Temporomandibular joint effusion and its relationship with perceived disability assessed using musculoskeletal ultrasound and a patient-reported disability index

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Abstract

The relationship between effusion of the temporomandibular joint (TMJ) and patient-reported disability is poorly researched. This pilot study explored the link between TMJ inflammation as measured by ultrasound and patient disability assessed by the Steigerwald Maher TMD Disability Index (SMTDI). The study design used a prospective correlational approach involving a sample with TMJ dysfunction (TMD). Twenty-four patients were recruited from the European School of Osteopathy and a Kent dental practice. Participants completed the SMTDI to determine the level of TMD (symptomatic score >20). A SonoSite SLA “Hockey Stick” [13–6 MHz] musculo-skeletal transducer was placed over the TMJ in a transverse direction and effusion was calculated indirectly by measuring capsular width. An upper left quadrant protocol was used throughout. A regression analysis was run with participants' gender, age and capsular width as predictor variables modelled against reported SMTDI. Larger capsular widths were found to be significant predictors of SMTDI scores ($r = 0.803$, $p < 0.0001$). The patient profile matched with the previous studies and the TMD sufferer population, indicating external validity. Results suggest that the SMTDI could be integrated into practice life as a quick, accessible and easy tool to monitor patients' progress and assess levels of inflammation, without the need for repetitive imaging. The study design proved reproducible and a larger scale study is indicated.

Keywords: Musculoskeletal ultrasound, temporomandibular joint, effusion, quality of life, questionnaire, ultrasound

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Introduction

Temporomandibular joint (TMJ) related pain is the third most common non-malignant chronic pain condition after tension headache and back pain.¹ The Research Diagnostic Criteria for Temporomandibular Disorders classifies patients into three groups: muscle pain, disc displacement and other common joint disorders (arthralgia, osteoarthritis and osteoarthrosis). Inflammation and neovascularisation are hypothesised to be the pathophysiological causes of most cases of TMJ dysfunction (TMD).² TMJ effusion is linked to pain,^{3,4} which is associated with decreased quality of life.⁵ TMD can lead to disability as jaw movement becomes restricted and painful⁶ and in the long term reduced social functioning⁷ and depression.^{1,8,9} Thus TMD negatively impacts on oral health-related quality of life.¹⁰ The majority of TMD sufferers try an alternative treatment approach, using treatments such as acupuncture, chiropractic and massage.¹¹

The Steigerwald Maher TMD Disability Index (SMTDI) (Appendix A) is a 10 question questionnaire, based on the

Oswestry Back Pain Questionnaire and the Neck Pain and Disability Questionnaire (Vernon Minor).¹² It is TMJ specific, including specialised functions of the TMJ (playing of instruments, talking, dental care, etc.); it provides a score of between 20 and 100. Although not fully validated, the SMTDI has been used previously in many manual therapy studies.^{13–15} At the time of the study, no validated TMJ orientated questionnaire existed.

Ultrasound measures joint effusion indirectly, by measuring capsular width.¹⁶ Diagnosis by ultrasound is sensitive, specific and accurate;¹⁷ thus as resources are developed, it is likely to be ever more utilised in diagnosis and analysis of TMD. Ultrasound diagnosis of effusion has been favourably compared to the gold standard MRI scan, especially when the capsular width is above 1.950 mm.¹⁸ It should be noted that it has been reported that the TMJ is one of the hardest joints in the body to scan,¹⁹ and a standard protocol for diagnosing TMJ derangement has not been agreed upon by ultrasonographers.²⁰

No prior studies on correlation between TMJ effusion and patient disability have been undertaken. This pilot

Figure 1 A diagram illustrating the position of the TMJ joint capsule (mouth closed)

study was synthesised to indicate whether joint effusion leads to disability.

Methods

The study was approved by the European School of Osteopathy Ethics Committee, Maidstone, Kent. Consent was gained from each participant; every participant was over 18 and had the mental capacity to understand the consent and information forms. The participants of the study were accompanied by a second practitioner, who was responsible for their well-being. Subjects were able to withdraw at any point during the study. Subjects were excluded if they were pregnant, suffered with a connective tissue disorder, inflammatory joint disorder, bruxism, autoimmune or neurological condition. Subjects were also excluded if they had experienced recent trauma to the jaw or had ever had severe facial trauma (such as TMJ dislocation) or surgery.

