The cranial mechanism: Its relationship to cranial-mandibular function

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Recent dental publications have addressed the possible relationship between the cranial mechanism and restorative dentistry.[1-6] The cranial mechanism includes the anatomic and physiologic relationships of the cranial bones, spinal dura, and sacral connection and is one of constant, rhythmic motion. Still[7] was one of the first physicians to introduce the concept that freedom of motion within the body was essential for optimal health, and that restriction of joints, muscles, or ligaments was a major cause of body dysfunction. This article is a literature review of salient reports that underscore the possible significance of Still's observations.

THE CRANIAL SUTURE OR JOINT

Sutherland[8] showed that the cranial bones meet in a series of sutural articulations that are actually joints, all bevelled in particular and specific shapes in all skulls (Fig. 1). He believed that their designs produce sliding planes, hinges, and pivotal parts that allow slight movement. He proposed that a lack or restriction of movement could result in physcal or emotional illness. Recently, anatomic and histologic analyses have resulted in the validation of his clinical observations.[9-11]

Evidence now suggests that the mode of attachment connecting several of the calcified structures of the cranial-mandibular region are similar. These joints provide attachment in bone-to-bone relationships, and the similarity of the attachment apparatus and functional mechanisms may be highly significant. The similarity is believed to extend to the tooth and bony socket

Fig. 1. Superior view of sagittal suture of cranium with deeply serrated borders of parietal bones. Cranial bone articulations allow specific but slight motion of bone within articular space. (From Libin B. The cranial mechanism and its dental implications. Int J Orthod 1984;22:7-11, with permission.)

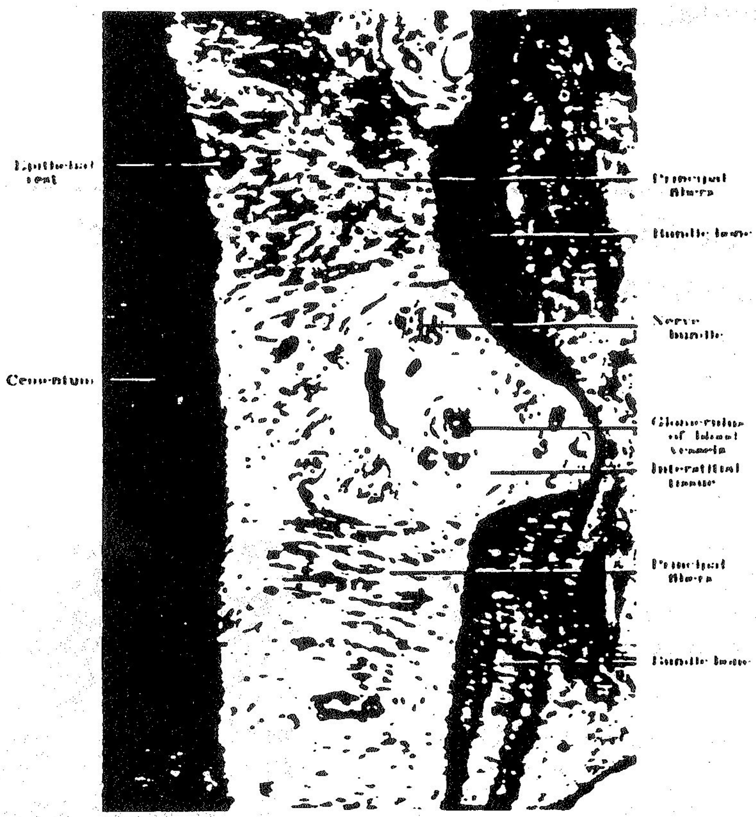

Fig. 2. Section of periodontal attachment apparatus showing collagenous attachment of cementum to alveolar bone. Same attachment may be present between cranial bone. (From Orban B. A contribution to the knowledge of the physiologic changes in periodontal membrane. J Am Dent Assoc 1929;16:405-14, with permission.)

attachment. Just as the periodontal articulation is a joint between tooth and bone, so is the cranial articulation, or sutural attachment, a joint. As a result of the unique adaptive response necessary for tooth function, the collagen fibers of the periodontal "ligament" are arranged in bundles that respond to occlusal forces[12] (Fig. 2) and act as a cushion to diminish the impact of these forces. Although a histologic resemblance does exist, it must be recognized that the embryologic development of periodontal ligaments and that of cranial sutures are different. Nonetheless, it is believed that a degree of similarity exists in the functional roles of cranial bones and the periodontal ligament.[1,2]

The 22 bones of the cranium meet at 106 different articulations. Like the tooth, these bones are held together by sheets of connective tissues situated between them at the suture line (Fig. 3). This attachment appears to provide a structural support similar to the periodontium, tying the cranium together, yet allowing a functional space for potential motion. Such motion between bones could provide the cushioning effect necessary to decrease the impact of traumatic forces to the head.

