Cervical Muscle Tenderness in Temporomandibular Disorders and Its Associations with Diagnosis, Disease-Related Outcomes, and Comorbid Pain Conditions

Galit Almoznino, DMD, MSc, MHA
Department of Oral Medicine, Sedation & Maxillofacial Imaging
Hebrew University-Hadassah School of Dental Medicine
Jerusalem, Israel

Avraham Zini, DMD, PhD, MPH
Department of Community Dentistry
Hebrew University-Hadassah School of Dental Medicine
Jerusalem, Israel

Avraham Zakuto, DMD

Hulio Zlutzky, DMD

Stav Bekker, DMD

Department of Prosthodontics
Oral and Maxillofacial Center
Israel Defense Forces Medical Corps
Tel-Hashomer, Israel

Boaz Shay, DMD, PhD
Endodontic Department
Faculty of Dental Medicine
Hebrew University-Hadassah School of Dental Medicine
Jerusalem, Israel

Yaron Haviv, DMD, PhD

Yair Sharav, DMD, MS

Department of Oral Medicine, Sedation & Maxillofacial Imaging
Hebrew University-Hadassah School of Dental Medicine
Jerusalem, Israel

Rafael Benoliel, BDS, LDS, RCS
Rutgers School of Dental Medicine
Rutgers, The State University of New Jersey
Newark, New Jersey, USA

Correspondence to:
Dr Galit Almoznino
Department of Oral Medicine,
Sedation & Maxillofacial Imaging
Hebrew University-Hadassah
School of Dental Medicine
P.O. Box 12272
Jerusalem 91120, Israel
Fax: 972-2-644-7919
Email: galit@almoznino.com

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Aims: To analyze cervical tenderness scores (CTS) in patients with various temporomandibular disorders (TMD) and in controls and to examine associations of CTS with demographic and clinical parameters. **Methods:** This case-control study included 192 TMD patients and 99 controls diagnosed based on a questionnaire and a clinical examination following the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) guidelines. CTS, adapted from the widely used total tenderness score, was the mean sum of the palpation scores from the suboccipital, sternocleidomastoid, and trapezius muscles. Depending on the variables, data were analyzed using Pearson chi-square, analysis of variance, *t* test, Bonferroni post hoc adjustment, and/or multivariate linear regression analyses. **Results:** CTS was higher in TMD patients compared to controls ($P < .001$). Across TMD subgroups, CTS was notable only in those with a myogenous TMD diagnosis, but not in arthrogenous TMD ($P = .014$). CTS was positively associated with: female sex ($P = .03$), whiplash history, higher verbal pain scores, comorbid headaches, body pain, increased pain on mouth opening, and higher masticatory muscles tenderness scores (MTS) ($P < .001$ for all). Sex ($P < .001$), MTS ($P < .001$), comorbid headache ($P = .042$), and pain on opening (mild: $P = .031$; moderate: $P = .022$) retained significant associations with CTS in the multivariate analysis, and these main effects were influenced by interactions with whiplash history and comorbid body pain. **Conclusion:** CTS differentiated between TMD patients and controls and between TMD diagnoses. Specific patient and pain characteristics associated with poor outcome in terms of CTS included effects of interactions between myogenous TMD, female sex, whiplash history, comorbid body pain and headaches, and pain on opening. It can therefore be concluded that routine clinical examination of TMD patients should include assessment of the cervical region. *J Oral Facial Pain Headache 2020;34:67–76. doi: 10.11607/ofph.2374*

Keywords: *cervical muscle tenderness, masticatory muscle disorders, muscle tenderness score, temporomandibular disorders*

Temporomandibular disorders (TMD) is an umbrella term representing a group of painful and nonpainful musculoskeletal disorders that affect the temporomandibular joint (TMJ), the masticatory muscles, or both.[1] Painful TMD form the most common chronic orofacial pain condition, affecting 5% to 12% of the population.[1,2] Painful TMD can have a negative impact on daily activities, social behavior, the psychologic status of patients, and quality of life.[1–3]

Cervical pain[4–6] and tender points are commonly found in TMD patients[7–9] and were described as early as the 1970s.[10] However, the relationships between pericranial, masticatory, and cervical muscle tenderness and the presence of TMD and self-reported neck disability have been underexplored.[11] The first paper directly measuring neck disability in patients with TMD was published in 2010.[12] A possible association was suggested between TMD and cervical dysfunction,[13–15] but the conclusions of the systematic reviews were unclear, highlighting the need for more research.[16,17]

