The Association Between the Cervical Spine, the Stomatognathic System, and Craniofacial Pain: A Critical Review

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Aims: *Craniofacial pain is a term that encompasses pain in the head, face, and related structures. Multiple etiologies and factors may be related to craniofacial pain; however, the association between the cervical spine and its related structures and craniofacial pain is still a topic of debate. The objective of this critical review was to present and analyze the evidence of the associations between the cervical spine, stomatognathic system, and craniofacial pain.* ***Methods:*** *A search of the databases Medline, PubMed, Embase, Web of Sciences, Cochrane Library, Cinahl, and HealthStar was conducted for all publications related to the topic in the English and Spanish languages. Relevant information was also derived from reference lists of the retrieved publications. The key words used in the search were cervical spine, cervical vertebrae, neck pain, neck injuries, neck muscles, craniofacial pain, orofacial pain, facial pain, temporomandibular joint pain, and temporomandibular joint disorders.* ***Results:*** *The search provided information referring to the biomechanical, anatomical, and pathological association between craniofacial pain, the stomatognathic system and the cervical spine.* ***Conclusion:*** *The information provided by this review suggests an association between the cervical spine, stomatognathic system, and craniofacial pain, but most of this information is not conclusive and was derived from poor-quality studies (levels 3b, 4, and 5 based on Sackett's classification). Better designed studies are needed in order to clarify the real influence that the cervical spine has in relation to the stomatognathic system and craniofacial pain.* J OROFAC PAIN 2006;20:271–287

Key words: cervical spine, craniofacial pain, neck, neck pain, temporomandibular disorders

Craniofacial pain is a term that encompasses pain in the head, face, and related structures and can originate from a variety of conditions, organs, and etiologies.[1] Many etiologies and factors can be related to craniofacial pain; however, the association between the cervical spine and its structures and craniofacial pain is a topic that is still debated. There are numerous types of associations (anatomic, biomechanical, neurological, and pathological) between the cervical spine and the craniofacial region. All can give some clue to the functioning of this system and also to the symptomatology that patients feel. According to some studies, the cervical spine and its structures are related to the symptomatology felt by patients in the face and head.[2–28] However, other studies indicate that the information about this relationship is unclear and lacks foundation.[29–33] The anatomic-neurological[16,34,35] and biomechanical relationship between the cervical spine and the stomatognathic system, according to some

Table 1	Adapted Levels of Evidence Stated by Sackett et al[39]
Level of evidence	**Description**
Level 1a	Systematic reviews of randomized controlled trials (RCTs)
Level 1b	Individual RCTs with narrow confidence interval
Level 2a	Systematic reviews of cohort studies
Level 2b	Individual cohort studies (prospective studies with follow-up with control groups) and low-quality RCTs
Level 3a	Systematic reviews of case-control studies
Level 3b	Cross-sectional studies (study 1 group and control of an outcome of interest in a determined time)
Level 4	Case series (study of an outcome of interest in group of patients), poor-quality cohort studies, and cross-sectional studies
Level 5	Expert opinion (reviews, clinical experiences)

authors,[11,18,22,23] is a foundation bridging the normal functions of the craniomandibular system (CMS) and its pathological aspects.[2,7,8,36–38]

The objective of this review was to present and analyze evidence of the associations between the cervical spine, the stomatognathic system, and craniofacial pain.

The Search Methodology

The Medline-PubMed (1966 through first week of May 2006), Web of Sciences (1929 through May 11, 2006), Cochrane Library and Best Evidence (1991 through first quarter of 2006), Cinahl (1982 through first week of May 2006), HealthStar (1966 through April 2006), and Embase (1988 through week 18 of 2006) databases were searched for all publications related to the topic in the English and Spanish languages. The key words used in the search were cervical spine, cervical vertebrae, neck pain, neck injuries, neck muscles, craniofacial pain, orofacial pain, facial pain, temporomandibular joint pain, and temporomandibular joint disorders. Some key word variations were necessary for different databases. A total of 384 articles resulted from the database search. Relevant articles were also obtained from reference lists of the retrieved publications. Articles on any cervical problem involved with any sign or symptom in the craniofacial region such as headache, muscular pain, or temporomandibular disorders (TMD) could be included, so long as they were relevant to the association between the cervical spine, stomatognathic system, and craniofacial pain. Articles related directly to whiplash and head or neck trauma were excluded.

The Classification Method

The studies were analyzed based on the adapted levels of evidence stated by Sackett et al.[39] These levels of evidence are a clear and easy method of classifying studies according to study design into a clear hierarchy (Table 1).

Results

The Anatomic and Biomechanical Relationship Between the Cervical Spine and the Stomatognathic System

The cranium is connected to the cervical spine through the atlanto-occipital joints. The occipital condyles articulate with the lateral masses of the atlas, which are part of the superior cervical spine. The cranium is connected to the jaw through the temporomandibular joints between the temporal bone of the cranium and the mandible, which contains the mandibular teeth. All of these structures are interconnected by the capsuloligamentous, muscular, vascular, lymphatic, and nervous systems.[22]

To understand the mechanisms that are necessary to maintain the equilibrium and stability of the cranium and cervical spine, it is necessary to understand the mechanical function of this complex system. This information has been described in level-4 and -5 studies (Table 2). At the level of the craniocervical joints, a first-degree lever exists with its rotation point located in the atlanto-occipital joints. Resistance is provided by the weight of the head, and the center of gravity is located anteriorly. Power for movement and stabilization is provided by the posterior cervical muscles (eg, the trapezius, splenius, semispinalis, and multifidus muscles), all of which work constantly to maintain the stability and position of the head, as the head has a tendency to "drop" anteriorly when in an upright posture.[22] This tendency is called "inverted pendulum behavior"[11] (Sackett level 5). To maintain this stability of the CMS, an equilibrium should exist between the anterior and posterior forces. Anterior forces are provided by the masticatory muscles, the supra - and infrahyoid muscles, and the anterior cervical muscles, while posterior forces are provided by the posterior cervical muscles. These muscular groups and the structures that compose the CMS work together as a functional chain[23] (Sackett level 5).