Pritchard et al.[10] studied the histology of the sutures of adjacent cranial bones and found that they were composed of two uniting layers and five layers of cells and fibers. The periosteum divides into two layers at the suture, with the outer layer continuing as the uniting layer and the inner layer of periosteum reflecting inward as an outer capsule of each adjacent bone (Fig. 4). Between the two capsular layers is a middle zone containing multidirectional weak fiber bundles and sinusoidal blood vessels. Pritchard et al.[10] believed that such a zone "could well allow some slight movement of one bone against the other, and so could be regarded as analagous to a synovial joint activity...permitting momentary adjustments of one bone relative to another, probably also enables slow progressive angulation to take place between the bones as the skull alters in shape during growth." Pritchard et al.[10] concluded that "it may be deduced from their mode of development and their histologic organization, that sutures form a strong bond of union between the adjacent bones, while permitting slight movement."

Retzlaff et al.'s[9,11,13] studies showed that adjacent

Fig. 3. Low-power view of human sagittal suture. Dark-stained material is parietal bones with sagittal suture coursing between them. Suture itself contains loose alveolar and connective tissue. (Courtesy of Dr. John Upledger.)

cranial bones are bound together by periosteum and a loose matrix of highly vascularized connective tissue consisting of collagenous, reticular, and elastic fibers. They found that the collagenous connective tissue bundles appear to have patterns of functional significance. Serrate and denticulate articulations allow slight flexion movements, and plane and squamous articulations allow sliding and separation movements. Retzlaff's group observed that the collagenous fibers were accompanied by nerve fibers and that with sensory function they could play a role in traumatic injury to the area.

Retzlaff et al.[11,14] also studied the microanatomy of living adult skulls during neurosurgical craniotomy. Using modified staining techniques they demonstrated viable myelinated and unmyelinated nerve fibers, nerve receptor endings, a potentially functional vascular network, and collagen elastic fiber complexes within the adult human cranial suture (Fig. 5). They observed that these structures frequently penetrate the suture bone margin and traverse from the diploe into the suture and vice versa. There is also evidence to suggest that some of the intrasutural vascular and neural structures may arise from the intracranial meninges.

CRANIAL MOTION

It is hypothesized that a major aspect of the cranial mechanism is motion. The cranial bones are in a dynamic relationship, moving in and out of their joint spaces six to 12 times per minute. This motion remains throughout life, varying in degree or frequency of movement with changes in health.[8,15,16] These movements can be palpated by the clinician, who, with practice and experience, can soon learn to read changes in rate, amplitude, symmetry, and quality of the motion. The normal motion of the cranium occurs and reoccurs in a specific pattern. By very lightly placing the hands on the cranium, a dimensional change can be felt that varies from a flexion to an extension phase. In flexion the head is foreshortened in the anteroposterior dimension, and fuller in the transverse dimension. In the extension phase the head is longer and narrower (Fig. 6). These movements are not like other joints in the body, but rather indicative of resiliency and compressibility. This cycle occurs six to 12 times per minute. Any change from this pattern is considered by some health professionals to be a cranial lesion and will produce a dysfunctional state. Often these states are termed psychosomatic or idiopathic.

The normal amplitude of bone motion results in a lateral displacement of the parietal bone of 1 to 1.5 mm.[13] Just as one can palpate the slight but normal motion of a tooth within its ligament space (0.15 to 0.38 mm),[17] so one can feel a similar movement of the cranial bones at each of the 106 articulations. Of equal importance is the corresponding motion of the sacrum. As the bones of the cranium move, there must be dura movement because this fascial sheath is the base for the cranial bones. This same dural sheath connects to the spinal dura at the second and third cervical vertebrae and tightly stretches to make a connection down the spinal cord to the second and third sacral segments. Thus a movement of the cranial bones into flexion (widening) will pull the dural sheath into a flexion position that brings the sacral apex superior and posterior.