Muscle tenderness scores are commonly used in headache practice and are referred to as total tenderness scores (TTS). These indices of muscle pain and severity, including a subset examining the cervical tenderness score (CTS),[18–23] are commonly used in headache practice and contribute valuable information beyond the number of muscles involved.[21,24,25] In myogenous TMD patients, muscle tenderness is the most important clinically elicited sign[8,26,27] used to support diagnosis.[1]

While cervical muscle tenderness in TMD patients has been studied,[5] much of the complexity of the issues, as well as many parameters potentially affecting cervical muscle tenderness in TMD patients, have not. The hypothesis of the present study was that the CTS in patients with TMD would be associated with specific TMD diagnoses, disease characteristics, and comorbid pain conditions. Therefore, the objectives of this study were to:

- Measure CTS in patients with subtypes of TMD compared to TMD-free controls.
- Analyze the associations between CTS and various demographic and clinical parameters; specifically, the impacts on CTS levels of a history of trauma, self-reported parafunctional habits, masticatory dysfunction, masticatory muscle tenderness score (MTS), reported pain intensity, and comorbid pains such as headaches and other body pains.

Cervical pain is very common in the general adult population, with prevalence estimates of 30% to 50%,[28] and an incidence rate of 146 to 213 per 1,000 persons per year.[29] Although, as mentioned above, it is often comorbid with TMD, cervical pain may occur independently. To account for this, a control group without TMD was included.

Materials and Methods

Study Groups

This is part of a series of papers focusing on the demographic, clinical, and behavioral aspects of patients with TMD.[30–32] This case-control study was conducted between March 1, 2011 and January 31, 2013. Data were collected from 192 consecutive individuals referred to the TMD Clinic (a secondary referral center) at the Department of Prosthodontics, Tel-Hashomer, Israel, with a primary complaint of pain localized to the orofacial region and/or jaw dysfunction.

Sample size calculation using WINPEPI software determined that at least 256 participants in two groups, with 60:40 ratio, was needed to provide 90% statistical power to identify a 2.0-point difference in the muscle tenderness score. Alpha was set at .05. An estimated standard deviation (SD) of 4.4 was used for the larger group and 5.3 was used for the smaller group based on the authors' experience in analyzing muscle tenderness scores among orofacial pain patients.[33]

A total of 99 TMD-free consecutive individuals fairly similar in age and sex attending a routine dental screening in a primary dental clinic formed the control group.

Ethical Approval

This study conforms to STROBE guidelines and was approved by the Institutional Review Board. Participants, including the controls, signed an informed consent form and received free and unconditional treatment.

Inclusion/Exclusion Criteria and Pain Diagnoses

Inclusion criteria were patients aged 18 to 30 years attending for new patient screenings. To minimize confounders such as aging and illnesses, only young individuals without comorbid mental, psychiatric, or physical disabilities were examined, which enhanced the ability to assess the effects of other demographic and clinical parameters on CTS.

Exclusion criteria were: mental, psychiatric, or physical disabilities; a comorbid malignancy; serious medical history; fibromyalgia; patients with medical and/or dental emergencies; pregnancy or lactation; presence or history of alcohol or drug abuse; current use of medication with effects on the central nervous system (eg, narcotics, antidepressants, anticonvulsants, triptans, and/or muscle relaxants); and medication overuse headache.

TMD patients were diagnosed according to Axis I of the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD),[34] which was the most accepted diagnostic instrument at the time of the study. TMD was divided into three diagnostic categories according to Axis I of the RDC/TMD: *(1)* masticatory muscle pain disorders (MMD), including Group I muscle disorders diagnoses; *(2)* isolated disorders of the TMJ (TMJD), including Group II (disc displacements) and Group III (arthralgia, osteoarthritis, osteoarthrosis) diagnoses; and *(3)* patients with both MMD and TMJD (TMP).

Controls, as well as cases, were examined, and any of the controls who met the criteria for an RDC/TMD diagnosis were excluded from the study.

Data Collection

Diagnoses were based on a questionnaire and clinical examination performed in both TMD and control patients at the first meeting and prior to treatment. The interviewer administered the questionnaire during the one-on-one consultation on a standard form that included questions concerning: demographics (male or female); history of trauma (yes or no); comorbid headache (yes or no); pain in other body sites present for at least 3 months (none, preauricular, temporal, periorbital, cervical, back, and combinations of these options; when aggregated to presence of comorbid body pain, response options were yes or no); and reports of parafunctional oral habits (clenching, grinding) (yes or no).