Subjects completed the SMTDI questionnaire, after completing a subject profile asking date of birth, ethnicity and gender. This screened the subject for exclusion factors. Subjects were asked to complete the SMTDI in isolated conditions (one practitioner independent of the study was able to explain questions if needed but did not assist with answers). The subject profile and completed SMTDI were placed in an envelope and sealed. On the front of the envelope the first practitioner marked the subject number and L or R to indicate the side of the jaw to be scanned.

After completion of the questionnaire the patients underwent a HR-US investigation; ultrasound methodology mirrored that in previous studies.^{3,19,21,22} The single investigator performing the HR-US investigation was blinded to the results of the clinical investigation of the SMTDI. Subjects were laid supine on a couch with their head supported by a sculpted foam pillow, allowing the head to be elevated to the same level and at roughly the

same angle. The subject was instructed to maintain a relaxed closed mouth position.

A SonoSite SLA "Hockey Stick" [13-6 MHz] musculo-skeletal transducer was placed over the symptomatic TMJ (if both joints were symptomatic the most painful side was chosen) in a transverse direction running parallel to the Camper line (the line intersecting the ala of the nose and the tragus of the ear), with the subject in a closed mouth position (see Figure 1). An upper left quadrant protocol was used throughout.

Capsular width was measured between the articular capsule (a hyperechoic line) and the condylar laterosuperior surface, using the calliper function. One marker was placed on the laterosuperior surface of the condyle and the other on the border of the capsule and surrounding soft tissue structures. The calliper function measures to 0.1 mm accuracy, as shown in Figure 2. In order to reduce placement error three measurements are taken and averaged.

Statistical analysis was carried out using Excel (Microsoft Corporation 2003) and Analyse-it (Analyse-it Software Ltd, Leeds). A regression analysis was run with participants' gender, age and capsular width as predictor variables modelled against reported SMTDI.

Results

Thirty-one subjects of white European origin were recruited between September and November 2012 from Longford Dental Practise (all symptomatic) and the European School of Osteopathy, Maidstone, UK (predominantly asymptomatic). Of those, one failed to complete the SMTDI and six subjects were then excluded (3 recent trauma to TMJ, 1 pregnancy, 1 history of severe TMJ trauma, 1 suffering neurological disorder). The final sample was made of 24 individuals (6 males, 18 females) aged between 21 and 71, mean age 32.79 (± 2.54). Twelve subjects were symptomatic, suffering from TMD (as diagnosed by an osteopath or

dentist), and 12 were identified as asymptomatic. Later statistical analysis indicated that there was no significant difference in correlation between capsular width and SMTDI score between individuals identifying as symptomatic and

Figure 2 An image displaying a capsular reading of 0.21 cm using the calliper function. The superior margin of the metric is defined as the hyperechoic cortex delineating the mandibular fossa. The condylar margin is the hyperechoic line delineating the cortex of the condyle. The calliper markers were positioned midway between the articular arc crescent

asymptomatic ($p = 0.943$), so they were summated and treated as the same population. By including all non-excluded control subjects, the final data set was reached (see Table 1).

Increasing SMTDI was correlated with increasing capsular width, $r = 0.803$, thus $p < 0.0001$, R^2 adjusted = 0.629 (see Figure 3). The 95% confidence intervals of r were calculated to be 0.003 to 0.006. A regression model using age and gender showed no significant effect ($p = 0.485$).

Discussion

The results showed positive correlation between capsular width and SMTDI score, with increasing SMTDI scores signifying increasing capsular width ($r = 0.803$, $p < 0.0001$). Increasing width is a marker for heightened fluid levels in the joint space, indicating increased synovial effusion and thus inflammation (individuals with non-inflammatory joint disorders were screened out prior to scanning). Therefore, these results imply a positive correlation between joint inflammation and patient-reported disability. The R^2 adjusted demonstrates that 63% of result variability is attributed to the relationship between capsular width and SMTDI.