The Cranial-Mandibular Relationship

To fully grasp the significance of the cranial mechanism in the study of the cranial-mandibular area, one must realize that this is a region encompassing 105 differently shaped joints in addition to the temporomandibular joint (TMJ). Therefore, to achieve true physiologic homeostasis for all of the structures within the cranial-mandibular region, one must be certain that all of these joints are freely movable and balanced in a

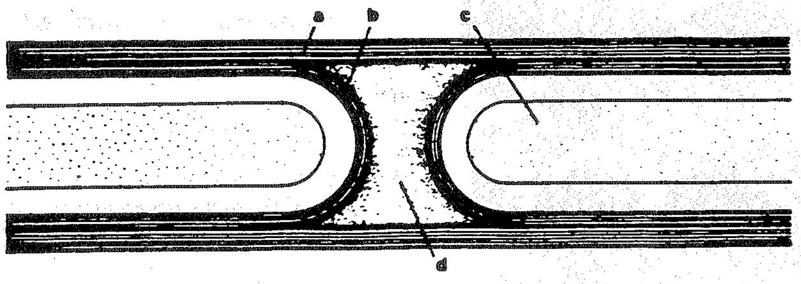

Fig. 4. Histology of cranial suture. *a,* Outer layer of periosteum; *b,* inner layer of periosteum; *c,* cranial bone (marrow); *d,* collagenous, reticular, and elastic fibers in patterns having possible functional significance, nerve and vascular supply. (From Libin B. The cranial mechanism and its dental implications. Int J Orthod 1984;22:7-11, with permission.)

position equidistant between opposing bones. This concept is now used in temporomandibular joint therapy, with no restriction of joint space. The consequences of joint restriction or asymmetry of the cranial bone motion can result in all of the symptoms encountered in daily cranial-mandibular clinical work. Indeed, it may often explain why treating only one of the joints may result in lack of complete correction and why, at times, the therapies that we provide are effective without our fully understanding the mechanism of the correction, as when a change in vertical dimension results in a cranial adjustment.

Cranial motion affects the cranial mandibular relationship within three basic regions.

The TMJ relationship. The TMJ should be recognized as functioning within a dynamic mechanism. We consider that the temporal bone also includes the housing for the condylar and disk attachments and moves into external and internal rotation 6 to 12 times per minute.[16] Sutherland[8] described this temporal bone as a "wobbly wheel" as the tip of the mastoid process moves from a posterior-medial position to a more anterior-lateral position (Fig. 7). When the motion goes as far as it can, it then reverses and returns to the other direction, going from internal rotation to external rotation. An understanding of this mechanism raises several important questions for the cranial-mandibular therapist. What effect does this temporal bone motion have on the condyle in terms of position, movement, balance, and occlusion? What is the result of sphenotympanic position on meniscal attachment? If, for example, temporal bone motion has been partially or completely restricted, what position does it remain in, and how does condylar position, and therefore occlusion, affect the potential correction of this cranial lesion?

Muscular relationships. Most cranial-mandibular therapists now realize that craniomandibular-cervical (CMC) muscular dysfunctions cause a significant percentage of head, facial, and cervical symptoms. To achieve optimum correction of the problem, we try, through a multitude of modalities, to relax the musculature of the region. Indeed, the results of therapy should not be evaluated by symptom relief, but by the state of relaxation. Muscular relaxation can be more quickly

Fig. 5. Higher magnification of sagittal suture shows loose matrix of collagenous fibers *(B)* inserting *(arrow)* at multiple points into parietal bones *(A)*. This is similar to periodontal attachment, allowing defined motion. (Courtesy of Dr. John Upledger.)

