The Effect of Head Posture on Muscle Contact Position: The Sliding Cranium Theory

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Abstract

The effect of head posture on initial occlusive contacts has been studied extensively by researchers in the basic sciences, dentistry, and physical medicine. The purpose of this paper is to review their theories and propose a new mechanism that attributes the effect of head posture to a change in the upper to lower jaw relationship. This mechanism is referred to as the sliding cranium theory. To understand how head posture alters initial tooth contact or muscle contact position, the arthrokinematics of the occipital-atlantal joint are covered in detail. The implications of the proposed new theory have relevance for dentists concerned with occlusal function and the treatment of temporomandibular joint dysfunction with temporomandibular repositioning, as well as for physical therapists who effect a change in head posture through mobilization procedures and therapeutic exercise. To conceptualize the proposed theory two easily performed tests are described. The sliding cranium theory presents a mechanical model that explains the interrelationship between the head-neck complex and the craniomandibular system in a way that has not been previously done.

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The relationship between head posture and the muscle contact position[1] (initial tooth contact) is of great interest to all disciplines concerned with the treatment of patients with cranio-facial pain as well as to those dentists concerned with bite registration for full denture, fixed reconstruction, and orthodontic diagnosis.[2]

The purpose of this paper is to review existing theories on the relationship between head posture and muscle contact position and to propose a new concept that demonstrates the direct relationship between the cranio-vertebral system and the initial contact position of the mandibular and maxillary teeth.

Literature Review

Many studies have been done investigating the relationship between head posture and mandibular function. It is well established that head-neck backward bending increases the electromyographic (EMG) activity of the masticatory elevator muscles, especially the temporalis muscle.[2–4] The possible mechanisms mediating this phenomenon include the tonic neck reflex,[4] the role of gravity,[5,6] and body position.[6]

The influence of head posture on the rest position of the mandible has also been studied extensively[7–10]; Kraus[11] has stated that head-neck posture has the most immediate and long-lasting effect on the mandibular rest position.

Solow and Tallgren[12,13] demonstrated a relationship between head posture and craniofacial morphology. Kraus' review of the effect of head posture on the development of the mandible concludes that a high correlation exists between an extended head-neck posture and the development of a retrognathic mandibular posture.[11]

Of greatest relevance to this paper, however, is the role of head posture as it influences the mandibular pathway of closure into the fully intercuspated position of mandibular and maxillary teeth. Mohl[14] suggests that a change in head posture will likewise alter the habitual closing path from rest position to maximum intercuspation. The consensus of most studies[14–16] is that initial tooth contacts are more retruded when the head is positioned in backward bending (extension or dorsiflexion), or when a subject is supine.[1,5,6,17] Ramfjord and Ash[18] have stated that initial contact will depend on posture.

On the contrary there is no evidence that body position or head posture can alter such structural relationships as tooth position in maximum intercuspation[1,6,15,16] or the vertical dimension of occlusion[19] (teeth maximally intercuspated).

Current Theories on the Influence of Head Posture on Muscle Contact Position (MCP)

With the exception of practitioners of cranial manipulative therapy who assert that MCP can be altered by small intracranial movements of the maxilla and/or temporal bones,[20,21] other theories on the influence of head posture on MCP deal exclusively with the change in mandibular position.[2–6,11,14–16,18,22]

Mohamed and Christensen[1] state that neck dorsiflexion (backward bending) causes the mandible to move away from the maxilla with resultant retrusion/depression of the mandible; in ventroflexion (forward bending) the opposite occurs. Other researchers[7–9,22] attribute the influence of head-neck backward bending on the mandible, i.e., down and back movement to increased inframandibular soft tissue tension (supra/infrahyoid muscles and fascia). This retrusive force is one attempt to explain the posterior occlusal contacts observed with the head-neck backward bent.[14–16]

Another popular theory involves the effect of head-neck backward bending on the temporalis muscle. Assuming increased EMG activity in this posture, a force of elevation and retrusion on the mandible would account for initial occlusal contacts that are posterior to the intercuspal position.[11]

The research on body position is also worth noting. In the supine position the MCP is consistently retruded.[1,5,6,17] According to McLean et al., mandibular position is affected by the position of the body in space through the activity of neuromuscular mechanisms.[6]

To demonstrate the principle of head-neck backward bending causing a posterior MCP and forward bending causing an anterior MCP, one need only perform a simple test. While lightly tapping the teeth (2–3 taps per second) with the patient sitting or standing, one can easily detect a change in contact pattern as the head-neck is moved from neutral to backward bending and from neutral to forward bending. This phenomenon is exactly what the aforementioned researchers/authors have studied, albeit in a nonexperimental fashion.