The mean age of participants in the study was 32.79 ± 4.97 years. This is a similar result to the average sufferer age in previous studies of 25.3 ± 13.12^{22} and $30.2-39.4$.²³ The majority of symptomatic participants (75%) had

Table 1 Study data

Subject	Age	Gender	Steigerwald Maher Disability Index (20–100)	Capsular width readings (cm)				Standard deviation capsular width	Capsular width (cm)
1	34	F	22	0.15	0.15	0.15	0.15	0	0.15
2	26	F	36	0.23	0.24	0.23	0.233	0.006	0.233 ± 0.012
3	50	F	42	0.28	0.28	0.28	0.28	0	0.28
4	23	F	30	0.18	0.18	0.17	0.177	0.006	0.177 ± 0.012
5	34	F	26	0.25	0.25	0.25	0.25	0	0.25
6	36	M	24	0.18	0.19	0.19	0.187	0.006	0.187 ± 0.012
7	23	M	42	0.21	0.22	0.22	0.217	0.006	0.217 ± 0.012
8	24	F	30	0.21	0.21	0.22	0.213	0.006	0.213 ± 0.012
9	21	F	28	0.18	0.18	0.18	0.18	0	0.18
10	44	M	22	0.15	0.14	0.14	0.143	0.006	0.143 ± 0.012
11	23	F	26	0.11	0.11	0.11	0.11	0	0.11
12	21	F	51	0.3	0.3	0.3	0.3	0	0.3
13	71	F	44	0.31	0.31	0.31	0.31	0	0.31
14	29	F	20	0.15	0.15	0.16	0.187	0.006	0.187 ± 0.012
15	32	M	24	0.18	0.18	0.19	0.183	0.006	0.183 ± 0.012
16	50	F	22	0.11	0.12	0.11	0.113	0.006	0.113 ± 0.012
17	21	F	22	0.21	0.22	0.22	0.217	0.006	0.217 ± 0.012
18	50	F	26	0.19	0.19	0.19	0.19	0	0.19
19	31	M	20	0.19	0.18	0.19	0.187	0.006	0.187 ± 0.012
20	37	M	20	0.15	0.15	0.15	0.15	0	0.15
21	30	F	20	0.14	0.14	0.13	0.137	0.006	0.137 ± 0.012
22	32	F	20	0.14	0.14	0.14	0.14	0	0.14
23	22	F	20	0.15	0.15	0.15	0.15	0	0.15
24	23	F	20	0.17	0.17	0.17	0.17	0	0.17

Figure 3. A scatter graph to show the correlation between SMTDI and capsular width

mean capsular widths spanning 0.19 cm or above. This is above the level found by Manfredini et al.¹⁸ to be a good critical level to assess effusion. However, histological and biomarker studies would be needed to fully assess the accuracy of using ultrasound to diagnose inflammation. Manfredini et al.²³ found a female-to-male TMD sufferer ratio of 3. This ratio was identical to the ratio of 3 found in this study. These data on age and gender indicate that the current study has external validity as the sample population can be shown to be similar to that of the general TMD sufferer population.

This study is believed to be the first in which capsular width was linked to a functional disability questionnaire. The statistically strong relationship found in this small scale study suggests that a larger scale study based on this work could add significantly to our understanding of relationships between TMD pathophysiology and patient quality of life. It could also indicate that the SMTDI should be integrated into practise life as a quick, cheap and easy tool to monitor patients' progress and assess levels of inflammation. The maximum disability experienced by subjects was recorded as moderate disability (a SMTDI score of 51). This may be because patients with incapacitating TMD would have been referred to an orthodontist or maxillofacial surgeon by the dentist or osteopaths who recruited for this research.

Pain and disability can have a fluctuating nature.²⁴ As the questionnaire was only presented on one day, it is a snapshot rather than an averaged value. If further research were carried out, subjects could be asked to complete the questionnaire on multiple occasions, and a parallel series of scans could be recorded. The SMTDI included categories for dizziness and tinnitus. Although these conditions are linked to TMD, they can have stand-alone causes such as noise overexposure, low blood pressure or diabetes, none of which were screened out, which is a study limitation.