Part of the association between the stomatognathic system and cervical spine can be explained by the sliding cranium theory[18] (Sackett level 5), which suggests that changes in head posture are able to produce a change in the occlusal contacts by altering the position of the maxillary teeth relative to the mandibular teeth. Biomechanically, when the cranium slides forward, an extension movement occurs in the occipitoatlanto joint. At the same time, the maxillary teeth slide forward since they are joined to the cranium and, consequently, the teeth contact position shifts posteriorly to the intercuspal position. When the cranium slides backward, the reverse situation occurs. Therefore, movements in the craniocervical unit cause adaptative movements in the jaw and related structures[11,18] (both Sackett level 5).

Some researchers have shown that the cervical and craniocervical posture are related to the position of the mandible and facial structures, and any intervention or modification to the craniocervical system can have an effect on the stomatognathic system and vice versa[19,21,23,44] (Sackett levels 5, 4, 4, and 4, respectively; Table 2). For example, Moya et al,[19] in a study with 15 patients (Sackett level 4), stated that when patients were treated with occlusal splints for sternocleidomastoid and trapezius spasms, the increase in the vertical occlusal dimension that occurred generated significant craniocervical extension and a decrease in the cervical spine lordosis. This observation can be explained by the fact that when the mouth opens, the head rotates in a backward direction, which results in a decrease in the cervical lordosis since the cervical spine tends to move in the opposite direction in relation to head movement[17,28] (both Sackett level 4). Yamabe and associates[28] (Sackett level 4) confirmed in their research using 10 subjects that the backward extension of the head accompanying the opening movement of the jaw increased the tension of the suprahyoid muscles, while a forward flexion position of the head increased the activity of the masticatory and cervical muscles in order to maintain the equilibrium of the CMS. According to studies performed by Schwarz,[42] Posselt,[20] and Preiskel[21] (Sackett levels 4, 5, and 4, respectively), head extension resulted in posterior displacement of the mandible, whereas head flexion caused the mandible to be displaced anteriorly. Later, McLean et al[41] (Sackett level 4) demonstrated that in the supine position, the initial tooth contacts were posterior to those found when the body was upright. Conversely, Makofsky et al[30] (Sackett level 4) studied the relationship of the head on teeth contact position and found no relationship between forward head posture and occlusal contact pattern; these findings differ from those mentioned previously,[18,20,21,41,42] although these studies are at the same level of evidence.

Solow and Tallgren[43] (Sackett level 5) determined that the extension of the head on the cervical spine was associated with a significant mandibular retrusion. In addition, Funakoshi et al[40] (Sackett level 4) determined that the craniocervical extension produced greater muscular activity in the temporalis muscle and a moderate increase in the masseter muscle. Goldstein et al[12] (Sackett level 4) concluded that alterations to the anteroposterior head and neck posture influenced the trajectory of mandibular closure in a normal population. Visscher et al[44] (Sackett level 4) found that head posture also influenced the intra-articular distance in the temporomandibular joint. However, these changes were too small to be clinically relevant.

In summary, many studies have attempted to show some relationship between the movement of the head, cervical spine, and changes in stomatognathic system. However, the information provided by these studies is based on descriptive experiences. The studies used small sample sizes and were not sufficiently clear in their methodology or results. According to Sackett's classification, there were 10 level-4 studies and 6 level-5 studies that supported the anatomical-biomechanical association. Thus, the conclusions that the authors have stated are based on studies of weak design. One must question whether these results would be seen in studies using larger populations, different methodologies, and different conditions. However, most of these studies agreed that there is a complex biomechanical interaction between the cervical spine movements and head and jaw position. A detailed analysis of the level of information provided by the previous studies is shown in Table 2.

Table 2 Analysis of Studies Referring to the Anatomic and Biomechanical Relationship Between the Cervical Spine and Stomatognathic System

Authors (year)	Study design	Level of evidence	Remarks	
Funakoshi et al (1976)[40]	Descriptive Case series	4	Sample Results Comments:	320 students, descriptive experience Jaw muscles responded to changes in the head position. No quantification of electromyography, only visual description. Interpret results with caution.
Gillies et al (1998)[11]	Descriptive	5	Expert opinion	
Goldstein et al (1984)[12]	Descriptive Case series study	4	Sample: Results:	12 normal subjects, small sample size, 1 group pre/post test, descriptive experience Alterations of anteroposterior head and neck posture appeared to have an immediate affect on the trajectory of mandibular closure in normal population.
Kohno et al (2001)[17]	Descriptive Case series	4	Sample: Results: Comments:	5 subjects, small sample size, pilot study During mouth opening the head moved backwards; during closing, it moved in the opposite direction. External validity is questionable.
Makofsky (1989)[18]	Descriptive	5	Expert opinion	
Makofsky et al (1991)[30]	Descriptive One group pretest/ post-test study	4	Sample: Results: Results:	39 subjects, descriptive experience There was not a relationship between forward head posture and occlusal contact pattern. There was not a relationship between for- ward head posture and occlusal contact pattern.
McLean et al (1970)[41]	Descriptive Case series	4	Sample: Results:	14 volunteers, small sample size, descriptive experience The resting position of the mandible appeared to be influenced by the position of the body in space.
Moya et al (1994)[19]	Descriptive Case series	4	Sample: Results:	15 subjects with the trapezius and the sternocleido- mastoid spasms, descriptive experience Cephalometric analysis showed that the splint caused a significant extension of the head on the cervical spine.
Posselt (1952)[20]	Descriptive	5	Expert opinion	
Preiskel (1965)[21]	Descriptive Case series	4	Sample: Results:	10 subjects, descriptive experience Postural position of the mandible may vary with head position.
Rocabado (1979)[22]	Descriptive	5	Expert opinion	
Rocabado (1983)[23]	Descriptive	5	Expert opinion	
Schwarz (1928)[42]	Descriptive Case series	4	Expert opinion Clinical experience	
Solow and Tallgren (1976)[43]	Descriptive	5	Expert opinion	
Visscher et al (2000)[44]	Descriptive Case series (no control group)	4	Sample: Results:	10 healthy subjects, small sample size, descriptive experience Head posture influenced intra-articular distance in the temporomandibular joint. However, these changes were relatively small and thus not clinically relevant.
Yamabe et al (1999)[28]	Descriptive Case series	4	Sample: Results:	10 healthy males, small sample size, descriptive experience Sagittal movement (flexion and extension) of the head often accompanied the jaw open-close movements.