Current pain intensity was rated on a 0 to 10 numeric rating scale (NRS), which was administered verbally using a verbal pain scale (VPS).[35] The 0 to 10 pain rating scale has been shown to have superior measurement properties (eg, reliability, validity, responsiveness) compared to other response scales and is considered the optimal self-report response scale for evaluating pain among adult patients without cognitive impairment.[35]

Pain on unassisted mouth opening was assessed on a 4-point ordinal scale, where 0 = no pain; 1 = mild; 2 = moderate; and 3 = severe.[30]

The diagnoses of comorbid conditions and history of whiplash trauma were assessed either from reported medical history or as a result of the patient being diagnosed at the Department of Prosthodontics as part of the patient evaluation process. Headaches were diagnosed according to the International Classification of Headache Disorders, 3rd edition (beta version).[36] According to the exclusion criteria, patients diagnosed with fibromyalgia were excluded from the study and referred for further evaluation and treatment by a rheumatologist.

Clinical Examination

The clinical examination was performed in both TMD patients and controls by one of two examiners (A.Z., H.Z.) (previous examiners calibration[30,31]). Muscle palpation was performed according to the RDC/TMD guidelines.[34] All diagnoses were initially established in the clinic and then reviewed and corrected by consensus (both senior authors, R.B., Y.S.) following data entry. This extra step, in a nonclinical setting, was performed in order to ensure an accurate diagnosis.

The masticatory and cervical muscles were palpated bilaterally in the same order for all patients. It should be noted that muscle palpation according to RDC/TMD guidelines concerns jaw muscles.[34] Cervical muscles included the following muscles: suboccipital group (as one), sternocleidomastoid, and trapezius. Muscle insertions were palpated according to published protocols.[18,37,38] Palpation was performed for masticatory as well as cervical muscles, with small rotational movements of the assessor's second and third fingers over the course of 4 to 5 seconds.[18] Muscle palpation was performed with about 2 to 3 pounds of palpation pressure based on prior reports of the average palpation force using similar methods[3,39,40] as for the masticatory muscles. Tenderness to palpation was graded on an ordinal scale by the participants as follows: 0 = no pain; 1 = mild; 2 = moderate; and 3 = severe.[18–23,41] CTS was the mean sum of the palpation scores from the cervical muscles. MTS was the mean sum of the palpation scores from the masseter and temporalis muscles.

Data Analyses

Data were tabulated and statistical analyses were performed using SPSS software version 21.0 (IBM). Statistical significance was considered as $P < .05$. Numeric variables are presented as means and standard deviations (SDs), and categorical variables are presented as frequencies and percentages.

Significance tests to assess relationships between CTS and the independent variables included Pearson chi-square (χ^2) test, likelihood ratio analysis of variance (ANOVA), *t* test , and Pearson correlation. Results were adjusted using Bonferroni post hoc test. For multivariate analysis, multivariate general linear model (GLM) analysis was used. The criterion for inclusion in the multivariate model was a statistically significant univariate result.

Results

General Description

The TMD group included 192 patients, and the control group had 99 subjects. The mean age of the TMD group was 21.2 ± 4.0 years; 79 (41.1%) were men, and 113 (58.9%) were women. TMP was the most frequent diagnosis (n = 122; 63.5%), followed by MMD (n = 44; 22.9%) and TMJD (n = 26; 13.5%). There were no significant differences in any of the demographic parameters between the TMD diagnoses ($P > .05$). The mean age of the control group was 20.8 ± 1.5 years; 52 (52.5%) patients were men, and 47 (47.5%) were women. A test was performed showing that there was no statistically significant difference between the TMD and control groups regarding age ($P = .3$) or sex ($P = .07$).

