

Rehabilitative Medicine

Upper cervical range of motion is impaired in patients with temporomandibular disorders

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Aims: Clinicians increasingly suggest assessment and treatment of the cervical spine in patients with TMD; however few studies have investigated upper cervical spine mobility in people who suffer from temporomandibular dysfunction (TMD). The purpose of this study was to investigate whether patients with TMD pain (with or without headache) present with upper cervical spine impairment when compared with asymptomatic subjects.

Methodology: A single blind examiner evaluated cervical range of motion (ROM) measures including axial rotation during the flexion-rotation test (FRT) and sagittal plane ROM. Twenty asymptomatic subjects were compared with 37 subjects with pain

attributed to TMD, confirmed by the Revised Research Diagnostic Criteria (RDC/TMD). Subjects with TMD were divided according to the presence of headache (26 without headache TMDNHA, 11 with headache TMDHA). One-way Analysis of Variance (ANOVA) and planned orthogonal comparisons were used to determine differences in cervical mobility between groups. All subjects with TMD were positive on the FRT with restricted ROM, while none were in the control group.

Results: The ANOVA revealed significant differences between groups for the FRT ($F(2,54) = 57.96, p < 0.001$) and for sagittal ROM ($F(2,54) = 5.69, p = 0.006$). Findings show that the TMDHA group had less axial rotation than group TMDNHA, and both TMD groups had less ROM than controls. For sagittal ROM, the only difference was between group TMDHA and controls.

Conclusions: Subjects with TMD had signs of upper cervical spine movement impairment, greater in those with headache. Only subjects with TMD and headache had impairment of cervical spine sagittal plane mobility. This study provides evidence for the importance of examination of upper cervical mobility determined by the FRT in patients who suffer from TMD.

Key Indexing Terms: Cervical spine; Upper cervical mobility;

Temporomandibular disorders ; Flexion-rotation test

Introduction

Temporomandibular disorders (TMD) are multifactorial involving the masticatory musculature, the temporomandibular joints or both. Recent studies confirmed that more women have this disorder than men,^{1,2} with a prevalence in women of 6.3%, compared to 2.8% for men.² TMD is a significant cost burden to society, with up to 3% of Americans seeking professional care for TMD symptoms,³ accounting for approximately \$2 billion in direct care costs in the United States alone per year.³

Other studies have found a significant association between TMD and cervical spine impairment, in addition to evidence of dysfunction of the muscles and joints around the jaw.⁴⁻¹¹ For example, people who suffer from TMD have been shown to have significantly worse cervical extensor muscles function,⁹ neck pain on movement, and pain on palpation of cervical muscles,⁷⁻¹⁰ as well as increased mechanical pressure-pain thresholds in the neck region.⁸

Undoubtedly, there is a direct anatomical relationship between the muscles of the cervical spine and temporomandibular region, and therefore, the potential for impairment in one region to influence the other. For example, there is evidence of a correlation between cervical spine and TMD disability¹² and a reciprocal positive dose-response pattern between frequency and severity of spinal pain and TMD.¹³

One possible explanation for a potential patho-physiological relationship between TMD and cervical spine impairment could be the neurophysiologic connections between the cervical spine and temporomandibular area, such as the convergence of trigeminal and upper cervical afferent inputs in the trigeminocervical nucleus.¹⁴⁻¹⁶ Another explanation could be the close biomechanical link between the cervical spine and the temporomandibular joint. Eriksson *et al.*¹⁷ reported that during normal mouth opening, extension occurs at the cervical-cranial junction and restriction in the upper cervical spine may decrease a patient's mouth-opening capacity. Furthermore, maximal mouth opening and pain on muscle palpation could be modulated by different cranio-cervical postures.¹⁸ In addition, Bevilaqua⁷ suggested cervical signs and symptoms could be defined as perpetuating factors for TMD.

Considering this evidence and the close neurological and biomechanical relation between the upper cervical spine and the temporomandibular joint, it is not surprising that manual therapists have suggested assessment and treatment of the upper cervical spine in patients with TMD^{19,20} and vice versa.^{21,22} Confirmatory evidence is lacking, but one recent study identified impairment in the cervical spine in patients undergoing treatment for TMD with associated features consistent with cervicogenic headache (CGH).¹¹ Another report from this study has highlighted the importance of including treatment to the orofacial region in patients with headache and TMD.²¹ Another study found that mobilization of the cervical spine, together with a cervical exercise protocol

had an effect to decrease pain, increase pressure pain threshold over the masticatory muscles, and increase pain-free mouth opening in patients with myogenous TMD.¹⁹ Although few studies have investigated cervical spine mobility in people who suffer from TMD,^{4,10} even fewer have specifically investigated the mobility of the upper cervical spine in this population. One study reported upper cervical impairment,²² but the precise way used to determine the degree of stiffness and the reliability of tests used to assess the passive segmental mobility were not reported in that study. Recently, magnetic resonance imaging results supported that the flexion-rotation test (FRT) is a valid measure of upper cervical mobility²³ and could be a useful marker of upper cervical impairment in people suffering from TMD; but there are no published reports of its use in people with TMD, apart from von Piekartz and Hall,¹¹ who evaluated the FRT in patients suffering from CGH with additional discrete signs of TMD.

