RESEARCH IN SUPPORT OF THE CRANIAL CONCEPT

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Introduction

William Garner Sutherland, DO, the originator of the cranial concept, held that Andrew Taylor Still was really the source for the cranial concept, and that he merely extended Still's concepts to the cranial structures.[1,2] Sutherland, like Still, based his concepts on systematic observation integrated with the published science of the times typical of the scientific endeavor of the early 1900s. Since the time that Sutherland introduced his concepts to the osteopathic profession through the present day, those who practice osteopathy in the cranial field (OCF) have conducted research on the nature of this work. This discussion is based on that research.

Research relevant to OCF is seen not only in the osteopathic medical literature, but in many areas of basic science and in other health care professions. The current summary and commentary on research related to OCF is not intended to be exhaustive, but rather to make the case that sufficient scientific evidence exists to justify the practice of the principles of OCF in medical practice.

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Osteopathic Manipulative Medicine Research and the Cranial Concept

In an era when all medical and health care practitioners are increasing required to "prove" the "validity" and "medical necessity" of their treatments, those who practice OCF have endeavored to oblige this need on the part of the medical service reimbursement industry and the medical/scientific world. Progress made in this endeavor may best be seen in comparison with the evidence-based medicine production effort exerted by the osteopathic medical profession in general.

Evidence of the efficacy of osteopathic manipulative treatment (OMT) has been slow to evolve and develop due to the relative paucity of funding for this research. Until very recent times virtually all OMT research has been funded by various segments of the profession itself, primarily the American Osteopathic Association, the American Academy of Osteopathy, the Osteopathic

Heritage Foundation, and to a lesser extent several of the osteopathic medical colleges. Most OMT related studies have been of a size considered small by pharmaceutical industry research standards. Even though a positive, "statistically significant" outcome for OMT may be found, "further study" has always been recommended.[1,2]

To date there has been only one systematic review and meta-analysis regarding OMT and that was for the treatment of low back pain.[3] This meta-analysis concluded that the data show that OMT in the treatment of low back pain has positive benefit. There has been only one multi-site clinical trial undertaken by OMT researchers, on pneumonia, and this trial is still ongoing at the present time.[4]

The only other OMT related multi-site clinical trial that has been developed into a proposal is in the treatment of recurrent otitis media and involves the use of OCF. This proposal, which awaits funding, was developed based on the opinion that the pilot studies on OMT in otitis media were sufficient to justify a multi-site clinical trial and will be described in greater detail below.[5-7] That such a large study would be proposed based on the application of OCF speaks to the credibility and efficacy of this modality of OMT and its perceived likelihood of success in research endeavors.

Furthermore, to place this discussion in proper context, it is worthy of note that research related to OCF is at about the same stage of development, implementation, and level of evidence-based medicine as that for all of the modalities of OMT utilized by osteopathic physicians.

Research done in other professions has had great impact on the substantiation and understanding of theoretical formulations of OMT in general and OCF in particular. For example, the underpinnings of osteopathic formulations of postural balance have been significantly supported and elaborated by "tensegrity" theory and its applications.[8] As described below research done by neuroscientists on cerebrospinal fluid flow and anatomy of the central nervous system have supported key concepts of the cranial concept.[9,10] Work done by the National Aeronautics and Space Administration (NASA) researchers pertains directly to the nature of cranial bone motion, a concept central to OCF.[11,12]

In what follows, the purpose is to set forth empirical research supportive of OCF and to provide for the scientist, physician, and the lay reader critical commentary and discussion.

Osteopathic Manipulative Medicine Research and the Cranial Concept - References

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Research on the Primary Respiratory Mechanism

Central to OCF is Sutherland's formulation of the primary respiratory mechanism (PRM) which is objectified by five phenomena.[1,2] Additional discussion of the nature of the PRM appears elsewhere on this website. These five phenomena of the PRM have traditionally been stated in the following way.
1. The inherent motility of the brain and spinal cord.
2. The fluctuation of cerebrospinal fluid.
3. The mobility of intracranial and intraspinal membranes.
4. The articular mobility of the cranial bones.
5. The involuntary mobility of the sacrum between the ilia.

Through many years of application of OCF by osteopathic physicians, these phenomena have been experienced and constructively applied. In light of modern day technology, scientific terminology evolution, advances in teaching and researching OCF these phenomena of the PRM have been updated as follows.
1. The inherent rhythmic motion of the brain and spinal cord.
2. The fluctuation of the cerebrospinal fluid (CSF) that bathes and nourishes the brain and spinal cord.