Cervical Tenderness Scores

There were no statistically significant differences in CTS between controls and the TMJD group, the latter presenting without cervical muscle tenderness. Across TMD diagnostic categories, there were no statistically significant differences in mean CTS between the MMD and TMP groups. No statistically significant differences in individual CTS were found between the MMD and the TMJD groups (except for the sternocleidomastoid) or between the TMP and the TMJD groups, but the total CTS was significantly

Table 1 Tenderness Scores for Cervical Muscles Among the Study Population

Muscle/study group	Mean tenderness scores	SD	95% CI Lower bound	95% CI Upper bound	P value Between all groups[a]	P value Between TMDs[a]	P value MMD vs controls[b]	P value TMP vs controls[b]	P value MMD vs TMJD[b]	P value TMP vs TMJD[b]
Suboccipital (mean right + left)										
Control	0.02	0.14	−0.008	0.05	.001	.101	.02	.005	.11	.10
MMD	0.19	0.48	0.04	0.34						
TMJD	0.00	0.00	0.00	0.00						
TMP	0.17	0.40	0.10	0.24						
Sternocleidomastoid (mean right + left)										
Control	0.01	0.10	−0.009	0.03	< .001	.048	.001	.001	.024	.052
MMD	0.21	0.42	0.08	0.34						
TMJD	0.00	0.00	0.00	0.00						
TMP	0.17	0.38	0.10	0.24						
Trapezius (mean right+ left)										
Control	0.02	0.18	−0.01	0.06	< .001	.068	.008	.002	.06	.06
MMD	0.28	0.61	0.09	0.47						
TMJD	0.00	0.00	0.00	0.00						
TMP	0.24	0.55	0.15	0.34						
CTS										
Control	0.11	0.69	0.03	0.25	< .001	.014	< .001	< .001	.006	.008
MMD	1.39	2.45	0.64	2.13						
TMJD	0.00	0.00	0.00	0.00						
TMP	1.18	2.06	0.81	1.54						

CI = confidence interval; SD = standard deviation; CTS = cervical tenderness score; MMD = masticatory muscle disorders; TMJD = temporomandibular joint disorders; TMP = both MMD and TMJD.
[a]Analysis of variance. [b]Post hoc Bonferroni test of the mean CTS according to diagnosis.

Table 2 Clinical Characteristics of the Study Population

Parameter	TMD group, n	Control group, n	P value
Whiplash history			
Yes	5	0	.040[a]
No	187	99	
Comorbid headache			
Yes	111	11	< .001[a]
No	81	88	
Comorbid body			
Yes	120	11,921	< .001[a]
No	72	78	
Clenching habit			
Yes	88	18	< .001[a]
No	104	81	
Grinding habit			
Yes	2	48	< .001[a]
No	95	144	
Pain on opening			
None	48	94	< .001[b]
Mild	74	5	
Moderate	52	0	
Severe	18	0	

[a]Pearson chi-square.
[b]Likelihood ratio.

different (Table 1). However, the differences between the MMD group and controls, as well as between the TMP group and controls, were statistically significant in all individual CTS and in total CTS.

CTS by Demographic and Clinical Parameters

As expected, the TMD group exhibited worse pain scores (VPS, TMD group: 3.03 ± 2.53; VPS, control group: 0.51 ± 1.74; $P < .001$, Table 2). CTS (Table 3) was positively associated with comorbid headaches ($P < .001$), specifically comorbid migraine (2.1 ± 2.8), followed by tension-type headache (1.8 ± 2.2) and then no comorbid headache (0.6 ± 1.5) ($P < .001$); comorbid complaints of body pains ($P < .001$), in particular the combination of cervical and back pain (data not shown), followed by back and periorbital pain; female sex ($P = .03$); whiplash history ($P < .001$); increased pain on opening ($P < .001$); higher MTS ($P < .001$); and higher VPS ($P < .001$ for all).

Multivariate GLM

The following variables retained a significant association with CTS in the multivariate analysis: sex ($P < .001$); MTS ($P < .001$); comorbid headache ($P = .042$); and pain on opening (mild: $P = .031$; moderate: $P = .022$).

In addition to the significant main effects of the independent variables on CTS that were found in the multivariate analysis, the following interactions among the independent variables were found (Table 4): the effects on CTS of the history of whiplash trauma, comorbid headache, and mild, moderate, and severe pain on opening were influenced by sex (Table 4, Fig 1); the effects on CTS of comorbid body pain and moderate pain on opening were influenced by whiplash history

(Table 4, Fig 1); the influence of comorbid body pain on CTS was dependent on moderate pain on opening (Table 4, Fig 1); and the effect of comorbid headache on CTS was dependent not only on sex, but also on mild and moderate pain on opening (Table 4, Fig 1).