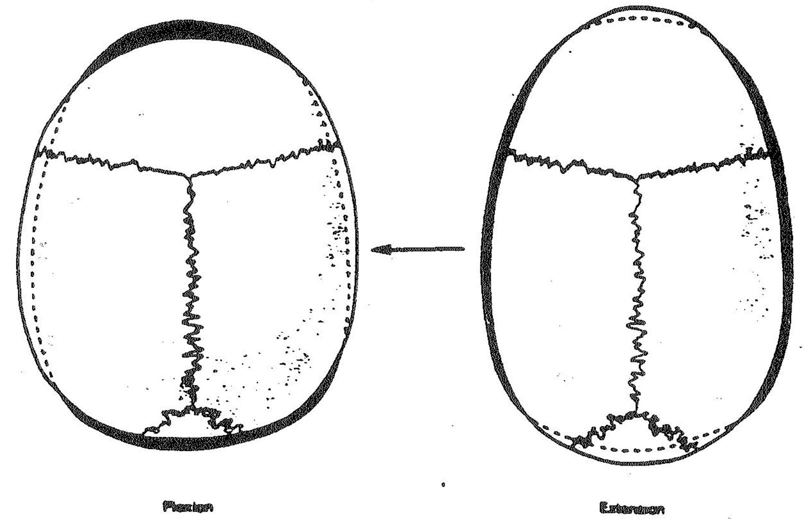

Fig. 6. Skull moving from full extension to full flexion. (From Libin B. The cranial mechanism and its dental implications. Int J Orthod 1984;22:7-11, with permission.)

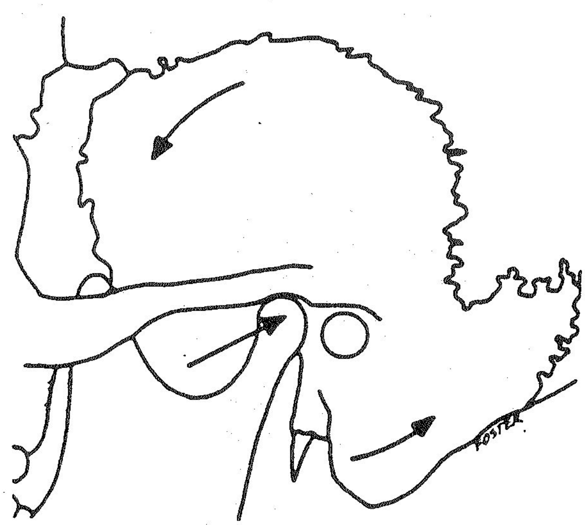

Fig. 7. Temporal bone moving into external rotation. Observe condylar movement during phase.

achieved if the osseous origin and insertion, that is, the cranial bones (including the mandible) are in their proper position. If the bones are out of position, a resultant reflex muscular contraction through physiologic adjustment to the abnormal state will occur. For example, if the temporal bone has been forced posteriorly into the occipital bone and is incapable of motion because the sutures have locked it into its unphysiologic position, the temporal muscle will not be able to assume its most relaxed, unstressed position. When the frontal bone, as the result of a motor vehicle accident, has been jammed into the sphenoid bone (Fig. 8), the lateral pterygoid muscle will remain in its unphysiologic state until the pterygoid plate returns to its normal anatomic position.

Entrapment neuropathy. Entrapment neuropathy results from anatomic stress, the common situation where trauma has resulted in cranial bones, fascia, or muscles impinging on or injuring neural tissue. For example, the jugular foramen is made up of the occipital and petrous portions of the temporal bone. Movement of the condyles into the temporal bone can result in a movement of the jugular foramen. Such movement can cause an impingement, however great or slight, on the glossopharyngeal or vagus nerves, producing pharyngeal symptoms, changes in taste, increased vagal stimulation to the heart, nausea, or gastric upset. In addition, temporal bone lesions may result in impingement on the middle meningeal artery and relate to chronic headache, whether migraine or tension. The anatomic implications of cranial lesions can be major. For example, restriction of only the sphenoid bone and its effect on the adjacent bones can result in any of the 24 cranial nerves being affected: the olfactory as it crosses the lesser wing; the optic within the foramen or on the body of the sphenoid; the oculomotor, trochlear, abducent, and ophthalmic division of the trigeminal, in the superior orbital fissure, or tension on the petrosphenoid ligament; the maxillary division of the trigeminal within the foramen rotundum; the mandibular division of the trigeminal nerve in the foramen ovale; the facial and acoustic nerves as they travel within the internal auditory meatus; the glossopharyngeal, vagus, and spinal accessory within the jugular foramen; and the twelfth nerve as it goes through the hypoglossal canal.[16] Thus, the cranial mechanism

