

Determining The Sensitivity and Specificity of two Questionnaires when comparing Odontogenic Pain with Temporomandibular Disorders-related Pain

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Dedication

To Javier, for his unconditional support over the distance, for his love, his light and his friendship during this period of my life.

To Antonio, Anna and Alba; my family in Minnesota.

To Manuel, Marta, Marta and Sara. Because you are always there.

Abstract

Objectives: Two common types of orofacial pains that are clinically important to distinguish are odontogenic pain and temporomandibular disorders (TMD) pain. The aim of this study was to determine the sensitivity and specificity of two screening instruments in distinguishing patients with odontogenic pain from patients with TMD pain.

Methods: A convenience sample of patients seeking care at an Endodontist's office and at an Orofacial Pain Clinic was recruited. The 14-item Dental Pain Questionnaire (DePaQ) (Pau *et al.*, 2005) was used to screen for odontogenic pain and the 6-item TMD-screener (Gonzalez *et al.*, 2011) was used to screen for TMD pain. Sensitivity and specificity calculations, with 95% confidence intervals, were performed for both instruments.

Results: Thirty-four patients with odontogenic pain and 37 patients with TMD pain were enrolled. Both groups had comparable age distribution (49 ± 12 vs. 45 ± 18 years) and gender composition (53% vs. 86% females). Results of the sensitivity and specificity are provided in the table below with determination of diagnostic accuracy of these measures evaluated using published guidelines.

		Odontogenic Pain versus TMD Pain (95% confidence interval)
DePaQ	Sensitivity	85% (69% to 95%)
	Specificity	11% (3% to 25%)
TMD-screener	Sensitivity	92% (78% to 98%)
	Specificity	59% (41% to 75%)

Conclusion: The point estimates for both the DePaQ and TMD screener were “acceptable” in identifying patients who had the pain condition in question (*i.e.*, sensitivity), although the point estimate for appropriately identifying patients who did not have the pain condition when they did not have it (*i.e.*, specificity) was “non-acceptable” neither for the DePaQ nor for the TMD screener. The potential for high amounts of false positive responses with the DePaQ limits its use as a screening instrument when patients are suspected as having TMD pain.

Table of Contents

Acknowledgements.....	i
Dedication	iii
Abstract.....	iv
Table of Contents	v
List of Tables	vii
List of Figures	viii
Introduction.....	1
Aim	7
Methods.....	8
Participants.....	8
Enrollment criteria	9
Inclusion Criteria	9
Exclusion Criteria:	9
Sample Size.....	10
Screening questionnaires used	11
Dental pain screening questionnaire	11
TMD screening questionnaire.....	12
Statistical analyses	12
Results.....	15
Description of patients	15
Analysis of the DePaQ Screener.....	16
Analysis of the TMD Screener	17
Discussion.....	18
Participants' enrollment:.....	19

Questionnaires:	19
Item analysis	21
Limitations:	23
Future studies	24
Conclusion	24
References.....	26
Tables	31
Figures.....	42
Appendix 1: Dental Pain Questionnaire	A
Appendix 2: TMD screener	D

List of Tables

Table 1: Pulpal and apical diagnostic terminology.....	31
Table 2: Non odontogenic tooth pain.....	32
Table 3: Patterns of pain referral to teeth and associated regions.....	33
Table 4: Diagnostic criteria for the patients recruited.....	34
Table 5: Characteristics of the 71 patients enrolled in the study	36
Table 6: AIM 1.0: DePaQ: Odontogenic pain versus all TMD pain	37
Table 7: AIM 1.1: DePaQ: Odontogenic pain versus TMD pain not referring to teeth only	37
Table 8: AIM 1.2: DePaQ: Odontogenic pain versus TMD pain referring to teeth only	38
Table 9: AIM 2.0: TMD Screener: All TMD pain versus Odontogenic pain.....	38
Table 10: AIM 2.1: TMD Screener: TMD pain not referring to teeth only versus Odontogenic pain	39
Table 11: AIM 2.2: TMD Screener: TMD pain referring to teeth only versus Odontogenic pain	39
Table 12: Comparison of the sample with other populations	40
Table 13: DePaQ and TMD screener item analysis.....	41

List of Figures

Figure 1: Patients enrolled 42

Introduction

Pain related to a tooth and associated structures, referred to as odontogenic pain, is known to arise from inflammation within the dental pulp and/or periapical tissues. Such inflammation is related to disease within these tissues, usually bacterial, and is thought to be the main etiological factor related to the symptom of pain arising from these tissues¹. The diagnoses of pulpal and periapical disease, as suggested by the American Association of Endodontists (AAE), are based on the signs and symptoms related to the tooth in question as reported by the patient². These diagnoses and their criteria are presented in Table 1.

In a prevalence study in the United States, within a sample of 45,711 households in the civilian population, 12% reported having had “toothache” over the last 6 months when asking them about five different types of orofacial pains³. Therefore, odontogenic pain is the most common orofacial pain and the most common reason for patients to seek dental care^{4,5}. Root canal treatment (RCT) is a common effective treatment for odontogenic pain and pathosis^{6,7,8}. Hence the reason why odontogenic pain and RCT are of great interest to dentists and patients alike⁸⁻¹².