3. The shifting tensions of the membranous envelope (dura mater) surrounding the brain and spinal cord. This entire membranous structure acts as a unit and is called a “Reciprocal Tension membrane.”
4. The inherent rhythmic motion of the cranial bones.
5. The involuntary motion of the sacrum (tailbone) between the ilia (hip bones).

Consideration of the research support for the PRM and the phenomena that actualize its existence and function follows the outline given above.

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The Inherent Rhythmic Motion of the Brain and Spinal Cord

As initially suggested, much of the support for this phenomenon of the PRM derives from research done basic science and medical laboratories outside the osteopathic profession. That the central nervous system anatomy moves has been proven and representative studies are presented here.

Greitz, et al.[1] utilizing MRI technology, demonstrated brain tissue movement characterized by a caudal, medial and posteriorly directed movement of the basal ganglia, and a caudad and anterior movement of the pons during cardiac systole. The resultant movement vectors created this “funnel shaped” appearance to the brain resulting in a “piston-like” remolding of the brain. The authors felt that this “piston-like” action of the brain during cardiac systole was the driving force responsible for compression of the ventricular system and thus the driving force for the intraventricular flow of cerebral spinal fluid.

Enzmann and Pelc[2] demonstrated brain motion during the cardiac cycle utilizing a similar MRI technology. Peak displacement of the brain ranged from 0.1-0.5 mm, except the cerebellar tonsils which demonstrated a displacement of 0.4 mm.

Poncelet, et al.[3] using echo-planar magnetic resonance imaging, was able to demonstrate pulsatile motion of brain parenchyma. Brain motion in Poncelet’s study appeared to consist of a single displacement during systole, and a slow return to baseline configuration during diastole. This displacement includes a descent of midbrain and brainstem toward foramen magnum with velocities ≤ 2 mm/sec and medial compression of thalami on 3rd ventricle 1.5 ≤ mm/sec.

Feinberg and Mark[4] postulated that the pulsatile nature of CSF flow and brain motion was driven by the force of expansion of the choroid plexus. In their study, via MRI, observations of pulsatile brain motion, ejection of CSF into the ventricles and simultaneous reversal of CSF flow in the basal cisterns suggested a vascularly driven mechanism, which may serve as the pumping force of CSF circulation. They reported the velocity in anterior cortex and corpus callosum is 0.4 ± 0.25 mm/sec and in basal ganglia and foramen of Monro is 0.63 ± 0.5 mm/sec.

Maier, et al.[5] demonstrated periodic brain and CSF motion associated with periodic squeezing of the ventricles due to the compression of the intracranial vasculature. They reported peak velocities up to 1 mm/sec followed by a slower recoil. Having the subject do a Valsalva maneuver (exert pressure like trying to defecate), the brain stem showed initial caudal and subsequent cranial displacement of 2-3 mm. Coughing produced a short swing of CSF in the cephalic direction.

Mikulis, et al.[6] demonstrated movement of the cervical spinal cord in an oscillatory manner, conducted in a cranio-caudal direction during cardiac systole. They also reported maximum rate of oscillation as 7.0 mm/sec ± 1.4.

These dimensions of motion of cranial and spinal central nervous system structures suggest that the intracranial structures may not move as far or as fast as spinal cord structures, but these structures do all manifest motion of a precise measurable nature. This motion appears to be related to the vascular dynamics of the circulatory system and the cardiac cycle. This element of the PRM is not controversial as such motion has been well studied and established.

The PRM also postulates a deep, cellular level respiratory, life sustaining function that contributes to the rhythmicity of the PRM. Rhythmic motion suggestive of such a phenomenon has been identified in animals and possibly humans. As long ago as 1951, oligodendrocyte tissue from rat corpus callosum, placed in tissue culture medium, were photographed by ciné-photomicrography.[7] The authors state, “These cells show a characteristic rhythmic pulsatility apparently identical with that described in 1935 by Canti, Bland and Russell[8] in the case of oligodendrocytes obtained from in culture from oligodendroglioma of the human brain. We believe also that we have seen similar cells in a few tissue culture preparations from the cortex of the normal human brain.”[8, p.114] Almost as far back, in 1957, Wolley and Shaw[9] reported rhythmic contractions of the oligodendroglial cells of brain and spinal cord. In the early 1960s Hyden[10] reported that glial cells, grown in a culture, pulsate continuously.

Using modern technology, Vern et al.[11] were able to measure rhythmic oscillatory patterns related to intracellular oxidative metabolism in the cat and rabbit. They demonstrated a synchronous rhythm at about 7 cycles per minute for the creation and then utilization of cytochrome oxidase within the cells of the cortex of the test animal subjects. Dani et al.[12] showed active waves of astrocytic Ca^{2+} in the rat hippocampus in response to neural activity. Propagation of the calcium wave was usually within 5 to 6 seconds from the beginning of neural stimulation, and under constant stimulation produced waves at the rate of 2 per minute. The findings of these studies are indicative of a regular periodicity propagates by biochemical activity of astroglia.