Discussion

The major findings of the present study are that CTS was positively associated with the TMD group compared to controls, and, within TMD patients, CTS was positively associated with myogenous and not with pure arthrogenous types of TMD. CTS was positively associated with many signs and symptoms reflecting disease severity, as well as with comorbid pain conditions. The significant main effects on CTS of sex, MTS, comorbid headache, and mild and moderate pain on opening in the multivariate analysis were influenced by interactions with whiplash and comorbid body pain. These findings suggest specific patient and pain characteristics are associated with poor outcome in terms of CTS. This vulnerable patient profile includes not only myogenous TMD, but also female sex, whiplash history, body pain, higher MTS, and pain on opening. These interactions highlight the importance of a multidisciplinary team approach addressing the complexity of these patients. The current perception is that TMD, particularly the myogenous type, is a complex condition not only localized to the orofacial area but also involving systems beyond the masticatory tissues. This fits with the biopsychosocial model of illness, blending biologic, social, and psychologic centrally mediated factors.[42] These findings are also consistent with the findings of the OPPERA study, that pain on palpation of masticatory, neck, and body muscles predicted TMD incidence.[42] Uniquely, this study individually addresses both myogenous and arthrogenous subclasses of TMD in relation to cervical muscle tenderness.

The best way to systematically assess cervical muscles still needs validation. For this, the authors are able to draw on the experience gained from the RDC/TMD and now the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD). Which cervical muscles and muscle sites should be examined? For example, the sternocleidomastoid is a long muscle; should this be examined at the upper insertion, lower insertion, or midway? Possibly all? What is the most adequate pressure to be applied, and for how long should it be held? In the past, higher pressures have been applied in the rheumatology literature (3 to 4 kg)[43] relative to that in the TMD literature (about 2 to 3 lbs).[39,40] These questions need to be addressed and researched, and specificity and sensitivity calculations subsequently made for specific diagnoses.

Table 3 Associations and Correlations Between Cervical Tenderness Scores and Demographic and Clinical Parameters

Parameter	No.	Mean CTS tenderness scores ± SD	*P* value[a]
Sex			
Women	160	1.0 ± 2.13	.03
Men	131	0.4 ± 1.1	
Whiplash history			
Yes	5	3.6 ± 3.3	< .001
No	286	0.6 ± 1.7	
Comorbid headache			
Yes	122	3.9 ± 3.2	< .001
No	169	1.3 ± 1.9	
Comorbid body pain			
Yes	140	1.2 ± 2.2	< .001
No	150	0.3 ± 1.0	
Co-morbid body pain-detailed*			
None	150	0.3 ± 1.0	< .001[b]
Preauricular	20	0.4 ± 1.2	
Back pain	47	0.4 ± 1.3	
Temporal	30	1.1 ± 1.7	
Periorbital	18	1.9 ± 2.1	
Back + Periorbital	2	2.0 ± 0.0	
Cervical	9	2.4 ± 3.1	
Cervical + back	15	3.3 ± 4.1	
Clenching habit			
Yes	106	0.8 ± 1.8	.666
No	185	0.7 ± 1.7	
Grinding habit			
Yes	50	0.8 ± 1.6	.770
No	239	0.7 ± 1.8	
Pain on opening			
None	142	0.3 ± 1.2	< .001
Mild	79	0.8 ± 1.6	
Moderate	52	1.5 ± 2.5	
Severe	18	1.4 ± 2.4	
		Pearson correlation	
Age (y)		0.045	.443
Verbal pain score (0–10 NRS)		0.328	< .001
Massseter right + left tenderness score		0.438	< .001
Temporalis right + left tenderness score		0.413	< .001
MTS (right + left masseter and temporalis)		0.595	< .001

CTS = cervical tenderness score; NRS = numeric rating scale; MTS = masticatory muscle tenderness score.
[a]*t* test.
[b]Analysis of variance.