From all the diagnoses for odontogenic pain (Table 1), of which some are always associated with pain and some are not. Those associated with pain are: symptomatic

irreversible pulpitis as pulpal diagnosis; and symptomatic apical periodontitis and acute apical abscess as apical diagnoses.

Jaw joint and/or face and cheek pain was also a common pain condition in the prevalence study for orofacial pains in the United States³, with prevalence of 6%. These conditions include TMD-related pain. TMDs are disorders related to the temporomandibular joint and masticatory muscles. TMDs can be classified into two subgroups; those that are associated with pain are: myalgia (muscle pain), myofascial pain (muscle pain with referral to other structures beyond the boundaries of the muscle palpated), and arthralgia (joint pain). It is important to know that having one diagnosis does not exclude having one or more of the others¹³.

In a systematic review of population-based epidemiological studies of orofacial pain, it was observed that the median prevalence of orofacial pain in the general population is 13%¹⁴. In the prevalence study for orofacial pains in the United States, it was indicated that some of the respondents could present with more than one type of pain; therefore a person that was complaining of “toothache” could be complaining about face pain too. This raises the question about the accuracy of self-reported orofacial pains because data suggests that patients may not easily separate different orofacial pains based on location of that pain¹⁵. Also, TMD is known to be perceived as “toothache”¹⁶ and odontogenic pain is known to contribute to TMD¹⁷. Diagnosing the etiology of odontogenic pain is usually fairly

straightforward, but on occasion can be challenging when signs and symptoms of pain are unclear or similar to other orofacial pain disorders that have a non-odontogenic origin.

A thorough exam to rule out the diseases that can provoke pain with a non-odontogenic origin should be performed if all the tests for dental pathosis are negative. Table 2 lists all these conditions, their characteristics and diagnostic tests required. When a condition is misdiagnosed with other, there is a risk of unnecessary treatment¹⁸. A recognized reason for such a misdiagnosis is when pain is referred. Referred pain can be defined as pain felt in a part of the body different from that in which it originates¹⁹. In the head and neck, referred pain is prevalent and always merits consideration when forming a differential diagnosis¹⁶. Equally, TMDs, presenting at different source (origin of the pain) can cause pain at a distant site (location where the pain is felt)¹⁶.

It is not completely known how odontogenic pain and TMD-related pain are associated, but a correlation has been noted, although there are a few studies comparing the two of them. One possibility could be the length of the intervention in the dental office: the longer the appointment and operating time, the more prone to develop TMD²⁰, there are also cases of pulpalgias that can contribute to TMD-like pain¹⁷.

Myofascial pain can refer pain to many structures, distant from the muscles palpated. The points in the muscle that can trigger the referred pain are called trigger points, and they are commonly found in skeletal muscles. Trigger points are localized, firm, hyperirritable nodules that patients often describe as “knots” within their muscles²¹. Muscles of the head

and neck area can refer their pain to the surrounding areas, and a possible site of pain, although not the most common¹⁶ is the teeth. Table 3 lists the sources and frequencies of pain referral to teeth in a study where firm pressure was applied for approximately five seconds to trigger points, nodules of spot tenderness, and selected masticatory structures within the head and neck region on 230 patients with TMD¹⁶.

One of the possible reasons for this ambiguous pain is of its location. It has been demonstrated that when pain is felt in areas of the face that are in close geographical proximity, such as within the TMJ and ipsilateral masseter muscle, patients have difficulties in discriminating between possible sources¹⁵. This suggests that discrimination between ipsilateral teeth and masticatory muscles may also be difficult.

A clinical evaluation with imaging by an expert practitioner remains as the gold standard for the identification of tooth pathosis and of TMD. This is a time-consuming and costly approach to deriving diagnoses for epidemiological studies, so the development and validation of question-based screening instruments are desirable. An accurate screening instrument should have high sensitivity and specificity. Sensitivity is the ability for the instrument to identify patients who have the disease when they have it. Specificity is the ability of an instrument to identify patients who do not have the disease when they do not have it. Screening tests that have high sensitivity and specificity, meaning they possess the ability to very accurately categorize patients by diagnostic status have a good discriminative value. Such a property is usually best achieved with multiple questions, but

this can make the screening questionnaire long and cumbersome to administer. Therefore, there is usually a balance between ease of implementation of a screening questionnaire and its ability to correctly categorize patients when constructing a screening questionnaire.

In regards to questionnaires focusing on screening for painful tooth-related disease, there are few studies that have been published. They are listed below:

- McGill Pain Questionnaire: screens for pulpitis and pericoronitis²²,
- McGill Pain Questionnaire: screens for irreversible and reversible pulpitis²³,
- McGill-Melzack Pain Questionnaire: screens for pulpal, periodontal and temporomandibular joint pain²⁴, and
- Dental Pain Screening Questionnaire (DePaQ): screens for acute periapical periodontitis, irreversible pulpitis, reversible pulpitis, dentine hypersensitivity and pericoronitis²⁵.