Whether or not there is any biomechanical impetus to the palpable characteristics of the PRM by cellular and intracellular activity, motility possibly associated with a primary respiration process has been identified.

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The Fluctuation of the Cerebrospinal Fluid (CSF) That Bathes and Nourishes the Brain and Spinal Cord

That the CSF moves in a fluctuant flow pattern through the ventricles of the brain and within the subarachnoid space around the brain and spinal cord is also a noncontroversial and well established phenomenon. In fact, much of research cited above which demonstrated the motion of the brain and spinal cord also showed features of the CSF fluctuant flow.

Summarizing over a century of research DuBolay et al.[1,p.497] stated, "The majority of workers throughout these seven decades have become convinced that the 'cardiac' CSF pressure rise measured in the ventricles, at the cisterna magna and in the lumbar theca, is caused by the rhythmic arterial input of blood to the cranial cavity." DuBolay further states, "Most authors, e.g. Becher[2] had envisaged the arterial inflow to the head as causing an expansion of the brain and of the vessels within the basal cisterns. O'Connell[3] suggested that the brains' expansion, by compressing the third ventricle, might constitute a CSF pump."

Of particular interest to the OCF practitioner is the effect of spinal dural membranes (the third listed phenomenon of the PRM discussed later) on the flow of CSF. Levy et al.[4] reported that in healthy people the spinal CSF flow rate was 12.4 ± 2.92 mm/sec. In patients with spinal dysraphism (conditions like spina bifida) the rate much slower at 2.12 ± 1.69 mm/sec. In patients with spinal cord compression (such as from traumatic injury or tumors) the rate was also slowed at 1.87 ± 1.4 mm/sec. They concluded further that, "The origin of cord pulsations is compatible with a direct transfer of motion from brain pulsations."

Based on the widely accepted nature of the fluctuant flow of CSF as demonstrated by decades of research and clinical application, this phenomenon of the PRM appears to be supported by the evidence and is not controversial.

The Fluctuation of the Cerebrospinal Fluid that Bathes and Nourishes the Brain and Spinal Cord - References

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The Shifting Tensions of the Membranous Envelope (dura mater) Surrounding the Brain and Spinal Cord. This Entire Membranous Structure Acts as a Unit and is Called a "Reciprocal Tension Membrane."

The existence of the dura mater membrane around the brain and spinal cord is well documented and utilized in anatomic research and medical practice. Every medical student and anatomist who has dissected the central nervous has seen this membrane. Every physician who has done a lumbar puncture (or spinal tap) has felt the "pop" as the needle penetrates the dura on the way to draw a sample of CSF.

Those who practice OCF utilize this anatomy to treat cranial and cervical mal-alignment from the sacrum, or sacral mal-alignment from the base of the skull because of the hypothesized direct connection between these structures in the form of the dural membranes. As a phenomenon of the PRM, the reciprocal tension membrane anatomy has proven useful by many clinicians in practice, but has received critical review even by cranial practitioners.[1,2] The misgivings are based on statistically insignificant findings between cranial and sacral palpatory recordings of motion,[1] and the apparent different lengths of the spinal canal between the forward bending and backward bending of the spine.[2] While these reservations raise questions yet to be answered, other experimental and anatomic findings tend to lend support to the concept that dural membrane linkage between the sacrum and cranial base may be correct and have clinical value.

Kostopoulos and Keramidas utilized a novel approach to anatomic research on a male cadaver that had been embalmed for 6 months.[3] The brain tissue was removed through two cut windows, leaving intact the intracranial dural membranes. The measurement used was a piezoelectric element attached to the falx cerebri with the motion recorded by oscilloscope. Application of the frontal lift cranial treatment maneuver then produced a 1.44 mm elongation of the falx cerebri and a parietal lift maneuver produced a 1.08 mm elongation. Even on embalmed tissue, application of the sphenobasilar compression maneuver produced a -0.33 mm movement, and the sphenobasilar decompression maneuver a +0.28 mm movement of the falx cerebri. The Kostopoulos and Keramidas data suggest that for cranial structures there is an identifiable association between cranial maneuvers applied to the cranium and the movement of cranial dural membranes.

A possible connection between the cranial structure motion and sacral motion was identified by Zanakis et al.[4] Utilizing infrared surface skin markers positioned over the subject's parietal and frontal bones, cranial bone motion was observed utilizing a 3-dimensional kinematic motion sensitive system. During the study there was simultaneous palpation of the sacrum by an experienced examiner. The findings reported a 92% correlation between the examiner who signaled perception of the flexion phase of sacral movement via a foot activated switch and the movement of the cranial bone markers.