Differences in CTS Between TMD Diagnoses and Between TMDs and Controls

Although the new DC/TMD classification only requires masticatory muscle (ie, masseter and temporalis) tenderness

Table 4 Multivariate General Linear Model Analysis of Cervical Tenderness Scores with Statistically Significant Clinical Parameters

					95% CI	
Parameter	B	SE	*t*	*P*	Lower bound	Upper bound
Intercept	–5.561	2.215	–2.510	.013	–9.924	–1.197
VPS	–0.025	0.049	–0.518	.605	–0.122	0.071
MTS	1.837	0.246	7.455	< .001	1.352	2.323
Diagnosis: Case vs controls	–1.173	1.291	–0.909	.364	–3.716	1.370
Sex	10.941	3.066	3.568	< .001	4.901	16.982
Whiplash	–0.964	2.563	–0.376	.707	–6.014	4.085
Comorbid body pain	1.565	4.545	0.344	.731	–7.389	10.519
Comorbid headache	5.586	2.728	2.048	.042	0.212	10.961
Pain on opening: Mild	2.322	1.071	2.168	.031	0.212	4.433
Pain on opening: Moderate	2.794	1.216	2.299	.022	0.400	5.189
Pain on opening: Severe	2.272	1.215	1.869	.063	–0.123	4.666
Pain on opening: None (reference)	0[a]					
Sex*Whiplash	–5.244	2.074	–2.528	.012	–9.329	–1.158
Sex*Comorbid headache	–8.733	4.363	–2.001	.046	–17.328	–0.137
Sex*Pain on opening: Mild	–2.804	1.276	–2.197	.029	–5.318	–0.290
Sex*Pain on opening: Moderate	–3.327	1.644	–2.024	.044	–6.565	–0.090
Sex* Pain on opening: Severe	–7.003	1.924	–3.639	< .001	–10.794	–3.212
Whiplash*Comorbid body pain	–5.038	2.235	–2.254	.025	–9.440	–0.635
Whiplash*Pain on opening: Moderate	6.179	2.118	2.917	.004	2.007	10.351
Comorbid body pain*Pain on opening: Moderate	–3.604	1.502	–2.400	.017	–6.562	–0.646
Comorbid headache*Pain on opening: Mild	–2.530	1.181	–2.142	.033	–4.858	–0.203
Comorbid headache*Pain on opening: Moderate	–3.682	1.325	–2.779	.006	–6.293	–1.072

VPS = verbal pain scale; MTS = masticatory muscles tenderness score; SE = standard error; CI = confidence interval.

to palpation,[1] cervical tenderness clearly seems to be associated with masticatory muscle disorders. Indeed, in the present study, CTS was only notable in patients with a muscular TMD component (Table 1). Moreover, masseter and temporalis tenderness to palpation scores (ie, severity) were positively correlated with the CTS even after adjusting for other confounders in the multivariate analysis. This suggests that cervical muscle pain has a significant association with masticatory muscle disorders and their severity. A recent study also found that neck disability was associated with masticatory myofascial pain and regional muscle sensitivity.[11] However, that study did not include patients with arthrogenous TMD, and the lack of correlation with joint disorders could not have been shown.[11] Indeed, neck pain is more prevalent in patients with TMD with a myogenous component than in those with an arthrogenous component.[44] Moreover, in addition to masticatory and cervical muscle tenderness and pain, muscle tenderness and pain in the hand was significantly greater in subjects with TMD compared to healthy subjects.[45] The finding of comorbid neck pain in a patient with head and/or face pain is not new (see coexisting headaches section of Discussion). It has been attributed to second-order neuronal convergence and the proximity of second-order trigeminal and cervical neurons in the trigeminocervical complex. Interestingly though, in the present study, the findings suggest that this may not be a simple relationship relating to pain location, since severity in the arthrogenous conditions was not associated with neck pain. Consequently, there seems to be a specific relationship between muscle tenderness and pain in remote areas in myogenous TMD. This phenomenon suggests the involvement of central mechanisms in TMD myalgia,[42] which may be common for those with cervical muscle pain. It also lends further support for separately diagnosing and researching myogenous and arthrogenous conditions, which are often grouped together as painful TMD.

Associations of CTS with Comorbid Pain Conditions

Coexisting Headaches. Patients with coexisting headaches exhibited higher CTS. Indeed, it has been demonstrated that subjects with TMD had signs of upper cervical spine movement impairment, more so in those with comorbid headache.[46] Only subjects with TMD and headache had restricted cervical spine mobility.[46] Patients with migraine exhibited the highest CTS, followed by TTH. Muscle tenderness is a common finding in migraine patients[25,47] and has been attributed to central sensitization.[47] Neck pain is also prevalent in subjects with TTH, and the frequency of neck pain correlates with the frequency of TTH.[48] Anatomical proximity, neuronal interconnections, and convergence inputs between cervical and trigeminal nociception could be responsible for the relationship between cervical pain and TMD and headaches, as discussed above.[7,11,36,49]