For those screening questions, the one with the greatest discriminating ability is the DePaQ, which demonstrated good sensitivity and specificity and, therefore, was our instrument of choice. More characteristics of this questionnaire will be described within the Methods section below.

In regards of TMD questionnaires, eight studies have been published, but only one of them used the Standards for Reporting of Diagnostic Accuracy-recommended parameters of assessment: operationalized criteria, examiners using a calibrated technique and

consensus diagnosis²⁶, and discriminated between pain-related TMD and mechanical symptoms associated with the temporomandibular joint (TMJ). This instrument is the TMD related-pain screener²⁷ which was used in this research and will be described in details in the Methods section below.

Aim

The primary aim of this study was to determine the sensitivity and specificity of two screening questionnaires, one designed for odontogenic pain (DePaQ) and one for TMD pain (TMD screener), in a group of patients experiencing pain of either odontogenic or TMD origin. The secondary aims of this study were to explore how the screening questions perform in subsets of patients, such as TMD pain referred to the dentoalveolar region and presenting as “tooth pain”, to assess whether limitations at the group level may be driven by responses from subsets of patients.

Methods

This study is derived from data collected within a parent study designed to explore item selection for the development of a Persistent Dentoalveolar Pain disorder (PDAP) screening questionnaire. Required ethics approval from the University of Minnesota Institutional Review Board regulations and informed consent for all human subjects was obtained before the initiation of the study protocol.

Participants

Recruitments of patients were performed by board certified Orofacial Pain practitioners and a board certified Endodontist. TMD pain patients were recruited from the TMD and Orofacial Pain Clinic in the School of Dentistry at the University of Minnesota, Minneapolis, Minnesota. Odontogenic pain patients were recruited in a private endodontic practice, The Dental Specialists, within the Twin Cities area. A convenience sample of these two groups of patients was collected. Patients presenting with both diagnoses were excluded for being in this study because the report of the symptom of pain could not be attributed to only one diagnosis and thereby making the response ambiguous. Some patients with TMD pain perceived their pain in the jaw and face, while others perceived their pain in a tooth / alveolus, as referred from other structures. These differences in the two subgroups will be covered in greater detail below.

Enrollment criteria

The following criteria were used to select patients for this study.

Inclusion Criteria

Odontogenic pain sample: Patients diagnosed with symptomatic irreversible pulpitis, symptomatic apical periodontitis and/or symptomatic apical abscess following the diagnostic criteria²⁸ (Table 4).

TMD pain sample: Patients with diagnosis of TMD pain, including myalgia, myofascial pain with referral or arthralgia following the diagnostic criteria for TMD (DC/TMD)¹³ (Table 4). Among the TMD sample, patients presenting with referred pain to surrounding areas, as it is described in myofascial pain with referral, were accepted. There were made two subgroups of patients in this group, depending on the presentation of the pain, if the site where it was referred was the dentoalveolar region, as it was described by Wright¹⁶, or not, which was specifically measured due to the increased potential for diagnostic confusion.

- Patients seeking treatment for their painful condition in one of the clinics of the study.
- Age, 18 years old and older.
- Comfortable communicating in English.

Exclusion Criteria:

- Patients with another comorbid orofacial pain diagnosis.

- Patients with a history of traumatic injuries to the orofacial region.
- Patients with a major systemic illness related to altered pain sensitivity, or with fibromyalgia and other widespread bodily pain conditions.
- Patients with a history of TMJ surgery or inter-articular steroid injection.
- Unable to give informed consent.
- Previously enrolled in this study.

Sample Size

The number of patients per pain group was calculated to be 20 per group, this was based on the needs for the parent study. Over enrollment of patients in both groups was to address a different research question, as well as to account for missing data.

Screening questionnaires used

Dental pain screening questionnaire

The Dental Pain Questionnaire (DePaQ) was used as the instrument to detect patients with odontogenic pain²⁵. It is a 14 item questionnaire developed in the United Kingdom, designed to differentiate three groups of odontogenic tooth pain:

- Group A: Acute periapical periodontitis and irreversible pulpitis,
- Group B: Reversible pulpitis and dentine hypersensitivity
- Group C: Pericoronitis.

The item generation study of this questionnaire was developed within a sample of 313 patients, where just over 50% were male. The sample consisted of Group A patients-35%, Group B-32%, and Group C-18%. Questionnaire items were generated through literature review and individual interview of all the subjects. Later on, a validation study of the questionnaire was performed within another group of 161 subjects, 60% of who were male. The sample consisted of 73% Group A subjects, 13% Group B and 14% Group C. The sensitivity (95% CI) was 80% (71 to 87%) for Group A, 85% (62 to 97%) for Group B and 59% (36 to 80%) for Group C; specificity was 83% (69 to 93%), 89% (83 to 94%) and 90% (84 to 95%) respectively. This questionnaire was recently validated in a different population²⁹ in South India resulting in sensitivity values of 85% (77 to 91%), 82% (65 to

93) and 79% (49 to 95%) for group A, B and C respectively. Specificity values were 75% (62 to 86%), 90% (83 to 94%) and 95% (91 to 98%) for group A, B and C respectively.