The Cervical Joints, Their Nerves, and Pain Referred to Craniofacial Region

Neck and head pain can result from dysfunction of the medial, lateral atlantoaxial, and atlanto-occipital joints and the C2-C3 and C3-C4 zygapophyseal joints, particularly the latter[7,36,38] (all Sackett level 4). Radiographic studies fail to show specific characteristics in patients diagnosed with cervical headache. However, local anesthetic block of the zygapophyseal joints[7,38] or their innervation from nerve roots alleviates headaches in most patients[2,36] (both Sackett level 4). Other studies supporting this concept have been performed. For example, Bogduk and Marsland[2] (Sackett level 4) evaluated the relief of headaches by blocking of the third occipital nerve. Most of the subjects reported that their pain was alleviated; the success rate was 70%. Also, it was found that patients who complained of headache in addition to neck pain had relief of both pains when the third occipital nerve, the greater occipital nerve, or the atlantoaxial joint was blocked.[45]

Dwyer et al[8] (Sackett level 4) evaluated the patterns of referred pain of the zygapophyseal joint of the cervical spine in 5 healthy volunteers. They obtained pain patterns similar to those reported by patients in the study by Bogduk and Marsland.[2] However, the difference between these patterns in asymptomatic versus symptomatic subjects was that the pain referral pattern was more extensive in symptomatic patients than in asymptomatic subjects, suggesting that referral patterns generated by provocation in asymptomatic subjects were reflective of a principal region (core region) of the typical referred pain in the symptomatic state. This finding was verified later (Sackett level 4) using a group of 10 symptomatic patients.[46] Using the map developed from their study of healthy volunteers, they evaluated a group of patients and blocked the regions of the zygapophyseal joint levels suspected of causing the referral pain pattern. The results of diagnostic-therapeutic blocks were positive in most patients and confirmed the diagnosis given by the clinicians. Although their sample size was small due to ethical considerations, they found that these joints could cause a pain referral pattern to the head.

Patterns of pain from the atlanto-occipital and atlantoaxial joints have been obtained in normal subjects. These joints can cause pain referral patterns into the occipital and suboccipital regions that do not correspond to dermatomes or to disc pain patterns[7] (Sackett level 4). The pain provoked by injection was primarily referred to the suboccipital and occipital regions but did not reach the vertex of the skull. The pain patterns of these joints in normal subjects coincided with those found in clinical practice and were verified later by the same authors[46] using a group of symptomatic patients. Another study performed by Aprill et al[38] (Sackett level 4) demonstrated that patients who presented with occipital headaches felt relief of their pain as a result of blocking of the lateral atlantoaxial joints, which demonstrated that the clinical characteristics of the pain could be due to atlantoaxial problems and also provided preliminary evidence that the atlanto-occipital and atlantoaxial joints of the upper cervical spine were capable of generating head and neck pain.

The results of all previous studies related to the involvement of the zygapophyseal joints in the presence of craniofacial pain and head pain were supported by Fukui et al[36] (Sackett level 4), who reproduced headache and cervical symptoms in 61 patients by injecting a contrast medium into the cervical joints (C0-C1[cranium-atlas] to C7-T1) or by electrical stimulation of the dorsal rami (C3-C7). They found that pain in the occipital region was referred from C2-C3 zygapophyseal joints, while pain in the upper posterolateral cervical region was referred from C0-C1, C1-C2, and C2-C3. Pain in the upper posterior cervical region was referred from C2-C3 and C3-C4; pain in the middle posterior cervical region was referred from from C3-C4 and C4-C5. In addition, pain in the suprascapular region was referred from C4-C5 and C5-C6; pain in the superior angle of the scapula, from C6-C7; and pain in the mid/scapular region, from C7-T1.

Another study[47] (Sackett level 4) evaluated the effect of sterile water injection on the greater occipital nerve in patients with headaches. The authors found that this procedure could cause pain in the area supplied by the greater occipital nerve and in areas innervated by other nerves, mainly those innervated by the ipsilateral trigeminal nerve, a finding that coincided with the clinical manifestations of patients with headaches. Thus, a stimulus arising from the neck can trigger ipsilateral headaches projecting into the trigeminal areas[47] (Sackett level 4).

The available research publications are case studies; they are descriptive in nature and included no control group (8 Sackett level-4 studies). The association between cervical zygapophyseal joints and craniofacial pain cannot be strongly supported. Although the studies did not have rigorous designs, they do indicate that injecting a contrast medium may reproduce symptomatology in normal

Table 3 Analysis of Studies Referring to the Relationship between Cervical Joints, Their Nerves, and Craniofacial Pain