Indeed, there is some overlap between headache attributed to TMD and TTH with pericranial muscle tenderness.[36] Furthermore, both diseases seem to have a common genetic basis, and both exhibit peripheral and central sensitization manifested in the development of craniofacial allodynia and muscle tenderness to palpation during painful exacerbations.[36,50] It may be that MMD represents a facial variant of TTH with pericranial tenderness, although MMD is usually unilateral. Nevertheless, MMD is currently not classified as a facial variant of TTH with pericranial tenderness, but grouped together with TMJ disorders (including arthralgia and pure mechanical joint problems) under the TMD umbrella.[1] However, unlike the similarities between MMD and TTH with pericranial tenderness, the diagnosis of TMJ disorders does not share many epidemiologic and clinical features with MMD, nor can it be described in terms of muscle tenderness to palpation or CTS (Table 2). This may suggest that grouping regional myalgias and arthrogenic conditions under TMD may not be the best alternative.

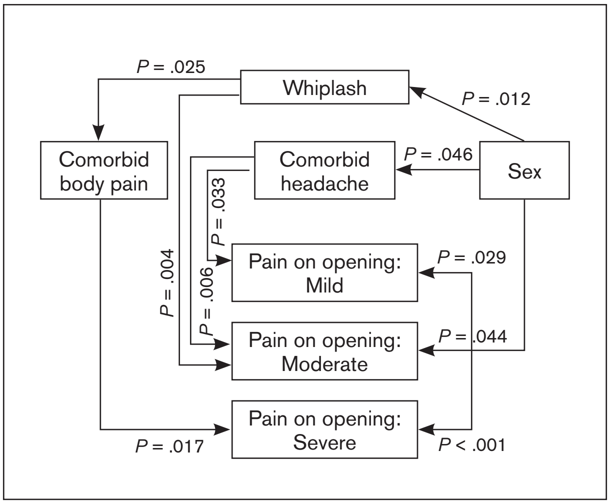

Fig 1 Interactions between independent variables in the multivariate general linear model analysis of cervical tenderness scores.

Coexisting Body Pain. Body pain had a negative impact on CTS, and its effect was dependent on whiplash history and on severe pain on opening; the influence of the latter on CTS was dependent on sex. Indeed, cervical disorders have been associated with pain and disorders in remote structures, such as fibromyalgia.[51] This finding is in line with data suggesting that TMD share many features (ie, sex and age distribution, pain parameters, and disability) with other chronic pain conditions, such as headaches, back pain, fibromyalgia, chronic fatigue syndrome, and irritable bowel syndrome, that are characterized by neuroendocrine abnormalities, frequent biopsychosocial distress, and complaints including sleep disturbances.[52,53]

Associations of Demographic and Clinical Parameters with CTS Scores

Female Sex. Women exhibited higher CTS, in line with previous reports that women have significantly more tenderness to palpation than men.[8,47,54] The risk of being diagnosed with pain in both the TMJ and the craniofacial region is higher in women than men.[28] In line with this trend, there was a tendency toward a higher proportion of women in the TMD group. Nevertheless, this difference between the TMD and control groups did not reach statistical significance ($P = .07$). To address the possible confounding effect of sex, sex was accounted for in the univariate regression analyses, as well as in the multivariate regression model. Sex retained its statistical significance with CTS in the multivariate regression analysis. The interaction analysis revealed that the effect of whiplash history on CTS was dependent on sex (Table 4, Fig 1). While women with a history of whiplash trauma exhibited higher CTS, the CTS remained almost unchanged among men regardless of the whiplash injury history (Table 4). This suggests that the consequences of whiplash injury in terms of CTS could be more severe among women than men. Moreover, there was also a significant interaction between comorbid headache, mild, moderate, and severe pain on opening levels, and sex (Table 4, Fig 1). These interactions can be explained by the fact that women are more sensitive to pain than men, are more likely to have chronic pain, and are more likely to respond differently to some analgesics.[55]

Whiplash History. The positive association between whiplash history and higher CTS coincides with the fact that following acute whiplash injury, patients may develop long-lasting signs and symptoms (ie, whiplash-associated disorders [WADs]). These include headaches, cervical pain, jaw pain and disability,[56–58] and higher total tender point scores in the neck region and in remote areas.[59] Indeed, the interaction analysis revealed that the effect of whiplash history on CTS was dependent not only on sex but also on comorbid body pain, which in turn was associated with severe pain on opening levels (Table 4, Fig 1). These complex interactions reflect the associations between whiplash history, jaw pain, and disability with the CTS. A systematic review assessing TMD (as one group) pain after WAD concluded that there is some evidence that prevalence and incidence of TMD pain increase after whiplash trauma, and this pain is associated with poor treatment outcomes, suggesting different pathophysiology than TMD pain localized only to the facial region.[60,61]

Whiplash history lost its significant association with CTS in the multivariate analysis. Due to the low number of whiplash patients in the present study (five), the authors remain circumspect regarding this variable, and therefore additional data are needed.

