second scan (Figure 2*B*). The fornix column etween the two openings shows a reduction in the idth of the fornix column by 4 mm when cranial anipulative pressure is being applied (Table 1). The PLVO appears to have diminished its anterior/posterior imension during the second scan, creating a superior/ nferior elongation appearance when compared with he first scan. A comparative assessment of the PLVO's nterior wall demonstrates an increased length of 2 mm ith the application of manipulative pressure (Table 1). Comparative angular measurements of the PLVO's nterior/superior wall demonstrates a cephalad increase of 51 degrees with the application of manipulative pressure (Table 2).

The superior aspect of the great cerebral vein measures 28 mm from the posterior apex of the ALVO in the first scan. Its general appearance is that of flexion toward the fornix column (Figure 2*A*). In the second scan, the great cerebral vein's superior aspect appears to have extended superior/posterior. However, upon measurement of the distance from the same intercranial landmark as utilized in the first scan, the distance remained 28 mm (Figure 2*B*).

The superior cistern and fourth ventricle appear to be well hydrated with CSF in the first scan and somewhat dehydrated in the second scan (Figure 2). Investigation of the anterior/posterior walls that make up the inferior region of the superior cistern reveal a change occurring with the application of cranial manipulation. Angular calculations of the anterior wall adjacent to the cerebellar central lobule and the corpora quadrigeminal posterior wall (adjacent to the inferior colliculi), reveal the angular surface of the central lobule as altered by minus 26 degrees and the posterior surface of the inferior colliculi as altered by minus 7 degrees (Table 2).

TABLE 1. Comparative structural data measurements

Region	Scan 1 CW/OP*	Scan 2 CWP†	Comparative difference
Width of fornix column	8 mm	4 mm	−4 mm
Posterior lateral ventricular opening (anterior wall length)	17 mm	19 mm	+2 mm

* CW/OP, contact without pressure.
† CWP, contact with pressure.
All measurements have a ±1 mm standard error of mean.

TABLE 2. Comparative angular measurements of the anterior/superior wall of the posterior lateral ventricular opening and the anterior/posterior walls along the inferior aspect of the superior cistern

Region	Scan 1 CW/OP*	Scan 2 CWP†	Comparative difference
Anterior/superior wall of the posterior lateral ventricular opening	21°	72°	+51°
Wall along the inferior colliculi	55°	48°	−7°
Wall along the central lobule	66°	40°	−26°

* CW/OP, contact without pressure.
† CWP, contact with pressure.
All measurements have a ±2 degree standard error of mean.

DISCUSSION

To support the theory that cranial manipulation will affect the structures of the brain, consideration must be given to the contention supporting suture and independent cranial bone mobility. Without this mobility the concept of specifically altering the structures of the brain would seem improbable. However, most anatomists are skeptical of this hypothesis because in the traditional theory, the adult cranial sutures are so completely ossified or fused that any movement of the individual bones relative to each other should be considered a physical impossibility (8, 9). *Gray's Anatomy* 35th British edition went so far as to report that it was clearly necessary that sutures should cease to function as mobile joints as rapidly as possible after birth (10). Despite the traditional theory's acceptance, numerous investigations have accumulated data to support an opposing viewpoint (5, 6, 11–17). Pritchard et al. (18) suggested that sutures possess the mechanics for motion. He also claimed the existence of five distinct layers of tissue present within the sutural system and that the middle layer housed vascular structures. Partially based on Pritchard et al.'s findings, Retzlaff and Michael (5, 6) conducted several investigations into the study of independent cranial bone movements. Although their studies were conducted on squirrel monkeys, they did favorably reflect the theory of sutural mobility and independent cranial bone motion. In 1971, Baker (19) cited a case study of an adult male in which he recorded cranial bone motion along the sutures from laterally expanding the maxillary arch. It would appear from these studies that sutures should remain mobile in a healthy individual to allow for protective stress management of the intercranial environment.

The attachment of the dura to the brain structure through association with blood vessels and cranial nerves is generally accepted. Subordinating this interconnection with the theory that cranial sutures allow for independent cranial bone motion, it would therefore appear plausible that an external application of manip-