The SMTDI was easy to administer, well understood by subjects and quick to complete; only 1 subject of the 32 failed to complete the questionnaire. The questionnaire was quick to analyse and produced results that could easily be plotted to give a visual measure. It would easily fit into a clinical environment to monitor TMD progression. One notable limitation to the SMTDI was that subjects reported feeling uneasy answering a question about sexual function. Davidson²⁵ studied the Oswestry Disability Index, finding that replacing the sex life question with one about housework was accurate and better tolerated. Replacing the sex life question may lead to more accurate results.

With some individuals, ultrasound scanning was difficult due to the location of the TMJ. In the closed mouth position, some subjects had mandibular heads which were positioned very posterior, so part of the image was obscured by the tragus. This reduced the quality of some images, although inspection of the data suggested that the standard error for these subjects was not significantly greater than for the larger population.

Further studies should be done to examine the levels of minimal important change and clinically important significance, in order to further develop the SMTDI as a clinical tool. This could be accomplished by correlating changes in SMTDI score with capsular width as time (or a course of treatment) progressed. A previous study²⁶ examining the Oswestry Disability Index (upon which the SMTDI is based) found that the minimum important detectable change (MIDC) was 12.8 points. This level could be applied to future studies to indicate if the SMTDI could be used to plot clinically relevant levels of treatment progression. Similarly, for a range of commonly used back pain outcome measures, a 30% change from baseline may be considered a clinically significant improvement when comparing before and after measures for individual patients.²⁷ This could be

examined to test the applicability of a 30% measure to TMD. However, it has been argued²⁸ that in oral medicine quality of life based studies, MIDC has limited relevance due to highly variable patient responses to pain and the wide range of calculation methods available.²⁹

It would be beneficial to perform a larger follow up study to build on the positive correlation already established, if possible, with a wide range of presentations, prior screening by a medical professional to exclude those suffering from TMD associated symptoms due to other medical conditions and a matched control group. A larger study would demonstrate whether correlation would continue to increase until a full score of 100 on the SMTDI is reached.

If future research could correlate SMTDI and ultrasound evaluated capsular width with histological studies looking for inflammatory markers, the SMTDI could be developed into an accurate clinical diagnosis tool. This would allow practitioners to use a questionnaire based method of diagnosis. This would additionally give more data detailing what percentage of sufferers have non-inflammatory based pain such as subchondral osteoarthritic degeneration.

Conclusion

Increasing TMJ capsular width is positively correlated to decreasing patient quality of life in those with low to medium TMJ related disability. A larger study is required to confirm these results across a larger population of TMD sufferers.

DECLARATIONS

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Contributorship: KJJ and LNB conceived the study. KJJ performed the study, completed the data analysis and completed the first draft. PB and LNB redrafted the manuscript. All authors reviewed and approved the final version of the manuscript.

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Appendix A

The Steigerwald/Maher TMD Disability Index

Please read the questions below and select the statement that most applies to you, please only select one statement from the list. If you need help understanding the question you may ask the practitioner.