The primary purpose of this study was to investigate whether patients with TMD (with or without headache) present with upper cervical spine mobility impairment determined by the FRT when compared with asymptomatic subjects. The secondary purpose was to evaluate whether the presence of headache in association with TMD had any impact on cervical impairment measures.

The hypotheses were that range recorded during the FRT and whole cervical spine mobility would be reduced in patients with TMD when compared to asymptomatic subjects, and that the presence of headache with TMD had no additional impact on

cervical movement impairment.

Methods

This study was a cross-sectional comparative measurement design. Ethical principles were followed according to the Declaration of Helsinki on research using human subjects. All participants provided written informed consent following an explanation about the study.

Subjects

Two different groups were evaluated in this study: TMD (further sub-classified by the presence or not of headache), and an asymptomatic control group. Patients with TMD were recruited between June and October 2012 from consecutive patients attending a physiotherapy clinic in Bordeaux, France. All symptomatic subjects had a primary complaint of TMD and were referred by a medical practitioner specializing in stomatology and oral and maxillofacial surgery. To be included in the TMD group, all subjects were females aged 18-60 years, with a history of side dominant TMD pain for at least 3 months. To exclude people with mild symptoms of TMD, subjects were also required to have a pain score of 30 mm on a 100 mm visual analogue scale (VAS) at rest or during mouth opening. A diagnosis of TMD pain was based on the Revised diagnostic algorithm classification of Dworkin and LeResche as having any myofascial pain (Ia or

Ib) or any joint pain (IIIa or IIIb).²⁷ The Revised Research Diagnostic Criteria (RDC-TMD) is the most widely used classification system for TMD,²⁴ and has excellent reliability²⁵ and validity²⁶ in diagnosing TMD of myofascial (Ia or Ib) or temporomandibular joint origin (IIIa arthralgia; IIIb osteoarthritis). This diagnostic criteria comprises: A history of pain in the face, jaw, temple, anterior to the ear, or in the ear;²⁴ provocation of the patient's pain complaint (familiar pain) on digital palpation of at least one of six muscle sites bilaterally in the orofacial region, or on digital palpation of a temporomandibular joint (lateral pole with 1 lb of pressure or around the lateral pole of at least 2 lbs of pressure)²⁴ or on jaw dynamic tests as maximum unassisted or assisted opening, and lateral excursive movements.^{24,27} A total of 166 consecutive patients were referred by the medical specialist for physiotherapy and were assessed by an independent physiotherapist for inclusion, and consequently 37 subjects were included in the TMD group (Figure 1).

To investigate the association between TMD and headache, researchers asked subjects with TMD if they had suffered headache, occurring at least once per week in the previous 3 months in association with their orofacial pain (headache provoked by an exacerbation of TMD symptoms), and the subjects were consequently assigned to TMD with headache (TMDHA) or TMD without headache (TMDNHA). The classification of headache was not sought or identified. None of the patients were undergoing treatment of the cervical spine or for their headache. A control group was a sample of

convenience, who had no history of TMD, neck pain or headache (mean age 30.6 ± 7.3 years, all female). Control subjects were excluded if they had any sign of TMD based on Revised RDC-TMD, if they had headache more than once per month and neck pain that had required treatment in the previous year. The sample size estimate to determine a difference in cervical range of motion between groups was based on data collected from a previous report with an effect size of 0.5, indicating 10 subjects were required per group.

Procedures and Measurements

One experienced physiotherapist, with 15 years of experience in management of TMD, evaluated suitable patients for inclusion in the study after referral of patients from the medical specialist. Suitable subjects were then combined with asymptomatic subjects. A second examiner with 2 years clinical experience, who was blind to the subject's group status, and who evaluated cervical range of motion (ROM) measures examined this combined sample.