TMD screening questionnaire

The TMD screener was developed as a self-report instrument in screening patients for pain-related TMD²⁷. It was designed in a short (three-item) and long (six-item) versions using psychometric methods for item selection, and evaluated for validity among 504 participants. It was compared pain-related TMD versus healthy controls; versus non-painful TMD; and versus headaches. Among the results, in all the groups and both questionnaires, the sensitivity was 99%, where specificity was slightly higher (97%) in the long version, while in the short version was at least 95%. In our study, we opted for the long version, because it had better specificity scores.

Statistical analyses

Data were managed using the spreadsheet software Microsoft Excel (Microsoft Excel 2010 for PC: Microsoft Corporation) and all analyses were performed using the statistical software package STATA (Stata Statistical Software: V12 for Mac. College Station, TX: StataCorp LP).

The data were analyzed comparing all patients with known odontogenic pain with all patients with known TMD pain group using the two questionnaires. This was contrasted

using two by two tables. Four subgroup analyses were performed, depending on the site where the pain was felt. The analyses were as follows:

- Aim 1.0. Determine the sensitivity and specificity of the DePaQ for identifying all patients with odontogenic pain versus all patients with TMD pain as controls
 - Subaim 1.1. Determine the sensitivity and specificity of the DePaQ for identifying all patients with odontogenic pain versus patients with TMD pain, excluding TMD pain referred to teeth as controls.
 - Subaim 1.2. Determine the sensitivity and specificity of the DePaQ for identifying all patients with odontogenic pain versus patients with TMD pain referred to teeth only as controls.
- Aim 2.0. Determine the sensitivity and specificity of the TMD screening questionnaire for identifying all patients with TMD pain versus odontogenic pain patients as controls.
 - Subaim 2.1. Determine the sensitivity and specificity of the TMD screening questionnaire for identifying patients with TMD pain, excluding TMD pain referred to teeth, versus odontogenic pain patients as controls.
 - Subaim 2.2. Determine the sensitivity and specificity of the TMD screening questionnaire for identifying patients with TMD pain referred to teeth only versus odontogenic pain patients as controls.

Results are presented as point-estimates for the sensitivity and specificity of the questionnaires for each comparison with 95% confidence intervals presented to demonstrate the level of precision these calculations offer.

Levels of diagnostic accuracy were measured using sensitivity and specificity estimates described by Dworkin and LeResche (acceptable sensitivity=70% and acceptable specificity=95%)³⁰.

Results

This study reports on data collected through 33 months, between October 2011 and July 2014, which was the duration of data collection.

Description of patients

A total of 82 patients participated in this study but 11 of them were excluded:

- 5 patients (4 diagnosed with TMD pain and 1 with odontogenic pain) were excluded because they left more than 10% of one of the questionnaires unanswered, that means two or more questions in the DePaQ or one or more questions in the TMD screener (4 of them left question number 13 in DePaQ questionnaire unanswered or not completely answered, which is related to the quality of the pain, and it is composed by 4 subquestions; and one left unanswered question number 2 of the TMD screener, about having pain upon awakening) and
- 6 odontogenic pain patients had concomitant TMD pain.

From the 71 patients included, 34 (47%) of them had odontogenic pain, [15% (5) with symptomatic irreversible pulpitis only, 50% (17) with symptomatic apical periodontitis only, 18% (6) with acute apical abscess, and 18% (6) with symptomatic irreversible pulpitis and symptomatic apical periodontitis. From those with a painful pulpal diagnosis only, the apical was asymptomatic because of having it normal]. Among the

TMD pain group [46% (17) with myofascial pain, 5% (2) with arthralgia, and 49% (18) with myofascial pain and concomitant arthralgia], there was a subdivision could be made for a secondary study, where 32% (12) of the patients, reported their pain being perceived in their teeth so their clinical chief complaint was “toothache” (Figure 1). The demographics of the patients enrolled are presented in Table 5.

Analysis of the DePaQ Screener

Using the DePaQ as the screening instrument, to discriminate between odontogenic pain group versus the whole TMD pain group, the sensitivity obtained was 85% (95% CI= 69% to 95%), and the specificity was at 11% (95% CI: 3% to 25%). Positive predictive value was 47% (95% CI: 34% to 60%). Negative predictive value was 44% (95% CI: 14% to 79%). Table 6 demonstrate further details.