Authors (year)	Study design	Level of evidence	Remarks
Aprill et al (2002)[38]	Descriptive Case series (no control group)	4	Sample: 34 patients with headache symptoms underwent lateral atlantoaxial block. Results: 21 patients obtained total relief of symptoms (62% success).
Aprill et al (1990)[46]	Descriptive Case series (no control group)	4	Sample: 10 patients with neck, head, shoulders, and upper limb pain Methods: Diagnostic study through anesthetic blocks of the cervical joint. Results: The clinician's diagnosis was confirmed by nerve blocks in 80% of the cases.Pain patterns from the cervical joint were confirmed.
Bogduk and Marsland (1986)[2]	Descriptive Case series (no true control group)	4	Sample: 10 patients with occipital and suboccipital headaches underwent third occipital block injection. Results: 7 of 10 patients obtained relief their symptoms after blocking of the third occipital nerve (70% success). Comments: Case series (no true control group). However, control blocks in different joints without relief of symptomatology in 5 patients served as a control.
Bogduk and Marsland (1988)[3]	Descriptive Case series (no control group)	4	Sample: 24 subjects with neck pain, 14 of whom had headache symptoms Methods: Diagnostic blocks were used. Results: 18 patients experienced relief of their pain after blocks of the specific joints (72% success). Pain patterns were obtained from these patients.
Dreyfuss et al (1994)[7]	Descriptive Case series (no control group)	4	Sample: 5 healthy volunteers Methods: Intra-articular injections of atlanto-occipital and lateral atlantoaxial joints were administered to determine the pain patterns of these joints. Results: Pain patterns of these joints were obtained.
Dwyer et al (1990)[8]	Descriptive Case series (no control group)	4	Sample: 5 volunteers (small sample size) Results: Pain patterns were obtained from cervical joints.
Fukui et al (1996)[36]	Descriptive Case series (no control group)	4	Sample: 61 patients (181 joints and 62 dorsal rami) who had occipital, neck, and shoulder pain underwent injection stimulation of the cervical zygapophyseal joint and the dorsal rami Results: Pain patterns were obtained.
Piovesan et al (2001)[47]	Descriptive Case series	4	Sample: 3 volunteers Results: Headache symptoms were reproduced after injection over the greater occipital nerve. Comments: The results reinforce previous evidence of central convergence of cervical afferents. However, because of its small sample size, the results can only be considered clinical evidence.

subjects and that the blocking of certain nerves or joints may relieve pain in subjects who complain of neck pain and headaches. However, the power and sample size of these studies are not representative of the population; thus, these studies can only be taken as clinical evidence of change. Studies with blinding, randomization, and control subjects are necessary to give more strength to the results obtained by the authors. An analysis of the information related to the cervical joints and craniofacial pain is provided in Table 3.

Cervical Muscles, Myofascial Pain Syndrome, and Craniofacial Pain

Myofascial pain syndrome (MFPS) is pain that is derived from myofascial trigger points (TPs), which are highly localized and hyperirritable spots in a palpable taut band of skeletal muscle fibers.[48–50] MFPS can be associated with other neuromusculoskeletal disorders and can be aggravated by mechanical stress, metabolic insufficiencies, and psychological factors[50] (Sackett level 5). MFPS can be associated with persistent pain that is often intense and disabling. Cervical myofascial pain has been reported to be associated with neuro-otologic symptoms, including imbalance, dizziness, and tinnitus. Other neurological symptoms include paresthesia, numbness, blurred vision, and trembling[48,49] (Sackett levels 4 and 5). For more information, the reader is encouraged to read some specific information about MFPS.[50]

Clinical experience demonstrates that MFPS from the cervical muscles can refer pain to the facial zone[26,48] (both Sackett level 4). Active TPs, which are spots with spontaneous pain or pain in response to movement,[50] (Sackett level 5) have been found in patients with headaches[27,48,51,52] (all Sackett level 4) and occipital neuralgia[13] (Sackett level 4). Myofascial pain referred from TPs in cervical muscles may be responsible for headaches of cervical origin[51,53] (both Sackett level 4). Moreover, stimulation of the TPs during a headache attack exacerbates or intensifies the headache[53] (Sackett level 4). Inactivation of these TPs can eliminate the symptomatology as well[48] (Sackett level 5). TPs from the suboccipital muscles may cause referred occipital pain in patients with occipital neuralgia[13] (Sackett level 4). Moreover, treating the TPs of the splenius capitis and the splenius cervicis can relieve pain in patients diagnosed with occipital neuralgia.[13]

Some muscles are more involved than others in pain that may be referred from the neck to the head and facial region. Muscles receiving their sensory innervation from the C1-C3 nerve roots, such as the cervico-occipital muscles, the sternocleidomastoid (supplied by the C1-C2 nerve roots), the trapezius (C1-C2 nerve roots), the splenius capitis and cervicis (C2-C3 nerves), and the semispinalis capitis and cervicis (C3 nerve root), could refer pain through TP activation to various regions of the head[26,48,49] (Sackett level 4). The referred pain from these muscles has been described by Simons[49] (Sackett level 5) in detail. For example, the trapezius muscle refers pain to the head and neck and the orbital and preorbital regions. The sternocleidomastoid can cause pain in the fronto-temporal region, the occiput, the vertex, the forehead, and the orbit. Pain is commonly referred from the splenius capitis and the splenius cervicis to the vertex of the head on the same side, the area behind the eye, and the occiput. The cervico-occipital muscles refer pain to the occiput, the eye, and the forehead[48] (Sackett levels 4 and 5).

Fricton et al[48] (Sackett level 4) described the pain patterns of 164 patients diagnosed with MFPS and found the results to be in agreement with the patterns described previously by Simons[49] (Sackett level 5), confirming the concept that MFPS can cause pain in the cranial and facial region. Interestingly, a study performed by Wright[26] (Sackett level 4) with 230 TMD patients demonstrated that the most common source of referred pain in the craniofacial region was from the trapezius muscle (induced by palpation).[26] Carlson et al[54] (Sackett level 4) found in a group of patients with MFPS of the upper trapezius that injection on the TP of this muscle caused a decrease in the pain felt in the masseter muscle and a decrease in its electromyographic (EMG) activity in the same group of patients. This relationship between trapezius muscle TP injection and decrease in the activity of the masseter muscle is a finding which requires more study, since the sample size was small and the EMG evaluation lacked clarity and showed methodological problems. Therefore, the conclusions obtained in this study must be considered with caution.

A study using lower cervical intramuscular anesthetic injections has demonstrated good results in the relief of symptoms in patients with intractable head or face pain[52] (Sackett level 4). However, this study was performed in only 7 patients, and the technique used, including the muscles injected, was not precisely defined, which makes the conclusion tenuous (Table 4).