Disability was determined by the Jaw Functional Limitation Scale (JFLS-20), which is a reliable and valid instrument for assessing functional limitations of the jaw.²⁹ Active cervical spine flexion and extension ROM were evaluated separately with an inclinometer (MIE Medical Research Ltd, Leeds, UK). After a practice trial, to prevent symptom exacerbation from repeated movement and because of previous reports of

stability of repeated movement measures,³⁰ a single measure of each movement was taken with the subject seated on an examination table with their feet touching the floor. Subjects were instructed to “sit up and look straight ahead” and were guided into a neutral sitting posture before any measurements were taken. The inclinometer was placed on the top of the subject’s head, aligned in the sagittal plane, and zeroed. For extension, subjects were asked to look up to the ceiling and bend their head back as far as possible. Following this, subjects were asked to bend the head forward as far as possible, aiming for their chin on their chest. Previous reports have indicated good validity³¹ and good reliability, with intraclass correlation coefficient (ICC) ranging upwards from 0.74 and standard error of measurement of 4.7° for flexion and 5.6° for extension in patients with mechanical neck pain^{32,33} and in asymptomatic subjects. The FRT was evaluated following the assessment of active cervical range of motion (ROM) and was tested with the subject in supine position according to the method previously described.³⁰ With the subject relaxed, in a supine position, with the cervical spine passively maximally flexed, the examiner rotated [passively] the head to the left and right. Range was determined either by the subject reporting the onset of pain, or firm resistance encountered by the therapist, whichever came first. At this point the examiner made a visual estimate of the rotation range and was required to state whether the FRT was positive or negative, and which side was positive. A positive state was based on an eyeballed, estimated limitation of more than 10° from the anticipated

normal range of 44°. ^{34,35} Following this, the examiner measured ROM using a modified cervical ROM (CROM) device attached to the apex of the head by Velcro straps, as previously described³⁰ (Figure 2). Range of less than 33°, when measured using a CROM device is the positive cut-off value when evaluating subjects with cervicogenic headache.³⁶ Examiner interpretation and range recorded using the CROM during the FRT has been shown to be consistent over days, with an ICC for intratester reliability of more than 0.95, and with a minimal detectable change at most 7 degrees.³⁷ Interexaminer reliability is also high for this test (ICC 0.93 ; CI, 0.87-0.96) with 92% agreement for experienced examiners, and an adequate-to-good interexaminer reliability for inexperienced examiners (ICC 0,76-0,89).³⁵

Statistical analysis

Statistical analysis was carried out using SPSS® V19.0. (SPSS Inc., Chicago, IL, USA). Alpha was set at 0.05 for each analysis. Prior to analysis, total whole cervical sagittal plane mobility was determined by combining flexion and extension ROM. Similarly total upper cervical rotation movement was determined by combining left and right rotation during the FRT. Descriptive statistics including means, standard deviations (SD), ranges and standard error of means (SEM) for all cervical ROM measures, including combined range, were calculated for the two main groups, as well as separately for subjects with and without headache in the TMD group. The distribution of all quantitative data was

assessed with the Kolmogorov-Smirnov test ($P>0.05$). Normally distributed variables (total sagittal movement and upper cervical rotation) were analyzed with parametric tests. One-way analysis of variance (ANOVA) and planned orthogonal comparisons were used to determine differences in total axial rotation determined during the FRT between groups.

Results

All subjects were female. Of those with TMD (mean age 34.68 SD=12.0), 21 (57%) had left side dominant and 16 (43%) right side dominant orofacial symptoms, with mean symptom duration of 25.6 months (SD=32.8) and mean disability 49.2 (SD=25.7). Furthermore, 26 (70%) had no headache while 11 (30%) had headache. The control group had a mean age of 30.7 years (SD=7.3). Figure 1 details the flow of subjects through the study. Table 1 shows mean means, SD, and SEM of the ROM variables in each group.

All subjects with TMD were deemed by the blinded examiner to have a positive FRT according to a subjective estimate of at least a 10° deficit in ROM. In contrast, none of the subjects in the control group were judged to be positive by this method. When observing the instrument determined ROM values for the FRT, all subjects in the TMD group had ROM to one side of less than 33°, while none of the control group did. Hence, examiner estimation of a positive FRT was consistent with instrumented measurement.

Analysis of ROM measures revealed statistically significant differences between group means as determined by one-way ANOVA for total axial rotation determined during the FRT ($F(2,54) = 57.96, p < 0.001$) and total sagittal movement ($F(2,54) = 5.69, p = 0.006$). The mean difference between groups and 95% confidence intervals are shown in Table 2.

These results indicate that there was a statistically significant difference in total sagittal ROM between the TMD group with headache and the control group, and the difference was substantial. Similarly, there were substantial differences between groups for total axial rotation determined during the FRT.