Given the relatively small numbers of subjects in both of the empirical studies,[1,4] and the difficulties inherent in ascertaining reliable palpatory data,[5] it appears that indeed further study is needed before the reciprocal tension membrane concept can be established empirically. The implications of anatomy based, spinal canal length differences in forward versus backward bending, are also in need of further study.

Therefore, while there is no doubt as to the existence of the continuity of dural membranes around the central nervous system, the clinical applications of this anatomy, as postulated by the concept of the PRM, are in of further validation. However, from the perspective of OCF practitioners who report treatment success using this particular formulation of OCF, there is little doubt of the clinical applicability of the cranial to sacral connection of the dural membranes.

The Shifting Tensions of the Membranous Envelope (dura mater) Surrounding the Brain and Spinal Cord. This Entire Membranous Structure Acts as a Unit and is Called a "Reciprocal Tension Membrane." – References

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The Inherent Rhythmic Motion of the Cranial Bones.

The most controversial phenomenon of the PRM from a scientific perspective is the concept of palpable cranial bone motion. Misgivings have been expressed based primarily on the assumed anatomic impossibility of such motion.[1,2] The basis of the traditional anatomic position of cranial bone immobility is derived primarily from forensic anthropology research done to estimate the age of skeletal remains. However, there is a growing body of literature that brings into question this long held anatomically based dogma. The challenge to the position that cranial bones are incapable of motion is based on examination of basis for this conclusion in the first place and empirical evidence of cranial bone motion in the second place.

To appreciate the conceptual change implied by the concept of cranial bone motion, it is important to know that respected scientists, anatomists, and anthropologists posited the fusion and inherent immobility of cranial bones. Most often cited are the works of Bolk,[3] Melsen,[4] Perizonius,[5] Cohen,[6] and Sahni et al.,[7] all of whom are reported to have held the view that cranial sutures were fused and immobile. Based on thorough examination of this debate, it may turn out that this view has been an anatomic version of "the world is flat" debate of the last millennium.

With the exception of Bolk,[3] all of the aforementioned anthropologists and anatomists cite as precedent for their work, that of Todd and Lyon as central to the idea that cranial bones fuse and therefore are immobile.[8,9] There is reason to question Todd and Lyon's conclusions based on a close reading of their lengthy manuscripts. Paul Dart, MD states,[10] "In interpreting this data, it must be noted that Todd and Lyon were attempting to establish 'modal' norms for sutural closure, and they discounted data that was clearly out of the modal pattern before creating their summary. 11.7% of their 307 white male specimens and 25.8% of their 120 negro male specimens were excluded from the data due to prolonged sutural patency."

Further reason to doubt the concept of universal sutural fusion was given by Singer.[11] He found a high percentage of specimens with much less closure than Todd and Lyon's norms, including a 64 year old specimen with no closure at sagittal, lambdoid, or left coronal sutures and 3 specimens ages early 40's with virtually no sutural closure in the coronal, lambdoid, or sagittal sutures. Also in the 1950s, Pritchard et al.[12] commented to the effect that obliteration of sutures and synostosis of adjoining bones, *if it happens at all*, occurs usually after all growth has ceased. In great apes synostosis of all sutures occurs immediately after growth has ceased, but in man and most laboratory animals sutures may never completely close.

A recent article by Sabini and Elkowitz[13] gives pictorial and systematic review of 36 human cadaver skulls ranging in age from 56 to 101 years, all well above the age when bone growth is complete. Twenty-six of the skulls showed less than 100% obliteration of the coronal suture, 31 of the skulls had unobliterated lamboidal sutures, and 24 of the skulls had unobliterated sagittal sutures. The lamboidal suture was the least fused on a majority and the attachment of musculature on the occipital bone cited as the probable cause of maintaining sutural patency. The authors speculate that the chewing motion contributes to muscular tension on the bones, maintaining some degree of sutural patency. The endocranial (inner) surface of the skull was not evaluated so that some estimate of through and through fusion of each suture could not be made. However, the finding of a significant amount of sutural patency (non-fusion) certainly brings in to question that all cranial sutures are fused and therefore can not move.