TMD Severity, Pain, and Disability. The associations between CTS and myalgia severity, pain, and disability are noted in the present study by the significant positive associations of CTS with pain severity, coexisting headaches and other body pains, and limited mandibular mobility, such as pain on opening (Table 3).

In support of this, fair to moderate correlations between the levels of muscle tenderness in the masticatory and cervical muscles with jaw dysfunction and neck disability have been demonstrated previously.[5] Therefore, the CTS may be considered a relevant proxy for neck disability.

Moreover, the interaction analysis revealed interactions not only between pain on opening levels and history of whiplash trauma, but also interactions between pain on opening and the presence of comorbid body pain, comorbid headache, and sex (Table 4, Fig 1).

Consistent with this finding, limited mandibular mobility—such as high pain on opening levels of tenderness in upper trapezius and temporalis muscles—has been shown to be correlated with jaw dysfunction.[5]

Moreover, patients with more frequent headaches have been shown to have increased muscle tenderness,[62] especially among TTH patients.[63]

The main strengths of the present study are the large sample size (291 patients) and the strict protocol utilizing standardized VPS scores and the validated RDC/TMD, allowing comparison with other published data across ethnic groups. Confounders such as aging and illness were controlled by focusing on the young adult age group, and the control group was age and sex matched. A clinical examination was also performed in the control group, allowing comparison to patients in the dental clinic not complaining of facial pain. Since TMD patients often consult dentists,[1] this control group seems more valid than using the general population.[64]

Limitations of this study include the possibility of selection bias of this convenience cohort. However, patients were referred from multiple clinics serving different populations. Furthermore, considering the steps that were taken to minimize confounding variables by focusing on young individuals without mental, psychiatric, or physical disabilities, the results are limited to individuals without these comorbidities who developed TMD in early adulthood or those who developed TMD as children or teenagers. Another limitation is lower accuracy and reliability of the patient self-report data. The case-control study design means that causality cannot be assumed, and therefore this paper only suggests associations between the variables. Further longitudinal studies are needed to follow up TMD patients and to determine the appearance of cervical tenderness and disability.

Tenderness of the masticatory and cervical muscles was not measured using an algometer; however, manual palpation, which is based on the diagnostic RDC/TMD as well as the DC/TMD protocols, is more representative of the clinical scenario. Each examiner performed all the clinical examinations for their patients, and therefore the examiners were aware of the diagnosis of the patients. Although the impacts of multiple parameters on CTS were considered, the depth and complexity of the issues mean that other parameters affecting the CTS were not considered. For example, there was no separation between myalgia and myofascial pain in Axis 1, Group 1. Only the impact of physical conditions (eg, Axis 1) was evaluated, whereas impact of depression and somatization (eg, Axis 2) were not investigated.

Conclusions

Although assessment of the cervical region is not mandatory for TMD diagnosis, it may reflect the complexity and/or severity of TMD, including involvement of remote pain areas. CTS was positively associated with muscular and not with arthralgic conditions, highlighting the differences between these entities and emphasizing the overlap between muscular TMD and regional muscle pains, such as TTH with muscle tenderness. The findings that suggest specific patient and pain characteristics are associated with poor outcome in terms of CTS include the effect of interactions between myogenous TMD, female sex, whiplash history, comorbid body pain and headaches, and pain on opening. Routine work-up of TMD patients, in particular those with myogenous components and the vulnerable patient profile, should include assessment of masticatory and cervical region musculature, as well as comorbid pain conditions. It can be concluded that:

- CTS has not been adequately studied in individuals with TMD.
- TMD patients exhibited higher CTS compared to controls.
- Among TMD patients, cervical tenderness was notable only in those with a myogenous component.
- CTS was positively associated with many signs and symptoms, including remote pain.
- Routine examination of TMD patients should include cervical region assessment.

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