When the TMD pain sample was divided in the two subgroups depending on if TMD pain was referred to teeth or not, the difference was negligible; when comparing odontogenic pain versus TMD pain not referring to teeth only, sensitivity and specificity were 85% (95% CI: 69% to 95%) and 12% (95% CI: 3% to 31%) respectively, positive predictive value was 57% (95% CI: 42% to 71%) and negative predictive value was 37% (95% CI: 9% to 75%) (Table 7), when comparing odontogenic pain versus TMD pain referring to teeth only, sensitivity and specificity were 85% (95% CI: 69% to 95%) and 8% (95% CI: 0.2% to 38%) respectively, positive predictive value was 72% (95% CI: 56% to 85%) and negative predictive value was 17% (95% CI: 0.4% to 64%) (Table 8).

Analysis of the TMD Screener

When the TMD screener was the questionnaire used to compare the odontogenic pain group versus the whole TMD pain group, it showed a sensitivity of 92% (95% CI: 78% to 98%), and specificity of 59% (95% CI: 41% to 75%). Positive predictive value was 71% (95% CI: 56% to 83%). Negative predictive value was 87% (95% CI: 66% to 97%) Table 9 demonstrate further details.

When the TMD pain sample was divided in the two subgroups depending on if TMD pain was referred to teeth or not, the difference was negligible; when comparing odontogenic pain versus TMD pain not referring to teeth only, sensitivity and specificity were 92% (95% CI: 74% to 99%) and 59% (95% CI: 41% to 75%) respectively, positive predictive value was 62% (95% CI: 45% to 77%) and negative predictive value was 91% (95% CI: 71% to 99%) (Table 10); when comparing odontogenic pain versus TMD pain referring to teeth only, sensitivity and specificity were 92% (95% CI: 61% to 100%) and 59% (95% CI: 41% to 75%) respectively, positive predictive value was 44% (95% CI: 24% to 65%) and negative predictive value was 95% (95% CI: 76% to 100%) (Table 11).

Discussion

The purpose of this study was to test the ability of whether one of two screening questionnaires, one used to identify odontogenic pain and one used to identify TMD pain, can adequately separate patients with these orofacial pain conditions. The results indicate that both questionnaires, the DePaQ and the TMD screener, have an acceptable sensitivity whilst the specificity is unacceptable for both screening questionnaires. This means that DePaQ will identify those patients that have odontogenic pain most of the time, 85%, when they have odontogenic pain and the TMD screener will identify those patients that have TMD pain most of the time, 92%. Nevertheless the questionnaires perform less well in identifying patients as not having the disorder when they do not have it. The DePaQ, with a specificity of 11% will classify 89% of the patients with TMD as patients having odontogenic pain. Such poor performance limits this questionnaire's use in populations with both TMD pain and/or odontogenic pain. The TMD screener, with a specificity of 59%, will classify 41% of the patients with odontogenic pain as having TMD pain. Furthermore, the TMD screener and the DePaQ do not seem to be influenced by the site of pain because subset analyses yielded very similar sensitivity and specificity results when patients with TMD pain perceived to be of tooth origin only (Table 8 and Table 11) were compared to TMD pain patients perceived to be in the jaw (Table 7 and Table 10). This is encouraging because TMD pain patients do not seem to distinguish between different locations of their TMD pain¹⁵ and dentists have been reported to misinterpret TMD pain perceived as "tooth" pain as being odontogenic in origin³¹.

Participants' enrollment:

To compare our enrolled patients with those enrolled in the development studies for each questionnaire used is difficult because of the minimal description of the population in the relevant articles, but we can compare our patients with notable studies that describe the typical patient with odontogenic pain, such as Nixdorf study designed to measure pain associated with initial orthograde root canal treatment³², and TMD pain, such as Schiffman study about the research diagnostic criteria for TMD³³, performed in similar locations as our study. Comparing the odontogenic pain group with Nixdorf's study and the TMD pain group with the painful TMD group that went to the clinic seeking for care in Schiffman's study, there is a high similarity, despite the lower number of patients in our sample, in all the characteristics except the level of education which is slightly lower in our study. In Table 12 are depicted the comparisons of each characteristic. This similitude means that the patients in our study were correctly selected as typical patients in each group, and likely our data relate to typical cases.

Questionnaires:

The DePaQ demonstrated sensitivity as acceptable as it presented in the development and validation studies, with the 85% value it scored even higher than in the development study. On the other hand, specificity results in our study showed an unacceptable specificity, 11%, completely different than the development study where they found a score of 83%. The DePaQ is widely recommended as a screening test for odontogenic pain.

However, the assessment of referred pain from other sources felt in the teeth was neglected when the questionnaire was developed. In fact, previous studies only compared different types of tooth pain, and did not compare these to other pains in the face/head that could confuse patient and practitioner when describing/giving a diagnosis.

The DePaQ was developed to classify patients into three different groups, depending on their condition, facilitating in this way the assessment of dental treatment needs. It has been seen in this study that there was a high probability of false positive results, in case of a non odontogenic origin of the pain, resulting in a risk of mistreatment.

The use of the DePaQ as a screening instrument for patients complaining of “toothache” can cause confusion to patient and practitioner when it scores positive for odontogenic pain and it is not the real cause of the pain. Given the low specificity score, this questionnaire is not recommended to differentiate between odontogenic pain and TMD pain.