Prior to the Sabini and Elkowitz publication, the work of Retzlaff and associates dealt directly with the nature of cranial suture morphology and cranial bone motion. Retzlaff et al. state, "Gross and microscopic examination of the parieto-parietal and parieto-temporal cranial sutures obtained by autopsy from 17 human cadavers with age range of 7 to 78 years shows that these sutures remain as clearly identifiable structures even in the oldest samples."[14, p.663] Retzlaff et al. identified sutural elements contradicting ossification and demonstrated the presence of vascular and neural structures in the sutures.[15] These studies also showed the presence of nerve and vascular tissue substantial enough to supply the needs of connective tissue activated beyond mere bony sutural adhesions and ossification. Additionally, Retzlaff et al. traced nerve endings from the sagittal sinus through the falx cerebri and third ventricle to the superior cervical ganglion in primates and mammals.[16] That such structures were found in cranial sutures brings further doubt to the idea that these sutures fuse and are immobile.

Empirically demonstrated cranial bone motion in animals is well documented. Michael and Retzlaff demonstrated cranial bone (parietal) mobility in the squirrel monkey.[17] In cats, parietal bone motion in the range of 200-300 microns was induced by laboratory controlled changes in the CSF volume.[18-20] Jaslow[21] demonstrated in goat skulls (*Capra hircus)*, that patent cranial sutures in adult animals may play a role in shock absorption and re-distribution of forces directed against the skull (e.g. ballistic forces directed against the goat's skull) and during chewing movements. Thus a compliant skull is a stronger skull in that it is capable of absorbing and re-distributing forces directed against it.

Research involving assessment of human cranial bone motion has been done by neurologists, space physiologists, and osteopathic medical profession physicians and basic scientists. In work later cited by NASA scientists, Frymann[22] developed a non-invasive apparatus for mechanically measuring the changes in cranial diameter. Cranial motion was recorded simultaneously with thoracic respiration. On the basis of her extensive recordings, she was able to conclude that a rhythmic pattern of cranial bone mobility exists and moves at a rate that is different than that of thoracic respiration.

In a 1981 neurology study, by Heifetz and Weiss,[23] using a stain gauge device, they were able to demonstrate cranial vault expansion associated with a rise in intracranial pressure (ICP) in two comatose patients. Utilizing a head holding device similar to Gardner-Wells tongs, accompanied by a strain gauge meter, the skull device was inserted into the calvaria above the external auditory canal. The strain gauge device was part of what is called a "Wheatstone Bridge," which was designed to detect any expansion of the skull of about 0.0003 mm or greater, which when it occurred, would produce a voltage change of 1uV. They performed 19 trials and each time ICP was artificially elevated, there was a voltage change. This voltage change indicated that the skull tong pins were being spread apart. This could only occur with expansion of the cranial vault.

A promising approach to assessing cranial bone motion after cranial manipulation was carried out utilizing x-rays (Dental Orthogonal Radiographic Analysis) on 12 subjects.[24] The before to after changes in cranial bone position measured in degrees ranged from 0^{o} to 8^{o} for atlas, mastoid, malar, sphenoid, and temporal bone position. The percentage of subjects with identifiable changes ranged 66.6% with the mastoid to 91.6 % for the atlas, sphenoid and temporal bones. There are plans to expand this research utilizing a larger number of subjects.

Russian and United States Space Research

One of the strongest areas of research which involved assessment of cranial bone motion has been that carried out by the Russian and United States astronaut programs. The concerns that led to this research had to do with the nature of human response to prolonged weightlessness in space. Without gravity would the human circulatory and central nervous systems function normally? In the process of assessing intracranial fluid dynamics, various types of radiographic and ultrasound equipment have been used to measure intracranial volume as well as cranial bone dimensions, and changes in these dimensions have been observed.

Yuri Moskalenko, PhD first published research on cats in space that described "third order waves" similar to that described above in glial cells.[25,26] After being introduced to OCF, Moskalenko and associates carried out several studies which showed cranial bone motion. One utilizing NMR tomograms, showed cranial bone motion between 380 microns to 1 mm, and cranial cavity volume increases by 12-15 mL, with a rhythmicity of 6-14 cycles per minute.[27] This work was followed by a study utilizing bioimpedence measures and transcranial ultrasound Doppler echography showing slow oscillations of the cranial bones at 0.08-0.2 Hz.[28] Moskalenko demonstrated that these oscillations, "…were of intracranial origin and were related to the mechanisms of regulation of the blood supply to and oxygen consumption by cerebral tissue, as well as with the dynamics of CSF circulation.[28, p.171] Moskalenko and Frymann have carried this work into a formulation of a theory that explains the physiology of the PRM.[29]

In the mid-1990s NASA was also concerned about intracranial fluid volume changes in astronauts in space. NASA carried out research and developed an ultrasound device, pulse-phase locked loop (PPLL) with sensitivity to 0.1 µm to more precisely assess intracranial anatomy and physiogy.[30] This NASA team at the Ames Research Center carried out a series of studies.[31-34]