The Sliding Cranium Theory

Goldstein et al.[22] state, "Although the exact mechanism by which head position affects the movement of the mandible is not completely understood, proper head-neck positioning appears important to all phases of dentistry."

One of the reasons why the "exact mechanism" remains unclear is that research to date has focused primarily on how head position affects the mandible. The sliding cranium theory suggests that changes in head posture are able to produce a change in MCP by altering the position of the maxillary teeth relative to the mandibular teeth. This is not to say that the previously mentioned mechanisms acting on the mandible do not play an important role but that there is an additional mechanism that deserves consideration. This theory only applies to a change in initial occlusal contacts and not to maximum intercuspation, which is a structural position and is therefore not affected by head posture.[1,6,15,16] To appreciate how maxillary occlusal position is altered by changes in head posture, a review of occipito-atlantal (O-A) joint arthrokinematics (intimate joint mechanics) is helpful. Kapandji[23] states that in extension or backward bending of the cranium the occipital condyles slide anteriorly on the lateral masses of the atlas (C-1); in forward bending the opposite occurs. An understanding of synovial joint mechanics will serve to elucidate this concept. When a convex joint surface moves on a concave surface, the rotary movement or roll and the translatory movement or slide occur in opposite directions simultaneously.[24] Consequently, when the occiput backward bends, the convex occipital condyles simultaneously slide anteriorly on the concave atlas, and during forward bending they slide posteriorly[23–26] (**Figure 1**). According to

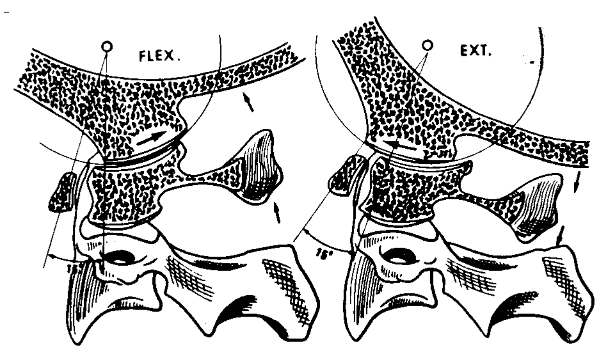


Figure 1
Lateral view of occipito-atlantal joint. A. Flexion (forward bending) of occiput on atlas is associated with posterior slide of the convex condyle on concave atlas. B. Extension (backward bending) of occiput on atlas is associated with anterior slide of convex condyle on concave atlas. (Figures taken from Kapandji IA, *The Physiology of the Joints* Vol 3. Edinburgh: Churchill Livingstone, 1974, with permission.)

Steindler[25] the total excursion of the convex occipital condyles on the lateral masses of atlas is 10 mm. This 10-mm slide in the joint is associated with a total rotary range of motion of 24.5° with 21° in O-A backward bending and 3.5° in forward bending.[27]

When the cranium slides forward on the atlas during backward bending the maxillary teeth also slide forward (being structurally joined to the cranium through the periodontal membrane system) relative to the mandibular teeth. Consequently the MCP shifts posterior to the intercuspal position (**Figure 2A**). However, as the teeth assume maximum intercuspation, the maxillary teeth will guide the mandible forward (through cusp-fossa relationships) such that in maximum intercuspation mandibular position in centric occlusion remain unchanged regardless of head position.

When the cranium slides backward on the atlas during forward bending the situation is reversed, i.e., MCP shifts anterior to the intercuspal position (**Figure 2B**). Ideally with the head in neutral, orthostatic posture[28] and the teeth free of interferences, MCP will be in direct alignment with the intercuspal position[1,29] (**Figure 2C**).