Anttila et al[55] (Sackett level 3b) evaluated the presence of tenderness in the pericranial and neck-shoulder region in children. They found that children with

Table 4 Studies Referring to a Relationship Between Cervical Myofascial Pain Syndrome and Craniofacial Pain

Authors (year)	Study design	Level of evidence	Remarks	
Anttila et al (2002)[55]	Cross-sectional with randomization. Random selection of subjects.	3b	Sample: Power: Methods: Results:	183 children (59 migraine, 65 tension-type headache, and 59 control subjects) 85% ($P < .05$) Blind examination of tender points of pericranial and shoulder girdle muscles. Children with migraine had increased tenderness in the pericranial and neck-shoulder region compared with controls and tension-type headache patients.
Carlson et al (1993)[54]	Descriptive Case series	4	Sample: Results: Comments:	20 patients with upper trapezius trigger points and pain in the ipsilateral masseter muscle Upper trapezius trigger point injection alleviated the pain and reduced EMG activity in masseter muscle. Methodological problems in validation of the results (No normalization of EMG).
Fredriksen et al (1987)[53]	Descriptive Case series	4	Sample: Results:	11 patients with cervicogenic headache In 10 patients, a cervicogenic attack was precipitated by firm manual pressure of a TP in the neck.
Fricton et al (1985)[48]	Descriptive Case series (no control group)	4	Sample: Results:	164 patients MFPS patterns were obtained in this study.
Graff-Radford et al (1986)[13]	Descriptive Case series study (no control group)	4	Sample: Results:	3 patients with occipital neuralgia Relief of symptoms after TP injection of splenius capitis.
Hong and Simons (1998)[50]	Descriptive Review	5	Expert opinion	
Jaeger (1989)[51]	Descriptive Case series (no control group)	4	Sample: Results:	11 patients with cervicogenic headaches Patients presented cervical dysfunction and MFPS, which were the cause of the headache. After myofascial pain treatment, 5 patients experienced relief of symptoms.
Mellick and Mellick (2003)[52]	Descriptive Case series (no control group)	4	Sample: Results:	7 subjects Relief of symptoms after lower cervical anesthetic injection in patients with intractable head or face pain.
Simons (1999)[49]	Descriptive	5	Expert opinion	
Wright (2000)[26]	Descriptive Case series (no control group)	4	Sample: Results:	230 patients with TMD MFPS pain patterns. The most common source of referred pain in the craniofacial region was the trapezius muscle.

migraines had increased tenderness in the pericranial and neck-shoulder region compared with children with tension-type headaches and control subjects, a result which demonstrated that the myofascial sensitivity of these muscles was increased, especially in association with severe headaches.

Based on this information, MFPS and cervical muscle evaluation should be considered when evaluating and treating patients with headaches and craniofacial pain problems such as cervicogenic headaches, occipital neuralgia, chronic tension-type headaches, pericranial tenderness, and head pain due to potential association with head and orofacial symptomatology. Based on the literature available, most of the studies presented do support an association between cervical myofascial pain and pain felt in the craniofacial region. Moreover, treating the TPs of the cervical muscles could relieve the symptomatology felt by patients with headaches or craniofacial pain[4,56] (both Sackett level 5). Thus, the information presented relating to cervical myofascial pain and craniofacial pain indicates that clinically cervical MFPS has been associated with craniofacial pain. However, from a research perspective, additional studies with greater scientific stringency are needed to clarify the role of TPs of cervical origin and their relationship with craniofacial pain. For a detailed analysis of the studies, see Table 4.

Cervical Muscles, Experimental Pain Models, and Craniofacial Pain

The study of pain behavior through an experimental pain model has been a strategy used to simulate a painful condition and to observe motor behavior to study the physiology of muscle pain with time and location variables standardized.[57] The most widely used and successful method for the inducement of pain has been the injection of hypertonic saline into muscles in order to model deep tissue pain in healthy humans.[58,59] The use of experimental pain has been widely accepted.[57] It has contributed to the understanding of local and referred pain and has allowed improvements in the diagnosis and treatment of the painful conditions. Although experimentally induced pain is brief, it has been shown to induce long-term changes in the central nervous system (CNS) in animals.[59] Some experiments investigating the sensory effect of an experimental pain model in cervical and jaw muscles have been conducted in order to understand the clinical manifestations of pain in patients with craniofacial pain. For example, Svensson et al[60] (Sackett level 3b) found that glutamate injections in the splenius capitis muscle referred pain to the ipsilateral neck and occipital region, and in some subjects, toward the ipsilateral upper head and temporal region (46.15%). In 1 subject, the reference pattern reached the teeth and masseter region. In another study[61] (Sackett level 3b), hypertonic saline solution in the upper trapezius referred pain at the base of the neck in 83% of the subjects, to the infra-auricular zone in 50%, and to the retro-auricular zone in 42%. Similar findings were also noted by Ge et al[62] (Sackett level 3b); however, Komiyama et al[61] found greater spread of pain to the temporomandibular joint region than Ge et al[62] or Madeleine et al[63] (Sackett level 3b). According to these authors, the area of pain referral in most of the subjects overlapped the region where TMD symptoms usually are reported. In addition, experimental pain in the upper trapezius caused a significant decrease in the mean maximum mouth opening (54 to 47.8 mm). Svensson et al[64] (Sackett level 3b) investigated motor behavior during different head positions of the sternocleidomastoid, splenius capitis, and masseter muscles when glutamate was injected into the masseter and splenius capitis. They found that when glutamate was injected into the masseter, the EMG activity of the masseter as well as the sternocleidomastoid was increased. However, when glutamate was injected into splenius, activity changed only in the sternocleidomastoid. No significant changes were observed in the masseter muscles, although there was a trend toward inhibition during maximal clenching. The authors highlighted the fact that jaw muscle pain could be linked to increases in neck EMG activity with the head and jaw at rest. The same group of researchers[65] (Sackett level 3b) investigated the effect of glutamate-induced pain on the masseter and splenius muscles on EMG activity and on stretch reflexes of sternocleidomastoid and masseter muscles. They found that the normalized amplitudes of the EMG activity from the masseter and sternocleidomastoid were significantly higher when pain was induced in the masseter muscle as well as in the splenius muscle.[65] According to the authors, "although the clinical implications of these findings are unclear, they highlight the interaction between craniofacial and cervical regions in the neuromuscular changes that may result from musculoskeletal pain in either region"[65] (p. 1292) (Table 5).