Discussion

To the authors' knowledge, this is the first reported study to examine upper cervical mobility determined by the FRT in people who suffer from TMD with and without associated headache. Mean ROM recorded during the FRT in subjects with TMD with and without headache was significantly less than asymptomatic subjects. Interestingly, there was also a significant difference in ROM between group TMDNHA and TMDHA, with less range in those subjects who reported headache. In contrast, there was only a

difference in cervical spine cardinal plane ROM between the control group and group TMDHA. These findings suggest that people with TMD have impairment of upper cervical mobility, but a cause and effect relationship cannot be determined.

While ROM recorded during the FRT^{34,36} and sagittal plane mobility^{30,38,39} was consistent with previously reported values in asymptomatic people, ROM in subjects with TMD was similar to reports for people with CGH.^{34,36} This implies significant dysfunction of the upper cervical spine as it has been shown that the FRT is a valid measure of upper cervical mobility.²³ One explanation may be that the presence of neck pain influenced the FRT in this sample. However dispelling this theory, a recent large-scale investigation found no relationship between the presence of neck pain and cervical ROM,⁴⁰ and the presence of lower cervical joint pain was not associated with a positive FRT.⁴¹

Thus, based on these results, it would seem logical to suggest that people with TMD have associated upper cervical dysfunction. However, it is not possible to say from the results of this study, which is the primary driver of TMD, the upper cervical spine or jaw structures such as the temporomandibular joint. Evidence of the interaction between the upper cervical spine and TMD is mounting. To the best of the authors' knowledge, only one previous study has reported upper cervical movement impairment in people with TMD,²² and the present study is the first study to report on the FRT in subjects with pain arising from TMD.

There may be a number of different explanations for the identified pattern of upper

cervical movement impairments in patients with TMD. One explanation may be that the cause of TMD is intricately linked with dysfunction in the upper cervical spine. Some authors suggested that cervical impairment could be considered as perpetuating factors for TMD.⁷ A previous study found that cervical disorders were associated with TMD severity. However, the inverse was not true, as TMD signs and symptoms did not increase with cervical spine disorders severity in female community cases with TMD.⁷ The authors of that study suggested that TMD originates first before cervical disorders, and that cervical disorders should be considered as perpetuating TMD.⁷ For example, in patients with TMD, both the maximal mouth opening and pressure pain threshold over the anterior temporalis and masseter muscles are significantly affected by the position of the upper cervical spine.¹⁸ Additionally, there is evidence of increased activity of the masseter muscles bilaterally when the head is retracted compared with the head in a neutral resting position.⁴² In contrast, there is a decrease in the EMG activity of the masseter muscle with a forward head position.⁴³ Furthermore, limitation of jaw movement occurs when the cervical spine is artificially fixed,⁴⁴ confirming the influence of the upper cervical spine on the movement of the temporomandibular joint.^{17,43} A study found that mobilization of the cervical spine, together with a cervical exercise protocol had an effect to decrease pain, increase pressure pain threshold over the masticatory muscles, and increase pain-free mouth opening in patients with myogenous TMD.¹⁹ Evidence of TMD contributing to upper cervical disorders has recently been

published.¹¹ In this randomized controlled trial, patients with features of CGH and signs of TMD¹¹ improved significantly when receiving manual therapy to the neck and temporomandibular region, when compared with cervical manual therapy alone. Thus, this evidence, in conjunction with the results of the present study, points to the potential involvement of the upper cervical spine in TMD and may justify upper cervical examination in patients presenting with TMD. Future studies may clarify the relationships between the upper cervical spine and TMD.

Another explanation for the identified pattern of cervical movement impairment in patients with TMD may be altered processing of afferent input, causing changes in the motor system distant to the TMD pathological site, specifically in the upper cervical spine. Some authors have proposed that TMD causes up-regulated central nociceptive processing of afferent input.^{8,45} For example there is evidence of generalized hyperalgesia in subjects with TMD, including lower pressure pain thresholds in the hypothenar region of the hand⁴⁶ or over the tibialis anterior muscle.⁸