The TMD screener scored 92% in sensitivity, even though it was 7 points less than in the development and validation study, it is still acceptable and expected because the score will always decrease if the questionnaire is primarily tested in the same type of population as where it was developed, which is the case with the TMD screener. The TMD screener has shown to be a good instrument when comparing TMD pain to other conditions, such as healthy patients, non-painful TMDs or headaches. During the development of the TMD screener, odontalgia patients were included; however, due to logistic restrictions in data

collection, TMD was not assessed in this group and, as a result, these data were not analyzed. To improve the specificity score for this questionnaire, and increase its accuracy level, it is recommendable changing something in the questionnaire to improve the screening to separate TMD pain from odontogenic pain.

Item analysis

An item analysis is needed to study how the TMD screener works, where does it fail separating the odontogenic pain patients from the TMD pain patients (giving a score very similar to the TMD pain patients and to the odontogenic pain patients) and where does it help. And it is also needed for the DePaQ to see if there is any question in this questionnaire that could help in the screening, separating the odontogenic pain group from the TMD pain group.

In Table 13 there are included the mean answers to the DePaQ and to the TMD screener for each item, and also Fischer's coefficients for each question for a positive result for odontogenic pain in the DePaQ. Appendix 1 and 2 include the questions of the DePaQ and the TMD screener.

The results of the item analysis are relevant in three questions:

1. Question number 2 in the DePaQ about duration of the pain: it is the only question in this questionnaire that actually differentiates between odontogenic pain and TMD pain, giving a mean (SD) result of 2.3 (1) for odontogenic pain and 4.2 (0.9)

or 4.2 (1.1) for TMD pain not referring or referring to teeth respectively. This means that the way this question is formulated helps to separate the two different pains: odontogenic pain from TMD pain. This question separates the duration between less than a week, 1 to 4 weeks, 4 weeks to 6 months, 6 months to a year and a year or longer. Moreover, if we look at this question only, the results say that 56% (21) of the TMD patients had the pain for a year or longer, whilst the odontogenic pain was suffered for shorter periods of time, between less than a week 23% (8), or 1 to 4 weeks 44% (15).

2. Question number 1 in the TMD screener about the duration of the pain: the results for the three groups are very close, the mean scores (SD) are 1.1 (0.8), 1.4 (0.5) and 1.3 (0.6) for odontogenic pain, TMD pain not referring to teeth, and TMD pain referring to teeth respectively. This shows that the wording of this question confuses the result. The TMD screener distinguishes in pain duration between no pain, from brief to more than a week but stopping, or continuous. The similar scores for the three groups indicate that this question should be changed for something more specific, like what it was seen in question number 2 of DePaQ.
3. Question number 3 in the TMD screener about having pain when chewing hard and tough food: the results in this question help in the confusion between TMD and odontogenic pain, with a mean score of 0.8 (0.4), 1 (0.2) and 1 (0) for odontogenic pain, TMD pain not referring to teeth and TMD pain referring to teeth respectively. This indicates that all the groups have pain when chewing, and that odontogenic

pain patients cannot differentiate between jaw and teeth, and they will answer as having pain in their jaw most of the times.

The information that is given by the TMD screener is important, but it is not enough, because it can be confusing for differentiating TMD pain from odontogenic pain, like we can see in the item analysis, in the TMD screener in question number 1 about duration of pain and in question number 3 about chewing hard or tough foods. We may not need to increase the number of questions in this questionnaire, but to change the wording of these two questions. In question number 2 of DePaQ we can observe how it is possible to distinguish between odontogenic pain and TMD pain with a question about duration: TMD pain tends more to a longer period (between 6 months and a year) of pain while odontogenic pain tends to be a short term (between 1 and 4 weeks).

Limitations:

A limitation of this study is the sample size, because group sizes greater than 50 each are desired. Also, larger subgroups, such as TMD pain referred to teeth, would be helpful in adding confidence that what we observed is not a spurious finding due to the clinic setting from which these patients were recruited. Furthermore on this idea, having a third group that had both odontogenic pain and TMD pain would be helpful in elucidating how these screening questionnaires performed in the presence of comorbid pain conditions.

Another limitation is the patients included and resultant subgroup comparisons that could be assessed. Different subgroup comparisons, such as patients with anterior tooth pain versus posterior tooth pain, because it is conceivable that the TMD questionnaire performs worse with patients experiencing pain from mandibular lower third molars than from superior central incisors based on location of the pain. As well, being able to assess whether patients with primarily a pulpal diagnosis for their pain, such as symptomatic irreversible pulpitis, respond differently than patients with apical diagnoses for their pain, such as necrotic pulp and symptomatic apical periodontitis, would be helpful because these pains have different characteristics and can be perceived differently²⁸.