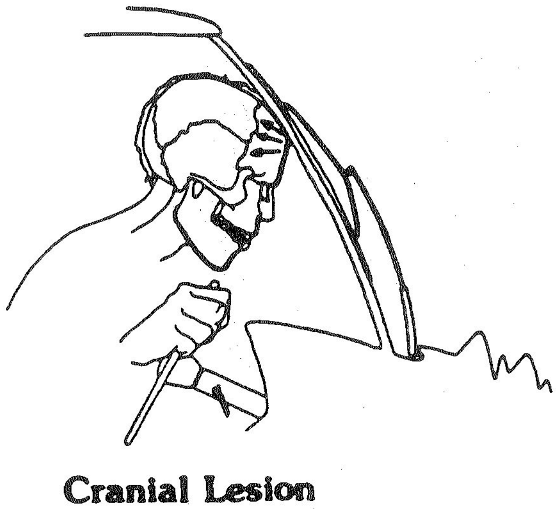

Fig. 8. Effect of force, such as a motor vehicle accident, can force cranial bones, muscles attached to them, and nerves and blood vessels that pass through them into unphysiologic positions. (From Libin B. The cranial mechanism and its dental implications. Int J Orthod 1984;22:7-11, with permission.)

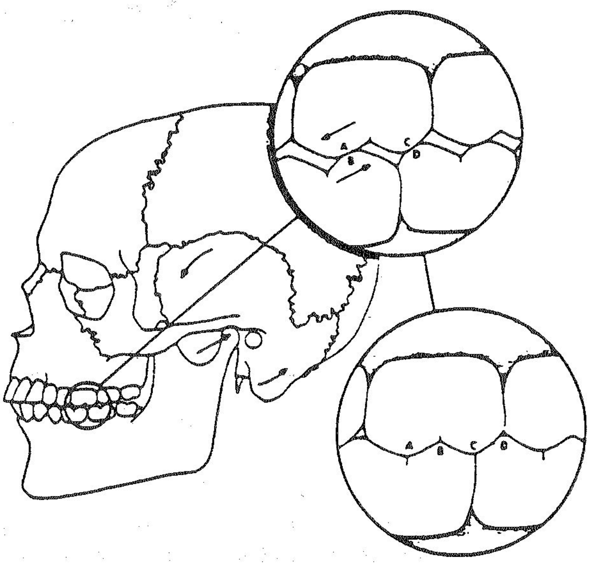

Fig. 9. Relationship of dental occlusion and cranial mechanism. Distally deflective occlusal prematurity forces temporal bone into extensive external rotation. (From Libin B. The cranial mechanism and its dental implications. Int J Orthod 1984;22:7-11, with permission.)

offers a rational approach to understanding and treating symptoms specifically through knowledge of cranial and neural anatomy.

These are some of the relationships inferred from the study and understanding of the cranial mechanism. Many of the major symptoms with which we deal are simple entrapments resulting from traumatically induced cranial lesions that are often iatrogenic in nature. Orthodontic therapies forcing bones into each other is one of the most common, often resulting in otolaryngologic symptoms. Forceful oral surgical extractions resulting in maxillary or mandibular strained patterns may produce symptoms of postsurgical parastesthia or tic type pains. Crowns in premature contact can force the mandible distally into the temporal bone, preventing full motion of the temporal bone and causing its impingement on cranial nerves VII and VIII (Fig. 9).

One of the main results of splint therapy is cranial correction. The splint removes the deflective contact from the occlusion, preventing unphysiologic movement of the mandible on the temporal bone and resultant entrapment. Indeed, one of the major results of a properly constructed splint is that it helps the temporal bone out of external rotation.

SUMMARY AND CONCLUSIONS

This review and discussion has raised many points relating the importance of the cranial mechanism to cranial-mandibular function. The increase of concern from one joint to 106 joints brings the cranial mechanism into the forefront of dental theory and practice. Every phase of dentistry is affected by mandibular position, and the cranial mechanism offers the dentist an added dimension for solving and avoiding clinical problems. Techniques for correction and evaluation of the cranial mechanism require a thorough knowledge of head and neck anatomy, but its application can be easily fit into the daily routines of clinical dentistry. Great satisfaction can be derived from being able to relax a lateral pterygoid muscle by diagnosing and correcting a frontal bone lesion, often within a few minutes. The importance of relaxing the musculature before final occlusal equilibration is even greater. As more research is devoted to the cranial mechanism, the findings will continue to supply answers to the unmanageable problems that confront dentists.

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