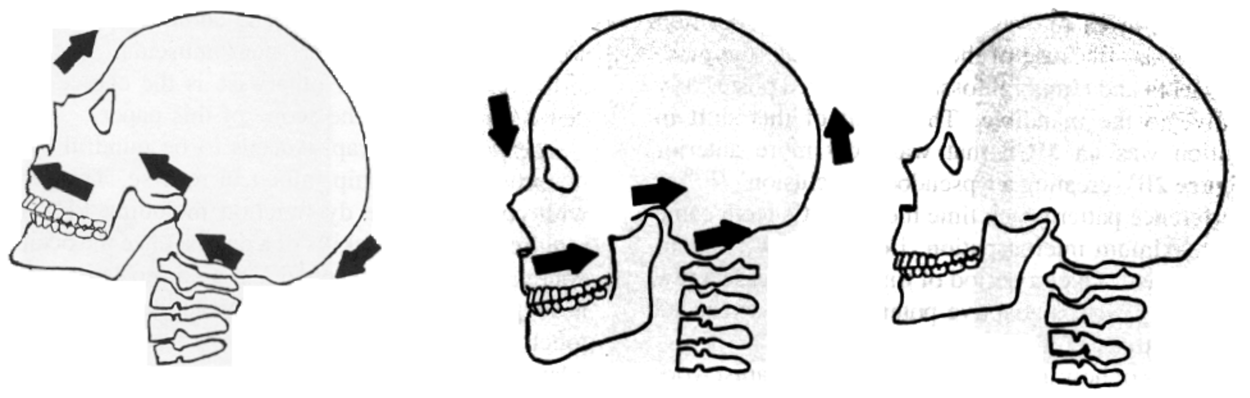
Regarding the arthrokinematics of the O-A joint during rotation and side bending[23,25,26] and the effect of these movements on MCP, the literature is inconclusive.[30,31] Therefore the proposed theory will not address the effect of these less understood movements of the cranium on initial tooth contact patterns.

Clinical Implications

Because of the profound implications of the effect of head posture on the initial tooth contacts and on craniomandibular function, numerous authors have studied this relationship.[1–4,7–16,18,19,22,28–31]

The sliding cranium theory builds on what is already known about the influence of head posture on craniomandibular function and adds to it the role of the O-A joints. In addition to the role of gravity, body position, tonic neck reflexes, and soft tissue factors all influencing mandibular position and function, there is yet another significant factor influencing the relationship of the maxilla to the mandible in response to head posture changes.

The sliding cranium theory offers a timely explanation of how the dental management of temporomandibular joint (TMJ) dysfunction affects the physical therapy management of associated head-neck dysfunction and vice versa. For example, a patient with forward head posture (FHP) received an anterior repositioning splint to manage an anterior TMJ disk dis-



A B C

Figure 2
A. Cranial backward bending is associated with anterior translation of occiput on atlas. This slide shifts muscle contact position (MCP) posterior. B. Cranial forward bending shifts MCP anterior secondary to posterior slide of occiput on atlas. C. Neutral head posture is ideally associated with MCP in direct alignment with maximum intercuspation.

placement with reduction. The patient responded well to splint intervention, but developed suboccipital pain. Conversely, a patient with head-neck dysfunction responded well to physical therapy procedures including the correction of FHP, but developed facial pain. While many theories attempt to explain these reciprocal relationships, the sliding of the cranium on the atlas offers another theoretical perspective.

In our example of the patient with FHP and a TMJ disk displacement, the anterior repositioning splint used not only affected mandibular position, but also head posture. As the mandible was repositioned anteriorly/inferiorly relative to the maxilla, the cranium hypothetically attempted to forward bend on the atlas (opposite to the head position in FHP). Providing that this patient had a long-standing FHP, the occipital condyles would have likely developed restrictions in posterior slide secondary to adaptive shortening of the soft tissues (joint capsule, musculature, connective tissue, etc.). Consequently, this limited ability of the occipital condyles to slide posteriorly as the cranium attempted to reposition itself in more relative forward bending resulted in suboccipital pain.

This theoretical explanation is based on neurophysiologic mechanisms mediated through the peridontal mechanoreceptors. It is postulated that a tooth interference activates the periodontal mechanoreceptors, which are capable of changing the habitual closing pathway of the mandible into centric occlusion.[18,29,32] This response is a function of supraspinal reflexes to the muscles of mastication and is an attempt by the body to eliminate the interference. It is also possible, although not well researched, that activation of the periodontal mechanoreceptors is able to effect changes in head-neck muscle function and thereby produce changes in head posture.[33,34] This reflex mechanism mediated through the trigeminocervical nucleus[11,35,36] is another attempt by the body to align the upper and lower jaws for the purpose of eliminating an undesirable interference pattern between one or more teeth.

Returning to the aforementioned hypothetical patient, the anterior repositioning of the mandible produced an interference that did not previously exist. As the patient closed into his new centric occlusion, he encountered a hit and slide forward. The periodontal mechanoreceptors activated by this interference act on the masticatory as well as the cervical musculature to reposition the mandible and maxilla such that the mandibular teeth (in the case of a maxillary splint) close directly into the occlusal splint. Because the patient was able to make this correction in mandibular position, the splint was able to obtain a successful result. However, the O-A restriction in posterior slide prevented the cranium from making a similar adjustment and symptoms resulted.