1. Communication (Talking)
 - () I can talk as much as I want without pain fatigue or discomfort
 - () I talk as much as I want but it causes some pain, fatigue and/or discomfort
 - () I can't talk as much as I want because of pain, fatigue and/or discomfort
 - () I can't talk much at all because of pain, fatigue and/or discomfort
 - () Pain prevents me from talking at all
2. Normal living activities (brushing teeth/flossing)
 - () I am able to care for my teeth and gums in a normal fashion without restriction, and without pain, fatigue or discomfort
 - () I am able to care for all my teeth and gums, but I must be slow and careful, otherwise pain/discomfort/jaw tiredness results
 - () I do manage to care for my teeth and gums in a normal fashion, but it usually causes some pain/discomfort/jaw tiredness no matter how slow and careful I am
 - () I am unable to properly clean most of my teeth and gums because of pain and/or limited opening
 - () I am unable to care for most of my teeth and gums because of restricted opening and/or pain
3. Normal living activities (eating/chewing)
 - () I can eat and chew as much of anything I want without pain or discomfort or jaw tiredness
 - () I can eat and chew mostly anything I want, but it sometimes causes pain/discomfort and/or jaw tiredness
 - () I can't eat much of anything I want, because it often causes pain/discomfort, jaw tiredness or because of restricted opening
- () I must eat only soft foods (consistency of scrambled eggs or less) because of pain/discomfort, jaw fatigue and/or restricted opening
- () I must stay on a liquid diet because of pain and/or restricted opening
4. Social/recreational activities (singing, playing musical instruments, cheering, laughing, social activities, playing amateur sports, other hobbies and recreational activities)
 - () I am enjoying a normal social life and/or recreational activities without restriction
 - () I participate in normal social life and/or recreational activities, but pain/discomfort is increased.
 - () The presence of pain and/or fear of likely aggravation only limits the more energetic components of my social life (sports, exercising, dancing, playing musical instruments, singing)
 - () I have restrictions socially, as I can't even sing, shout, cheer, play and/or laugh expressively because of increased pain/discomfort
 - () I have practically no social life because of pain
5. Non-specialised jaw activities (yawning, mouth opening and opening my mouth wide)
 - () I can yawn in a normal fashion, painlessly
 - () I can yawn and open my mouth fully wide open, but sometimes there is discomfort
 - () I can yawn and open my mouth wide in a normal fashion, but it almost always causes discomfort.
 - () Yawning and opening my mouth wide are somewhat restricted by pain
 - () I cannot yawn or open my mouth more than two finger widths (2.8-3.2cm) or, if I can, it always causes greater than moderate pain.
6. Sexual function (including kissing, hugging and any and all sexual activities to which you are accustomed)
 - () I am able to engage in all my customary sexual activities and expressions without limitations and/or causing headache, face or jaw pain
 - () I am able to engage in all my customary sexual activities and expressions, but it sometimes causes headache, face or jaw pain, or jaw fatigue
 - () I am able to engage in all my customary sexual activities and expressions, but it usually causes headache, face or jaw pain to markedly interfere with my enjoyment, willingness and satisfaction.
 - () I must limit my customary sexual expression and activities because of headache, face or jaw pain or limited mouth opening.
 - () I abstain from almost all sexual activities and expression because of the head, face or jaw pain it causes.
7. Sleep (restful, nocturnal sleep pattern)
 - () I sleep well in a normal fashion without any pain medication, relaxants or sleeping pills.
 - () I sleep well with the use of pain pills, anti-inflammatories or medicinal sleeping aids

- ☐ I fail to realise 6 hours restful sleep, even with the use of pills
- ☐ I fail to realise 4 hours restful sleep, even with the use of pills
- ☐ I fail to realise 2 hours restful sleep, even with the use of pills
- 8. Effects of any form of treatment, including, but not limited to, medications, inpatient treatment/treatment in the dentist/doctor surgery, manual treatments, oral orthotics (e.g. splints/mouthpieces), ice/heat, etc.
 - ☐ I do not need to use treatment of any type in order to control or tolerate headache, face or jaw pain and discomfort
 - ☐ I can completely control my pain with some form of treatment
 - ☐ I get partial, but significant, relief through some form of treatment
 - ☐ I don't get "a lot of" relief from any form of treatment
 - ☐ There is no form of treatment that helps enough to make me want to continue
- 9. Tinnitus
 - ☐ I do not experience ringing in my ear(s)
 - ☐ I experience ringing in my ear(s) somewhat, but it does not interfere with my sleep and/or my ability to perform my daily activities

- ☐ I experience ringing in my ear(s) and it interferes with my sleep and/or my ability to perform my daily activities, but I can accomplish set goals and I can get an acceptable amount of sleep
- ☐ I experience ringing in my ear(s) and it causes a marked impairment in the performance of my daily activities and/or results in an unacceptable loss of sleep
- ☐ I experience ringing in my ear(s) and it is incapacitating and/or forces me to use a masking device to get any sleep
- 10. Dizziness (light headedness, spinning and/or balance disturbances)
 - ☐ I do not experience any dizziness
 - ☐ I experience dizziness, but it does not interfere with my daily activities
 - ☐ I experience dizziness which interferes somewhat with my daily activities, but I can accomplish my set goals
 - ☐ I experience dizziness which causes a marked impairment in the performance of my daily activities
 - ☐ I experience dizziness which is incapacitating

Thank you for taking the time to complete this questionnaire