Pointing away from up-regulation of sensory processing in the group TMDNHA, was the fact that global cervical mobility was not significantly reduced, while upper cervical mobility was decreased relative to asymptomatic subjects. A more likely focus of up-regulation may be the trigeminocervical nucleus, where sensory information from the first three cervical nerve roots converges with trigeminal afferents.^{16,44} Afferent input from TMD could induce sensitization of second-order trigeminal neurons, facilitating

input from the upper cervical spine and vice versa.^{16,44,47} Studies have demonstrated this sensitization phenomenon in animal experiments as well as in humans. For example, in humans, cervical spine nociceptive stimulation by hypertonic saline on the splenius capitis muscle¹⁵ or glutamate in the trapezius muscle¹⁴ induced significant decrease in maximum mouth opening (54 to 47 mm),¹⁵ and referred pain in the ipsilateral temporal region in 46% of cases,¹⁴ and in the temporomandibular region in 8% of subjects.¹⁵ Furthermore, neurons in C1 and C2 dorsal horns were activated by noxious stimulation in the trigeminal nerve territories in rats.⁴⁸ Therefore, based on these data, in the presence of TMD-induced trigeminocervical nucleus sensitization, afferent input from movement of the upper cervical spine could provoke pain, altered muscle tone and consequent upper cervical hypomobility. Although the present study has shown that people with TMD have upper cervical movement impairment, this does not necessarily imply a cause-and-effect relationship between TMD and upper cervical spine dysfunction. Future studies may clarify the relationships between the upper cervical spine and TMD in order to identify any causal relationship.

In subjects with TMD without headache, the present study found no limitation of cardinal plane movement, despite upper cervical movement loss. The upper cervical spine has a large range of sagittal plane movement, and it is therefore surprising that despite a loss of upper cervical movement, there was no loss of overall cervical ROM in this group. Other studies have also reported similar findings for cervical ROM.^{4,10}

The present study found that subjects with unclassified headache had significantly less range recorded during the FRT when compared to asymptomatic subjects and those with TMD and no headache. Total upper cervical ROM identified by the FRT was 34° in group TMDHA, 51° in group TMDNHA, and 89° in the asymptomatic group. In the present study the authors did not differentiate the type of headache because of sample size limitations, but headache is commonly associated with TMD or signs of TMD.⁴⁸⁻⁵³ It has previously been shown that the presence of headache was not associated with the chronicity of TMD,⁵¹ but severity of TMD was associated with headache frequency.⁵⁴ It was suggested that the co-occurrence of TMD and headache implied a central facilitation of nociceptive inputs,⁵⁵ or the same pathophysiological mechanism forms the basis for different types of headache,⁵⁶ namely sensitization of the trigeminocervical nucleus.^{46,57} Hence, signs of TMD and cervical movement impairment may be secondary to this sensitization process. Further studies are required to investigate this.

It is unclear why total cervical sagittal ROM was diminished in the group TMDHA compared to healthy controls. Several studies have reported cervical spine ROM loss in people with headache, but the pattern is not consistent. Nevertheless, most recent studies report migraine as the most prevalent primary headache form found in subjects with TMD⁵¹ and vice versa.^{52,53} Migraine frequency was positively associated with TMD pain severity.⁵¹ The authors of that study reported 55% of subjects with TMD had migraine headaches.⁵¹ Recently a pilot-study found that migraineurs commonly have

cervical spine impairment.⁵⁸ Thus, it is possible that the current study's findings may be explained by a higher prevalence of migraine headache in the subjects with TMD.

Headache arising from TMD is a defined secondary headache form, according to the Classification Committee of the International Headache Society.⁵⁹ Yet the results of the present study and others^{11,21} indicate that due to the interaction of the upper cervical spine with TMD, it may be impossible to differentiate TMD headache from cervicogenic headache, as people with TMD have impairment of cervical movement and pain on palpation of the upper cervical region.¹¹ Thus, diagnosis of cervicogenic headache may be reconsidered in the presence of signs of TMD.¹¹ Future studies are required to investigate the prevalence of different forms of headaches in people with TMD.

This study contributes to the body of knowledge regarding TMD. The current study findings, together with previous research,^{11,21,60} suggest that clinicians should look for impairment of the upper cervical spine when managing their patients with TMD and vice versa.

The authors recognize a number of limitations of this study, which warrant caution when extrapolating these data. First, only women with TMD were examined; male sufferers of TMD may have different presentations. Secondly, the cause of headache was not defined, nor was a causal relationship between headache pain and TMD identified. The presence of headache may have been coincidental, causal of TMD, or secondary. Future studies are required to investigate this in more detail.

Conclusion

This is the first study to report upper cervical movement identified by the FRT in people with TMD with and without headache. Range recorded during the FRT was significantly less in people with TMD compared to asymptomatic controls, with up to a 51° difference in mean ROM. Furthermore, ROM was significantly less in people with headache, compared to those who did not have headache, in the subjects with TMD. Sagittal plane cervical spine movement was reduced in those subjects with TMD and headache when compared with asymptomatic controls. These findings, together with previous reports, provide evidence for the importance of examination of upper cervical mobility determined by the FRT in patients who suffer from TMD.

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