On two fresh cadavera (less than 24 hours post-mortem), female 83 and male 93, ICP pulsations were generated manually by infusing saline into the intracranial ventricular system at a rate of 1 cycle/second (1 hertz).[31] In this study an increase in ICP of 15 mL Hg caused a skull expansion of 0.029mm, and this was interpreted by the authors as similar to that found by Heisey and Adams,[18] Hiefetz and Weiss,[23] and Frymann.[22]

In another study, 7 healthy volunteers fitted with the PPLL device were placed in 60,^{o} 30^{o} head-up tilt, supine, and 10^{o} head-down tilt positions. The average path length from forehead to occipital bone increased 1.038 ± 0.207 mm at 10^{o} head down tilt relative to 90^{o} upright. "In other words, when intracranial pressure increases, arterial pulsation produces a higher amplitude ICP pulsation. Increased amplitude of ICP pulsations will be manifested by larger fluctuations in distance across the skull."[32, p.3]

Summarizing their work to a certain point, the NASA research team stated, "Although the skull is often assumed to be a rigid container with a constant volume, many researchers have demonstrated that the skull moves on the order of a few µm in association with changes in intracranial pressure."[33,p.66] In their last publication in this series they state, "…analysis of covariance reveled that there was a significant effect of tilt angle on amplitude of cranial diameter pulsation ($p < 0.001$)….As a result, amplitudes of cranial distance pulsation increased as the angle of tilt decreased. The observed changes in cranial diameter pulsation are considered to be statistically significant."[34,p.883]

Recent Osteopathic Research on Cranial bone Motion

Research comparing palpatory assessment of cranial bone motion with simultaneous assessment by laser Doppler flowmetry technology has been done. Striking correlations have been found between cranial palpation reports and the technologically measured physiologic motion phenomena identified by the laser Doppler flowmetry. Nelson, Sergueef and Glonek posit that it is the Traube-Hering and Meyer oscillations that they have now empirically can assess.[35-38] They describe oscillations which occur about 4 to 6 cycles per minute and in their studies have been shown to occur at the same time the osteopathic cranial practitioner reports a certain phase of the cranial bone motion. To have instrumented recordings of physiologic activity correspond to the palpatory experience is strong support for the PRM and the concept of cranial bone motion. This line of research is continuing.

[The Cranial Academy and Sutherland Cranial Teaching Foundation sponsored a "PRM Research Symposium" which was held in October 2003. Pictured was a panel featuring several of the most outstanding cranial osteopathic researchers. From left to right: Viola M. Frymann, DO, Yuri Moskalenko, PhD, Kenneth Nelson, DO, Tom Glonek, PhD and Toshiaki Ueno, MD, PhD.] Can the picture be placed about here – perhaps Mark has a better picture of the panel?

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<u>The Involuntary Motion of the Sacrum (tailbone) Between the Ilia (hip bones).</u>

That the sacrum moves in its position between the ilia is an anatomical fact. It would not be possible for humans to walk or run if the ilio-sacral joints did not allow motion. It is hard to imagine, but for centuries it was believed by scientists of the day that the pelvis was a solid array of bone and that there was no independent motion of the sacrum.

The biomechanical dimensions of ilio-sacral joint motion was delineated by Weisl in the mid-1950s.[1] Elaboration on ilio-sacral motion characteristics was done by Kissling who has subjects perform flexion, extension movements of the spine and one-legged stance to induce sacroiliac motion.[2] The range of motion was 0.2 mm to 1.6 mm, with an average of 0.7 mm for males and 0.9 mm for females. Other research describes a number of different axes of sacral motion, a concept already well integrated into OMT training programs, and motion noted to be in the range of 1-3mm.[3]

As seen in the debate over sacro-iliac joint motion, history may be repeating itself in the debate over cranial bone motion. It is unfortunate that today there is doubt about cranial bone motion despite the growing evidence for the reality of this phenomenon.

The controversy of sacral motion from the perspective of the PRM has to do with the nature of the impetus for the sacral motion. There is some evidence to support the contention of *involuntary active motion* of the sacrum between the ilia. Mitchell and Pruzzo[4-6] demonstrated a horizontal axis for sacral motion located anterior to the second sacral segment. Movement around this axis was measured at 0.9 to 4.7 mm at the sacral apex, and the impetus for this motion was simply breathing, which associated sacral motion with the normal respiratory excursion.[4] While the Mitchell and Pruzzo research establishes possible physiologic functions, other than ambulatory activity, which cause sacral motion, other research describes the breathing motion of humans (the respiratory excursion) as a separate and distinct motion from that induced by the PRM.[7]