Cervical Discs and Craniofacial Pain

Based on the anatomic description of the cervical disc by Bogduk et al[66] (Sackett level 4), it is known

Table 5 Studies Referring to a Relationship Between Experimental Muscular Pain and Craniofacial Pain			
Authors (year)	**Study design**	**Level of evidence**	**Remarks**
Komiyama et al (2005)[61]	Cross-sectional study using a nonpainful stimulus as a control	3b	Sample: 12 healthy men Methods: Controlled muscular pain experience in upper trapezius muscle using hypertonic saline (6%). Results: Pain patterns from upper trapezius were obtained. Pain often spread to the infra-auricular zone. Mouth opening was significantly reduced after experimental pain was induced in upper trapezius.
Ge et al (2003)[62]	Cross-sectional study using a nonpainful stimulus as a control	3b	Sample: 15 healthy volunteers (14 males, 1 female) Methods: Controlled muscular pain experience in upper trapezius muscle evoked by hypertonic saline (6%) (unilateral and bilaterally). Results: Pain patterns from upper trapezius were obtained. Pain from bilateral injections often spread to remote areas such as temporal regions, orofacial mandibular regions, upper arms, and posterolateral neck. Experimental pain was induced in the upper trapezius.
Svensson et al (2004)[64]	Cross-sectional study using a nonpainful stimulus as a control	3b	Sample: 19 healthy men Methods: Controlled muscular pain experience in masseter and splenius muscles evoked by glutamate. Results: Glutamate injected in masseter muscle was associated with an increase in EMG activity in masseter, sternocleidomastoid, and splenius muscles at rest.
Svensson et al (2005)[60]	Cross-sectional study using a nonpainful stimulus as a control	3b	Sample: 26 healthy men Methods: Controlled muscular pain experience induced by glutamate injection in masseter and splenius muscles. Results: Pain patterns from masseter and splenius muscles were obtained. Masseter pain pattern did not extend to the neck region; however, pain from the splenius muscles extended into the temporal region.
Wang et al (2004)[65]	Cross-sectional study using a nonpainful stimulus as a control	3b	Sample: 19 healthy men Methods: Controlled muscular pain experience induced by glutamate injection in masseter and splenius muscles. Results: Experimental pain in masseter and splenius evoked increase in the stretch reflex amplitude in both masseter and sternocleidomastoid.
Madeleine et al (1998)	Cross-sectional study using a nonpainful stimulus as a control	3b	Sample: 20 healthy men Methods: Pain induced by intramuscular injection of hypertonic saline in the trapezius and infraspinatus muscles. Results: Pain patterns from these muscles were obtained. The referred patterns from trapezius muscles were in the posterolat eral aspect of the neck and around the temporal mandibular region; for the infraspinatus muscle, they were from the anterior part of the shoulder.

Table 6 Analysis of Studies Referring to the Connection Between Cervical Discs and Orofacial Pain

Authors (year)	Study design	Level of evidence	Remarks	
Bogduk et al (1988)[66]	Descriptive	5	Sample:	10 embalmed human adult cadavers
			Results:	Anatomic description of the innervation of the cervical discs.
Grubb and Kelly (2000)[14]	Descriptive Case series	4	Sample:	160 patients with intractable neck pain
			Methods:	Discography procedure.
			Results:	Pain disc patterns were obtained.
Schellhas et al (2000)[67]	Descriptive Case series	4	Sample:	40 patients with suspected disc degeneration
			Results:	Pain disc patterns of C2-C3 were obtained.
Schellhas et al (1996)[37]	Cross-sectional study	3b	Sample:	10 control and 10 patients with nonlitigious chronic head-neck pain
			Methods:	An experimental and a control group underwent discography at C3-C4 through C6-C7 after resonance imaging.
			Results:	Pain disc patterns were obtained.

that disc pathology can be associated with pain. The sinuvertebral nerve supplies the disc at its level of entry (same level) and the disc above. Branches of vertebral nerve supply the lateral aspects of the cervical disc. Furthermore, it was found that the nerve fibers were located as deeply as the outer third of the annulus fibrosus.

Pain originating in the discs of the cervical spine can cause headaches as well.[14,37,67] Grubb and Kelly[14] (Sackett level 4) and Schellhas et al[37,67] (Sackett levels 3b and 4, respectively) obtained similar results related to the reference patterns of the cervical discs. They reproduced the symptoms through a discography procedure. They reported that the upper disc of the cervical spine (the C2-C3 disc) referred pain to the upper cervical area. This pain often spread to the occipital region and the head and was commonly referred to as an occipital headache, with pain sometimes referred to the level of the throat and into the ears. The C3-C4 vertebral level referred pain in a similar pattern to the C2-C3 vertebral level. Pain was referred to the mastoid, the jaw, the temporomandibular joint, the parietal area, the occiput, the craniovertebral junction, the neck, the throat, the upper back, the trapezius muscle, the top of the shoulder, the upper extremity, and the interscapular region. According to Grubb and Kelly,[14] stimulation of discs from the C4-C5 level and below caused no pain in the head region. Disc pain was referred principally to the neck and the upper extremities. However, according to the reports of Schellhas et al,[37,67] pain from the C4-C5 disc could be felt in the mastoid, the temporomandibular joint, the parietal region, the occiput, and the craniovertebral junction. However, these data were derived from small samples of patients (40 and 10 patients, respectively) compared with the 160 patients studied by Grubb and Kelly.

The information available on cervical intervertebral discs is limited to a few studies because the procedures for evaluating pain related to intervertebral discs are invasive. These studies are descriptive and range from levels 3b to 5; nevertheless, they show a tendency toward a link between cervical discs and craniofacial pain. For a detailed analysis of the studies, see Table 6.