Future studies

For future studies, it would be interesting to test the TMD screener once the change in the wording in those two problematic questions has occurred, to observe how it performs in separating odontogenic pain patients among the TMD pain patients. Also, it would be interesting to assess how this questionnaire would perform in patients having two comorbid orofacial pain conditions, such as those that were studied here as well as others, because that is how frequently patients present.

Conclusion

Both the DePaQ and the TMD screener have acceptable sensitivity, but unacceptable specificity. The extremely low result in the specificity in the DePaQ means that it is not

suitable for use for diagnostic purposes in populations that are known to have TMD pain because it will misdiagnose people with odontogenic pain, but it can be used in epidemiological studies designed to estimate prevalence rates of tooth pain, because it can be applied the error rates, which is known, to the results to calculate the misclassification. The TMD screener, because it has modest specificity and excellent sensitivity, has potential for use in distinguishing people with odontogenic pain from TMD pain for population-based research and also for diagnostic purposes. Further research is needed to improve the specificity of the TMD screener, such as by adding additional questions that either positively identify or rule out odontogenic pain, to produce a questionnaire suitable for epidemiological research purposes.

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Tables

Table 1: Pulpal and apical diagnostic terminology²

Pulpal diagnosis	Chief complaint	History	Radiographic findings	EPT	Thermal testing	Percussion	Palpation	Mobility	Other
Normal Pulp	None		Normal	R	R, NL				
Reversible pulpitis	Hot &/or cold sensitivity		Normal	R	Exaggerated				Caries, cracks, restorative procedures or trauma
Symptomatic irreversible pulpitis	Lingering hot &/or cold sensitivity	Spontaneous pain	Normal, widened PDL, or ARL	R	Exaggerated L				
Asymptomatic irreversible pulpitis	None		Normal, widened PDL, or ARL	R	R				
Necrotic pulp	Variable	Variable	Normal, widened PDL, or ARL	NR	NR				
Previously treated	Variable		Normal, widened PDL, or ARL	NR	NR (Normally)				Coronal microleakage?
Previously initiated therapy	Variable		Normal, widened PDL, or ARL	NR	NR (Normally)				Coronal microleakage?
Apical diagnosis	Chief complaint	History	Radiographic findings	EPT	Thermal testing	Percussion	Palpation	Mobility	Other
Normal Apical tissues	None		Normal	R	R, NL	NS	NS	Physiologic	
Symptomatic apical periodontitis	Discomfort when biting or chewing	Recent restoration?	Normal, widened PDL, or ARL	R or NR	R or NR	S	S or NS	±	Occlusal trauma
Asymptomatic apical periodontitis	None	Asymptomatic	ARL	NR	NR	NS	NS	±	Necrotic or previously treated/Initiated
Acute apical abscess	Pain and swelling	Coronal microleakage?	Normal, widened PDL, or ARL	NR	NR	S (+++)	S (variable)	Variable	Necrotic or previously treated/Initiated
Chronic apical abscess	Bad taste or "gum bump"	Asymptomatic	ARL	NR	NR	NS	NS	Generally Physiologic	Necrotic or pulpless with Sinus Tract
Condensing osteitis	Asymptomatic or variable pulpal symptoms	Extensive restorative history/crack	Increased radiodensity/Opacity	R or NR	Variable	S or NS	S or NS	Generally Physiologic	Evidence of chronic inflammation
Focal osteopetrosis/periapical osteosclerosis	Asymptomatic	Unrestored tooth or normal pulp	Increased radiodensity/Opacity	R	R, NL	NS	NS	Physiologic	Non-restored tooth with normal findings

EPT: Electric pulp tester, PDL: Periodontal ligament, ARL: Apical radiolucency, R: Response, NR: Non response, L: Linger NL: Not linger, S: Sensitive, NS: Not sensitive

Table 2: Non odontogenic tooth pain^{18, 31, 32}

Types	Condition	Characteristics	Investigations
Musculoskeletal	TMDs (From DC/TMD): –Myofascial pain –Arthralgia (pain but no DJD) Sinus and/or nasal mucosal origin Salivary gland pain	Chronic dull ache following muscular distribution Muscular dysfunction	Muscle tenderness Imaging normal Diagnostic block no effect Radiograph or CT may show bone morphology changes MRI may show disc abnormality
Neurovascular	Primary Headache Other Primary Headaches – Cluster Headache – Paroxysmal Hemicrania – Hemicrania Continua – SUNCT – Cough / Stabbing / Exertional / Hypnic HA	Throbbing, usually unilateral, intermittent lasting 4-72 hours. Photophobia, phonophobia, nausea or vomits may be present	Muscle palpation normal. Image normal Blood tests normal
Neuropathic	– Neuralgia (classic Tic Douloureux) – Neuritis – Neuroma – Neuropathy (idiopathic & deafferentation related pains) – Persistent dentoalveolar pain – Sympathetically mediated pain	Burning, constant. Sharp shooting. Dull, constant or almost constant. Trigeminal nerve distribution	Neuropathic pain is a diagnosis of exclusion: • Thorough dental exam & imaging • Brain MRI with contrast, to rule out an intracranial lesion and look for nerve root impingement, as well as elsewhere • Consider investigations of demyelinating disorders, such as MS (autoimmune) • Rule out osteomyelitis of the jaw – bone scan
Pathological	– Oral squamous cell carcinoma – Brain tumor	Usually painless unless advanced	Abnormal CT
Psychogenic	Abnormal often exaggerate description of symptoms Abnormal response to treatment		Objective tests normal Subjective tests atypical Known previous psychiatric history and treatment

Table 3: Patterns of pain referral to teeth and associated regions

(Adapted from Wright, 2000)¹⁶.