The second patient scenario involved the correction of head-neck dysfunction in a patient with neck pain. Using specific physical therapy procedures,[10,28,31] the patient responded well to treatment with improved head-neck mobility, posture, and reduction in symptoms. Why, however, did this patient develop facial pain? Let us assume that this patient not only had a significant FHP of long duration, but also had a class II malocclusion, which is often the case.[12,13,37] As this patient responded to physical therapy and began approaching an orthostatic head-neck posture[28,31] the occipital condyles moved to a more posterior position on the atlas. Because of this posterior slide, the maxillary teeth and temporal fossae also moved posteriorly relative to the mandible. The result of this shift in position was an MCP that was now more anterior (**Figure 2B**), creating a "pseudomalocclusion"[11,29] or interference pattern each time the patient's teeth came into maximum intercuspation, i.e., swallow, clench, bruxism, etc. Over a period of time (in this case a few days) the patient's adaptive potential[38] was exceeded and symptoms of TMJ/facial pain ensued.[29]

In terms of how a dentist and physical therapist work together with a team approach to manage TMJ and cervical spine dysfunction,[39-41] the sliding cranium model functions as a type of "bridge" in spanning this interdisciplinary relationship. The dentist who uses occlusal splint therapy must recognize that an adjustment of mandibular position necessitates associated movement of the O-A joints. Consequently, a physical therapist trained in manipulative therapy is needed to evaluate the head-neck region and render the appropriate treatment if indicated. The dentist who recognizes the need for an in-depth assessment of the craniovertebral region at the outset of occlusal splint therapy must also appreciate that altered head-neck mobility/posture necessitates ongoing occlusal splint adjustment. If the splint is not adjusted as head posture changes then no allowance for an altered MCP is being made. The result of this oversight will be either interferences in the appliance (from MCP to centric occlusion) or a tendency for head-neck posture to remain as it was at initial splint fabrication. This clinical dilemma is frustrating to the dentist, physical therapist, and most importantly the patient who is not recovering.

There are several suggestions regarding the type of splint that is best suited for a patient who is experiencing a change in MCP as a result of changing head posture, i.e., a patient receiving orthopedic physical therapy.[42]

A splint that repositions the mandible into a predetermined position may provide relief of TMJ/facial pain; but will it allow for a correction in head posture simultaneously? Our data and experience suggest that repositioning, if necessary, should await the correction of head-neck dysfunction. Once head posture is normalized, or at least improved upon, then mandibular repositioning will be more easily tolerated by the patient and a superior result obtained. If, however, splint therapy is warranted in the presence of head-neck dysfunction (including FHP), then the appliance of choice is one with shallow inclines to allow for a changing MCP, i.e., long centric.[16] The choice of hard versus soft, upper versus lower, neuromuscular versus anterior repositioning or otherwise is the choice of the dentist and beyond the scope of this paper.

The physical therapist needs to be mindful of this reciprocal relationship, albeit in reverse. The patient with cervical spine dysfunction including FHP may require the occlusal skills of a dentist once the occipital condyles are "repositioned" in an orthostatic, neutral head posture. This patient may notice that his teeth touch differently than previously. If this patient's adaptive potential[38] for change is not compromised he may remain asymptomatic. However, if it has been compromised by physical, biochemical, and/or emotional factors, then he will either develop TMJ/facial pain or relapse to his former head posture in an attempt to eliminate his tooth interferences.

Testing the Model

There are a few simple tests that can be done to add credence to the sliding cranium theory. One test is to compare the amount of cranial backward bending present with the TMJ in neutral, and in retrusion. With a lateral radiograph, the space between the occiput and the posterior arch of atlas (O-A space) is measured (millimeters) in head-neck backward bending and then remeasured following passive mandibular retrusion by the patient. As noted in **Figure 3** head backward bending is essentially blocked if the mandible is retruded beforehand. This is because the cranium is unable to slide forward on the atlas secondary to a bony stop between the posterior temporal fossa and the posterior aspect of the mandibular condyle.

A second simple test that can be done without radiographs is to compare passive mandibular retrusion with the head first backward bent, then in neutral, and lastly in forward bending. With the head in backward bending, retrusion of the mandible is blocked as the condyle abuts the temporal bone, whereas in head forward bending, it is free to retrude even more so than in neutral. This is because of the increase in posterior TMJ space created by a posterior slide of the cranium during forward bending.

Once the mechanism is understood, many such tests can be performed to confirm the mechanics that prevail at the occipito-atlantal junction.