Head and Cervical Posture and Clinical Evidence Associating the Cervical Spine with TMD as a Source of Craniofacial Pain

TMD have been associated with alterations in head and cervical posture[24,32,68–74] (see Table 7 for details). For example, Nicolakis et al[70] (Sackett level 3b) demonstrated that patients with TMD presented more postural abnormalities than controls. This finding was similarly obtained by Braun[73] (Sackett level 4) and Armijo Olivo et al[72] (Sackett level 3b). They reported that patients with TMD had a tendency to have a forward head position and also a decrease of cervical lordosis compared to healthy controls. These findings were in agreement with those of a study performed by Lee

Table 7 Analysis of Studies Referring to Head and Cervical Posture and TMD

Authors (year)	Study design	Level of evidence	Remarks
Armijo-Olivo et al (2001)[72]	Cross-sectional study	3b	Sample: 25 subjects with TMD and 25 healthy subjects Power: 0.94 Methods: Descriptive analysis with experimental and control groups Results: Patients with anterior disc displacement had a tendency to present a posterior rotation of the head and a decreased cervical lordosis compared with a control group.
Braun (1991)[73]	Descriptive Cross-sectional (experimental and control groups)	4	Sample: 40 asymptomatic subjects and 9 symptomatic subjects Comments: Low-powered; symptomatic subjects were not representative of population; poor statistical analysis Results: Female patients with TMD presented major forward head position than compared with healthy controls.
Darlow et al (1987)[71]	Descriptive Cross-sectional study	3b	Sample: 30 patients with myofascial pain of the masticatory muscles and 30 control patients Power: 0.37 Results: No significant differences in posture were found between myofascial pain patients and healthy controls.
Hackney et al (1993)[31]	Descriptive Cross-sectional study (experimental and control groups)	3b	Sample: 22 patients with internal derangement and 22 healthy volunteers Results: There were no differences between patients and controls in head posture.
Huggare and Raustia (1992)[75]	Cohort study	4	Sample: 16 subjects with TMD and 16 asymptomatic subjects Comments: Statistical analysis not appropriate for all outcomes; poor quality Results: Head posture changed after treatment of patients; this may have been related to a decrease in TMD symptoms.
Kritsineli and Shim (1992)[68]	Case series Descriptive	4	Sample: 40 children with primary dentition and 40 children with mixed dentition Methods: TMD and malocclusion factors were evaluated and head posture was measured. Comments: Statistical analysis unclear. Results: Forward head position had a significant relationship to TMD in the mixed-dentition group.
Lee et al (1995)[69]	Descriptive Cross-sectional study (experimental and control groups)	3b	Sample: 33 patients with TMD and 33 healthy subjects Comments: TMD diagnosis mixed Results: The head was positioned more forward in patients with TMD than in healthy volunteers.
Nicolakis et al (2000)[70]	Descriptive Cross-sectional study (experimental and control groups)	3b	Sample: 25 patients with TMD and 25 control subjects Comments: General description of posture Results: Patients with TMD had more postural abnormalities than healthy controls.
Sonnesen et al (2001)[74]	Descriptive Case series	4	Sample: 96 children Comments: TMD diagnosis mixed and based on Helkimo Index; sample size by categories (muscular, articular problems) small; caution needed in analysis of results Results: Children with clicking and reduced mobility of the joints had marked forward positioning of the head.

Visscher et al (2002)[32]	Descriptive Cross-sectional study (experimental and control groups)	3b	Sample: Comments: Results:	85 nonpatients and 106 patients Analysis of posture was carried out by group (muscular, articular or mixed). Convenience sample used. Clear diagnosis (muscular, articular and mixed). However, the sample size for each group was very unequal; thus, caution must be used in making comparisons between groups. No significant differences in head posture were found between patients and healthy subjects.
Wright et al (2000)[27]	Randomized controlled trial	1b	Sample: Results:	51 women and 9 men ranging in age from 18 to 60 years with diagnoses of TMD with moderately severe pain in the masticatory muscles for minimum of 6 months There was a statistically significant improvement in the modified symptom severity index, maximum pain-free opening, and pressure threshold of the training group compared with self-management. The authors concluded that posture training and TMD self-management together are more effective than self-management alone for patients with TMD, specifically those with muscular problems.

et al[69] (Sackett level 3b), who concluded that head posture was significantly different between patients with TMD and a control group. In addition, a close relationship between head and cervical posture improvement and the relief of symptoms of TMD was found[27] (level 1b). However, some studies do not support these findings. For example, Hackney et al[31] (Sackett level 3b), who studied the relationship between internal derangement of the temporomandibular joint and head posture, reported that patients and healthy controls had no differences in head posture. These results are in accordance with results obtained by Visscher et al[32] (Sackett level 3b), who did not find significant head posture differences between patients with TMD and cervical spine dysfunction and healthy controls.

In a recent systematic review[76] about the relationship between cervical and head posture and TMD, it was concluded that most of the studies investigating this association were of a poor methodological quality; and therefore, their findings and conclusions must be interpreted with caution. Based on these findings, it is not clear that head and cervical posture is associated with intra-articular and muscular TMD. More controlled studies with greater sample sizes, objective posture evaluation, and precise TMD diagnosis are necessary. Analysis of the studies referring to the relationship between head and cervical posture and TMD is presented in Table 7.

Association Between Cervical Spine Dysfunction and TMD

Cervical spine dysfunction is a collective term embracing a number of clinical problems of the musculoskeletal structures of the cervical spine. Pain is usually aggravated by moving the head or adopting certain head positions.[33] Neck pain related to macrotrauma (acute pain) or microtrauma (chronic pain) is often the main symptom of cervical spine dysfunction. The joints or periarticular tissues surrounding the cervical spine are affected. Cervical spine dysfunction has been associated with TMD[5,6,9,33] (for detailed information of studies, see Table 8. De Wijer et al[5,78] (both Sackett level 4) concluded that symptoms of the stomatognathic system overlap in patients with TMD and cervical spine dysfunction, and symptoms of the cervical spine overlap in the same group of patients (TMD and cervical spine dysfunction). Also, it was found that patients with chronic TMD more often suffered from cervical spine pain than those without this disorder[33] (Sackett level 3b). Stiesch-Scholz et al[25] (Sackett level 3b) found that asymptomatic functional disorders of the cervical spine occurred more frequently in patients with internal derangement of the temporomandibular joint than in a control group. The presence of tender points in the cervical and shoulder girdle in patients with the same diagnosis was more common, especially in upper seg-