Furthermore, the correlation of sacral motion with cranial bone motion has not been established empirically,[8] and may be related to the apparent differences in spinal canal length previous mentioned by Chaitow[9] who cites the work of Butler.[10]

<u>The Involuntary Motion of the Sacrum Between the Ilia – References</u>

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Clinical Research

Introduction

Over the years there have been a number of reports of the clinical applications of OCF. Some of the earliest appeared in the OCF text by Magoun[1,p.112] in charts done by G. A. Laughlin, DO which showed an apparently reduced sweat production before and after application of the technique known as the compression of the fourth ventricle (CV_4). This appeared to reflect a decrease in sympathetic nervous system activity, which has also been demonstrated in more recent research.[2] Also in the Magoun text are illustrations documenting, in a group of 5 patients, substantial lowering of blood sugar and white blood cell counts before and after application of the CV_4.[1, p.113]

The Magoun text devotes a chapter to the "Practical Application of the Cranial Concept," and report on a number of conditions in which application of OCF techniques has proven beneficial for the individuals involved. A number of these applications of OCF are amplified in other publications.[3-5]

It is significant to note that OCF treatment is like any other modality of OMT in the hands of a capable osteopathic physician. It is the specific attention to the anatomy of the particular part of the body being manipulated that facilitates the OMT and enhances the probability of benefit. Furthermore, it is the knowledge of anatomy and especially neuroanatomy in the cranial area that provides the basis for a strong rationale for how OCF might be beneficial. This point is exceeding well illustrated in a series of articles by Magoun on the theme of entrapment neuropathy in the cranium.[6-8] That is, if cranial bone motion exists and OCF maneuvers can affect cranial bone and intracranial structures such as cranial nerves, then there may be great utility in applying such technique in clinical practice.

From a philosophy of science perspective, appropriate application of OCF based on systematic observation of anatomic relationships palpated by the osteopathic physician and correlated with changes in the patient's symptoms is indeed scientific procedure. It remains for the osteopathic medical profession to develop documentation procedures which will facilitate collection of this type of data from many physicians utilizing OCF and thereby obtain large scale population data appropriate for analysis. In the meantime, those who utilize OCF in clinical practice are following a tried and true scientific methodology in the application of OCF. That is practice based on proof of benefit to patients as reported by many clinicians on many patients. This is the principle of appeal to authority and precedence of success by practice. That having been said, what does the research literature report about clinical applications of OCF?

Otitis Media

The anatomy of the eustachian tube and the possible derangement of the temporal bone during a difficult labor and delivery comprise the anatomy and life circumstance that have been described as the basic for application of OCF. The clinical success reported by OCF clinicians has been validated by positive results in several studies and has resulted in plans for a multi-site clinical trial.[9-11] These studies showed improvement in health as measured by fewer ear tubes, improved tympanography assessment, and generally reduced need for antibiotics in children suffering from recurrent ear infections (otitis media).

Pregnancy, Labor and Delivery

The prenatal application of OMT has been a staple of the osteopathic medical profession since its inception.[12] Clinical research on the application of OMT in prenatal care has a long history too. As early as 1911 studies on hundreds of women who received prenatal OMT were published, and benefits with shorter durations of labor and fewer complications were reported.[13] In a study where the application of OCF was not the only OMT modality applied in prenatal care, but was included in OMT delivered to virtually every patient, the results were statistically significant (N = 321 patients) for fewer preterm deliveries and fewer cases of meconium-stained amniotic fluid.[14]

A promising pilot study that awaits a larger follow-up was done by Gitlin and Wolf[15] on women who were overdue to deliver and had not yet perceived uterine contractions. Eight women were treated using only the compression of the fourth ventricle – CV_4. Two were eliminated due to disruption during the post-treatment monitoring, while the other six all began uterine contractions within 34 minutes with an average of 17.5 minutes. The theory underlying the use of the CV_4 is that this maneuver "helps nature take its course." It is probably incorrect to be concerned about the use of the CV_4 in pregnant women out of fear of inducing contraction, as the women in this study were "over due" and the OCF only facilitated a normal gestational phase.

Pediatric Applications

Besides the previously mentioned research on otitis media, the general concern for the effects of a difficult labor and delivery involves many unfortunate outcome possibilities. Frymann evaluated the cranial bone mechanics of 1250 newborns and found that 88% had identifiable mal-alignment in the form of cranial bone strain patterns.[16] Frymann has gone on to present data indicating benefit of OCF in the treatment of children with learning problems,[17] children with neurological deficits,[18] and seizure disorders.[19]

Inspired by Frymann's work, research was done in Russia by Lassovetskaia on children with language and learning problems.[20] In this study 96 children undergoing neuropsychological tutoring in a large school program due to delayed academic performance were selected and compared to the performance of the rest of the children before and after receiving OCF for 6-12 weeks. The children who received the OCF were significantly higher in virtually all categories of academic performance compared to the comparable population of children who did not receive OCF.