Summary

Many theories have been proposed in the literature to explain the mechanism by which the head-neck

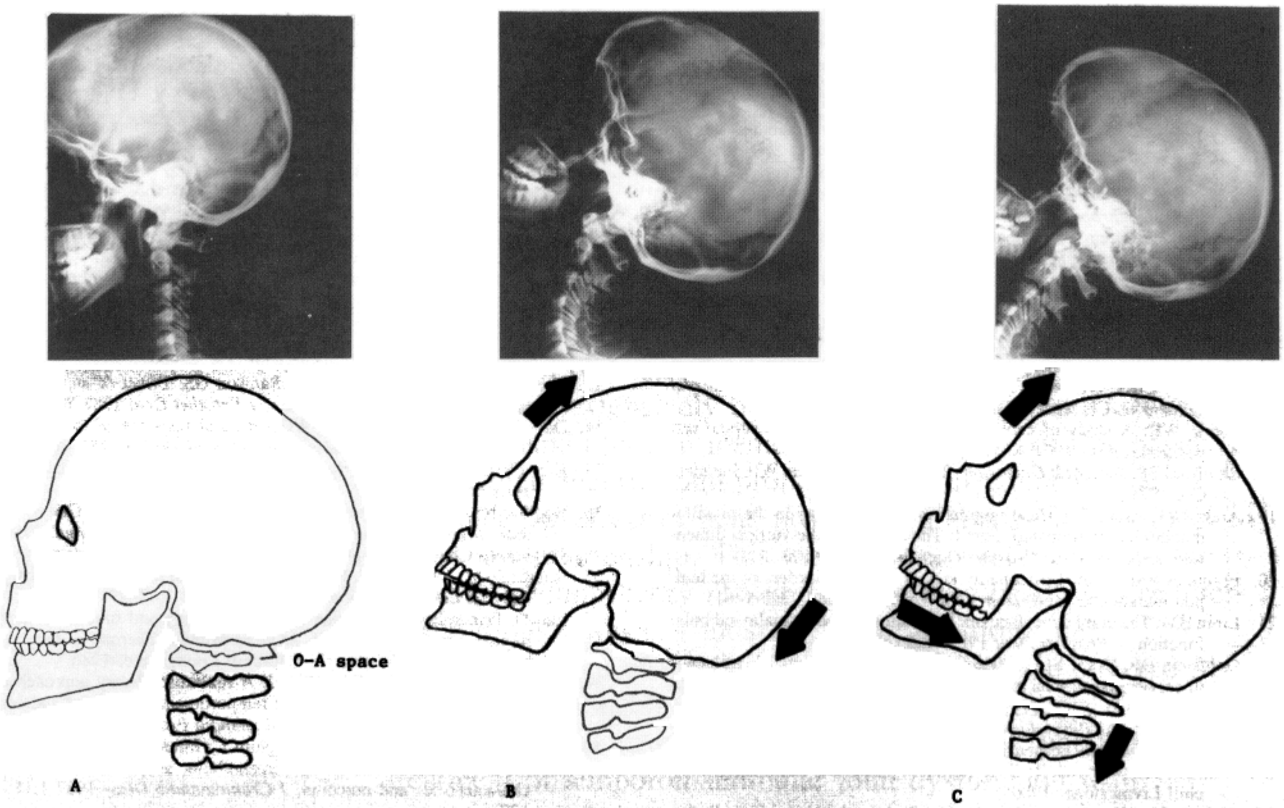


Figure 3
A. With the mandible relaxed and head-neck in neutral note the occipito-atlantal (O-A) space. B. With the mandible relaxed but the head-neck backward bent note the decreased O-A space. C. With the mandible passively retruded, note the inability of the occiput to backward bend on the atlas by virtue of a "boney block" between the posterior aspect of the condyle and the posterior aspect of the temporal fossa (backward bending occurs in the lower cervical spine instead).

complex influences the muscle contact position of the teeth as well as the rest position and movement behavior of the mandible. What has been lacking, however, is the influence of head posture on the maxillary component of MCP. To describe the mechanisms whereby changes in head posture influence the position of the maxillary teeth, the sliding cranium theory has been elucidated. The forward and backward slide of the cranium on the cervical spine follows the joint mechanics of the occipito-atlantal articulation. Implications for treatment concern the dentist who must recognize the relationship between mandibular repositioning therapy and its effect on head posture, as well as the physical therapist who must appreciate the influence of head posture on initial tooth contact patterns. Two simple tests are discussed for the purpose of illustrating the mechanics of the sliding cranium theory, which adds a new dimension to the understanding of how head posture and craniomandibular function are inextricably linked together.

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