Table 8 Analysis of Studies Referring to the Relationship Between Cervical Spine Dysfunction and TMD

Authors (year)	Study design	Level of evidence	Remarks
Ciancaglini et al (1999)[77]	Cross-sectional study	3b	Sample: 483 randomly selected subjects Results: 188 patients (38.9%) had neck pain and 266 patients (55.1%) had TMD. A significant correlation was found between neck pain and TMD. The severity of neck pain increased with severity of TMD.
de Wijer et al (1996)[6]	Descriptive Case series	4	Sample: 111 patients with TMD complaints and 103 patients with cervical spine dysfunction (CSD) Results: No evidence to support the theoretical concept that CSD may give rise to TMD. Patients with TMD differed from patients with CSD regarding signs and symptoms of bruxism, joint sounds, symptoms in and around the ear, and the dimension pain.
de Wijer et al (1996)[78]	Descriptive Case series (no control group)	4	Sample: 111 patients with TMD and 103 patients with symptoms of CSD Results: Patients with CSD had signs and symptoms of TMD.
de Wijer et al (1996)[5]	Descriptive Case series (no control group)	4	Sample: 111 patients with TMD and 103 patients with CSD Results: There was considerable overlap between patients with signs and symptoms of TMD and patients with CSD.
Fink et al (2002)[9]	Descriptive Cross-sectional study	3b	Sample: 30 patients (with painful internal derangement) without any subjective neck problems and a control group of 30 healthy subjects Results: Patients with internal derangement presented more silent cervical disorders in the cervical spine than healthy controls.
Sipilä et al (2002)[79]	Descriptive Cross-sectional study	3b	Sample: 40 patients with orofacial pain and 40 controls randomly selected from a total of 162 patients and 200 controls. Results: Facial pain is strongly associated with TMD.
Stiesch-Scholz et al (2003)[25]	Descriptive Cross-sectional study	3b	Sample: 30 patients (with painful internal derangement) without any subjective neck problems and a control group of 30 healthy subjects Results: Patients with internal derangement presented pain on pressure of the neck muscles more often than healthy controls.
Visscher et al (2001)[33]	Descriptive Cross-sectional study (experimental and control groups)	3b	Sample: Convenience sample of 147 patients with craniomandibular disorders (CMD) complaints and 103 healthy subjects (control group) Results: Patients with CMD suffered from CSD more often than persons without it.
Pallegama (2004) et al[80]	Cross-sectional study	3b	Sample: 38 volunteers with myogenous TMD (16 males and 22 females, mean age 29 years) and a group of 41 matched healthy individuals Results: Patients with myogenous TMD had increased resting EMG activity of the upper trapezius muscles as well as the sternocleidomastoid muscles when compared with control subjects. Comments: No normalization of the EMG activity. Interpret results with caution.

ments of the cervical spine, compared with healthy controls. These results are in agreement with those obtained by Sipilä et al[79] (Sackett level 3b). They found that facial pain was associated with reported pain in the neck area and clinical pain evoked by palpation of the muscles of the neck-occiput area. Significant differences in mobility of the cervical spine were not found between patients with facial pain and controls. In addition, Ciancaglini et al[77] (Sackett level 3b) analyzed a randomly selected sample of 483 individuals in northern Italy and found a positive relationship between neck pain and TMD. This association was more marked when the TMD dysfunction was more severe. These results demonstrated that TMD patients had more than double the risk (odds ratio of 2.33) of suffering neck pain than patients without TMD (odds ratio of 1). (Odds ratio provides an estimation of the number of times the risk of neck pain increases for a single subject when TMD is present.) Individual symptoms such as facial and jaw pain were significantly associated with neck pain, with an odds ratio of 2.09. Based on these results, the authors suggested that an association between neck pain and TMD may be possible and that systematic clinical examination of cervical spine areas could be important in identifying possible causes of craniofacial pain. In a recent report, Pallegama et al[80] found that patients with myogenous TMD had increased resting EMG activity of the upper trapezius as well as the sternocleidomastoid muscles when compared with control subjects. The presence of pain over the sternocleidomastoid and trapezius muscles was significantly associated with masticatory muscle pain without disc displacement. Analysis of the studies that referred to the relationship between head and cervical posture and TMD is presented in Table 8.

Even if the association between cervical spine dysfunction and TMD has been supported only by level-3b and level-4 studies (Sackett), a clinical tendency was demonstrated. However, in order to support a cause-effect relationship, more rigorous studies, such as cohort studies, should be conducted.

Conclusions

The associations between the cervical spine, stomatognathic system, and craniofacial pain have been presented in this critical review. However, if one analyzes the information presented from a research perspective, and based on the levels of the evidence presented by Sackett et al,[39] it can be seen that most of the studies included in this review are descriptive experiences, cross-sectional studies, cohort studies with small sample sizes, and other investigations with low power. These studies must be interpreted with caution because of their lack of scientific rigor. However, they do point out a tendency toward a link between the cervical spine, neck structures, and craniofacial pain. This tendency should not be undervalued. Future investigators working on this topic should consider the findings of this review when designing future trials and attempt to overcome the limitations of the studies presented (eg, small sample sizes, low power, lack of randomization, lack of controls).

Although Sackett's method of evaluation is very easy to use for the hierarchical organization of studies, the method has weaknesses, as it lacks specific analysis of some important methodological points such as sample size, power, confounding variables, quality of the outcomes, and internal and the external validity, which makes the analysis of the studies limited to a specific point (study design). Also, in some cases, where the studies are not treatment interventions, such as neurophysiological or anatomical studies, Sackett's classification does not express the real value of the publication.

From a clinical perspective, there are probably associations between the cervical spine and the stomatognathic system, and consequently, a link to craniofacial pain. In addition, patients can have overlapping symptoms from different sources. The authors' advice is to consider the information but to realize the limitations of the studies. Investigators should be careful in the interpretation of the results and be aware that well-designed studies are required when studying the relationship between cervical spine and craniofacial pain in order to effectively prove this interaction.

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