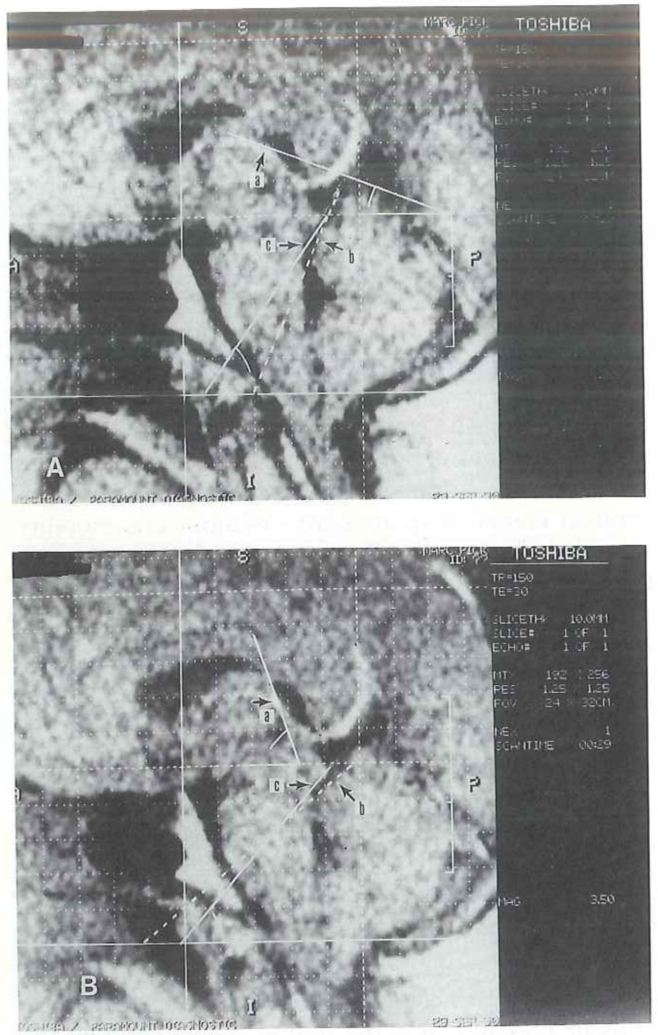

Figure 3. Comparative angular measurements of the PLVO superior/anterior wall and the anterior/posterior walls of the superior cistern's inferior borders. Angular measurements were acquired by intersecting the regions in question with a stationary horizontal computer grid line. Although the computer grid was horizontally set to match the comparative images, a ± degree standard error of means is calculated into the following findings. *A*. Image recorded without application of cranial manipulative force: (*a*) Depicts a 21-degree angulation of the PLVO's superior/anterior wall; (*b*) depicts a 66-degree angulation of the anterior wall adjacent to the cerebellar central lobule; (*c*) depicts a 55-degree posterior surface of the inferior colliculi. *B*. Image recorded with application of cranial manipulative force: (*a*) depicts a 72-degree angulation of the PLVO's superior/anterior wall; (*b*) depicts a 40-degree angulation of the anterior wall adjacent to the cerebellar central lobule; (*c*) depicts a 48-degree posterior surface of the inferior colliculi.

ulative force would effect changes to the brain structure and its environment. Magoun (20) and Upledger and Vredevoogd (21) independently suggested tension lesions existing within the meninges could create fixations within the cranial sutures. They both believe this suture fixation would inhibit osseous mobility and affect the normal flow of CSF and blood and, therefore, neuron function. Both of them also suggested that the use of external cranial manipulative force administered in conjunction with the intercranial fluid pressures would generate positive results in neuron function. Kostopoulos and Keramidas (4) were able to demonstrate measurable changes in the elongation of the falx cerebri with the application of external cranial manipulation to the dissected head of an embalmed cadaver. They further speculated if suture mobility does exist, the external force applied to the cranial bones will affect the dural membrane and consequently the brain itself. Unfortunately, the brain was removed through two windows cut in the cadaver's skull, rendering relevant observations of the brain *in situ* impossible.

The findings of this paper's preliminary study indicate that structural alterations deep within the brain substance can be produced to a gross visual level by the application of external cranial manipulative force. In light of this observable phenomenon and the previous mentioned studies, we can conclude that external cranial manipulation could affect intercranial meninges as they pass through the sutures of the skull and eventually affect structures within the brain.

Although this study appears to substantiate the validity of external cranial manipulation as a viable noninvasive method to affect the internal brain structures, it must be kept in mind that this was a single case study and does not necessarily reflect or guarantee that all external manipulative applications will produce the same effect. Further investigations should be undertaken to examine whether intercranial structural alterations can be predictably produced and reproduced through cranial manipulation. The limiting factor on such investigations is accurate measurement of force application. Most known pressure measuring devices incorporate some form of metallic substance within their makeup, which would interfere with the magnetic resonance field of the MRI unit and thus distort the scan image. Without this monitoring factor, precise duplication of the cranial maneuver would be virtually impossible.

CONCLUSION

The gross visible alteration of the brain's internal structures with the application of external cranial manipulative force demonstrated in this study suggests that suture mobility does exist in the adult human skull and that cranial manipulation does appear to effect change within the cranial vault.

This suggests the possibility of altering the volume w of CSF and blood through cranial manipulation. nce both intercranial fluids play a major role in the nctional harmony of the brain, such modifications ay even lead to the alteration of neuron function. It ay even be hypothesized that cranial manipulation ay in fact represent a viable noninvasive approach in dressing a broad number of neurological disorders.

At present, further studies into the validity of gross sual changes within the brain must first be established. future investigations produce similar effects, studies ilizing MRI to cardiac gait or magnetic resonance-ted intracranial CSF (liquor) dynamics (MR-GILD) chniques (22) may be incorporated to investigate the edictability of specific procedures upon the intercranl CSF and blood volume systems. These investigations ould open the door to chiropractic management of ch diseases as hydrocephalus, epilepsy and hypertenon.

ACKNOWLEDGMENTS

The author thanks D. Wayne Allen, D.C., Ph.D., D.I.C.S. for his helpful comments and donation of his MRI facility; Ronald S. Grusd, M.D. for his guidance s coauthor to the Materials and Methods portion of this study and diagnostic consulting of the MRI films and The Sacro Occipital Research Society International for funding the investigation.

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