In the chapter on General Pediatrics in the *Foundations for Osteopathic Medicine*[21] the authors, three of whom use OCF in their medical practices, describe the benefits of OCF in the treatment of pediatric diseases. Respiratory conditions such as asthma, pneumonia, bronchiolitis, and newborn diaphragm restrictions are described as responding favorably to OCF. They go on to describe the applications of OCF in gastrointestinal disorders such as colic, gastroesphageal-reflux (GERD), constipation, and diarrhea. As with all OMT, OCF is described as an effective means to correct anatomic mal-alignment and restore optimal physiologic function by improving the anatomic structures associated with those functions. For example, in the treatment of colic, the commonly found impingement of the tenth cranial nerve (which coordinates the peristaltic wave action of the gastrointestinal tract) as it passes through the jugular foramen, caused by compression during the birth process, between the occipital and temporal (mastoid area) bones, can be relieved by gentle OCF to decompress and relieve the obstructed flow of coordinated nerve supply to its intended destination.

<u>Dental Applications</u>

In that teeth are cranial "bones' themselves and subject to movement within the socket of the tooth, and the bones housing the teeth are cranial structures, application OCF for dental conditions can and has been successfully used in treatment. In a series of articles Magoun gives case studies and specific technique for OCF treatment of individual whose cranial mal-alignment involves dentition.[22-24] Edna Lay carried on this work on dental applications and described more case studies utilizing OCF with an emphasis on temporomandibular joint dysfunction.[25] With the publication of these articles many dentists have been attracted to study and even apply OCF in their practices. There is even a special membership section within The Cranial Academy for dentists.

Empirical research was done by Baker who showed on a patient receiving OCF that there were measurable changes in the dental arch.[26] Serially measured models of maxillary teeth over six months showed overall lateral dimensional changes between permanent second molars of 0.0276 of an inch. It is common in the practice of orthodontics today to move the maxillary arch this much and more, up to 2 mm by dental appliances, but the in case reported by Baker, the changes were brought about by OCF alone.

Effects of OCF on Vascular and Autonomic Nervous System Functions

A commonly applied OCF technique called the "venous sinus technique" has been reported by many who practice OCF to be successful in the relief of headache and sinus congestion symptoms. A study by Huard suggests that the efficacy of this techniques may be in the restoration of optimal intracranial vascular flow.[27] Huard applied the venous sinus technique to 39 subjects, with 39 others receiving light touch only, and another group of 39 subjects received no touch at all. The outcome measure was a radiology procedure called the encephalogram which utilized ultrasound technology to record blood flow. Huard's results showed that the subjects receiving the OCF venus sinus technique had demonstrably improved hemodynamic perfusion, that is improved blood flow, in the area of the cranial base.

A study by Cutler et al. showed statistically significant effects of application of the CV_4 on sleep latency and the reduction of sympathetic nerve activity.[2] In a controlled environment, healthy subjects went to sleep faster if the CV_4 was applied compared to subjects who received only a light touch control protocol or no touch at all. Sympathetic nerve activity measured at the peroneal nerve at the popliteal fossa using standard microneurographic technique was also significantly reduced in the CV_4 compared to control or no treat groups.

Further evidence of the impact of OCF on physiological function is the work on healthy humans which showed a statistically significant improvement in heart rate variability. In this study Giles et al.[28] used soft tissue manipulation to the cervical spine with emphasis on the occipito-atlantal decompression maneuver, a commonly OCF technique. With an N=24 in a cross-over design, heart rate variability was best when the OCF was applied compared with sham and time control conditions.

Clinical Research - Summary

OCF clinical research compares favorably with the amount of clinical research done on the other commonly used OMT modalities. From a technical perspective, the application of OCF takes longer than other OMT modalities and is often not applied due to time restraints. Critics of OCF cite lack of clinical evidence for benefits thereof and raise the question of risk-benefit ratio. There has never been a report of an adverse event from the application of OCF, and the improvement reported in the reviewed clinical articles on OCF is certainly suggestive, if not compelling, evidence of benefit for OCF.

As The Cranial Academy presents this information for examination by interested researchers and potential patients, it is important put it all in perspective. The Cranial Academy can not say that every aspect of the PRM is proven, but the majority of elements appear to be sufficiently substantiated for general acceptance. The evidence presented is certainly sufficient justification to continue the use of OCF in clinical practice and it is hoped will garner support for more research to be done.

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