Source of referred pain	Site of perceived referred pain					
	Frequency					
	Maxillary molars	Maxillary premolars	Maxillary anterior teeth	Mandibular molars	Mandibular premolars	Mandibular anterior teeth
Temporalis muscle	3	3	2	1	1	1
Temporomandibular joint	2	1	1	2	0	0
Masseter muscle	25	11	4	40	8	8
Lateral pterygoid area	6	6	2	1	2	2
Medial pterygoid area	0	0	2	0	0	0
Coronoid process	0	0	0	1	0	0
Sternocleidomastoid muscle	0	0	0	1	1	1
Anterior digastric muscle	0	0	0	0	1	1
Posterior digastric muscle	0	0	0	1	0	0

Of the 230 patients with pain referral, a total of 140 had referral to teeth regions and were included in this table.

Table 4: Diagnostic criteria for the patients recruited^{13, 28}

Group	Diagnostic criteria
<u>Odontogenic pain group</u>	<p style="text-align: center;">Symptomatic irreversible pulpitis</p> <ul style="list-style-type: none"> - Lingering thermal pain, <li style="text-align: center;">AND/OR - Spontaneous pain <li style="text-align: center;">AND/OR - Referred pain.
	<p style="text-align: center;">Symptomatic apical periodontitis</p> <ul style="list-style-type: none"> - Painful response to biting and/or percussion or palpation. - It might or might not be associated with an apical radiolucent area
	<p style="text-align: center;">Acute apical abscess</p> <ul style="list-style-type: none"> - Rapid onset - Spontaneous pain - Tenderness of the tooth to pressure - Pus formation - Swelling of associated tissues
<u>TMD pain group</u>	<p style="text-align: center;">Myalgia</p> <ul style="list-style-type: none"> - <u>Pain History:</u> <ol style="list-style-type: none"> 1. Pain in the face, jaw, temple, in front of the ear, or in the ear in the last 30 days. 2. Pain changed with jaw movement, function or parafunction. <p style="text-align: center;">PLUS</p> - <u>Pain Report on Examination:</u> <ol style="list-style-type: none"> 1. Palpation results in report of FAMILIAR pain (1 kilogram) <ol style="list-style-type: none"> a. Temporalis muscle: posterior, middle, and anterior, or b. Masseter muscle: origin, body, and insertion <p style="text-align: center;">OR</p> 2. Opening movements results in FAMILIAR pain (temporalis or masseter muscles) <ol style="list-style-type: none"> a. Maximum unassisted, or b. Maximum assisted opening <ul style="list-style-type: none"> • Familiar pain is pain that is similar or like their pain complaint
	<p style="text-align: center;">Myofascial pain with referral</p> <ul style="list-style-type: none"> - <u>Pain History:</u> location of pain confirmed during exam Same as Myalgia <li style="text-align: center;">AND - <u>Pain Report on Examination:</u> Same as Myalgia <li style="text-align: center;">AND Report of pain with palpation at a site beyond the boundary of the muscle(s) being palpated.
	<p style="text-align: center;">Arthralgia</p> <ul style="list-style-type: none"> - <u>Pain History:</u> location of pain confirmed during exam <ol style="list-style-type: none"> 1. Pain in the face, jaw, temple, in front of the ear, or in the ear in the last 30 days.

	<p>2. Pain changed with jaw movement, function or parafunction. PLUS</p> <p>- <u>Pain Report on Examination:</u></p> <p>1. Palpation of any joint site results in FAMILIAR joint pain</p> <p>a. Lateral pole with fingertip applying (0.5 kilogram), or b. Around the lateral pole (1 kilogram).</p> <p>OR</p> <p>2. Range of motion results in FAMILIAR joint pain</p> <p>a. Maximum unassisted opening, or b. Maximum assisted opening, or c. Lateral or protrusive movements d. Familiar pain is pain that is similar or like their pain complaint</p>
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Table 5: Characteristics of the 71 patients enrolled in the study

	Odontogenic pain n=34	TMD pain n=37
	Mean (SD) or % (n)	
Age in years	49 (12)	45 (18)
Gender: female	53 (18)	86 (32)
Ethnicity: non-Hispanic	100 (34)	97 (36)
Race: white	79 (27)	92 (34)
Income \geq \$30,000	85 (29)	43 (16)
Dental insurance: yes	94 (32)	81 (30)
Level of education: college degree or more	53 (18)	46 (17)

Table 6: AIM 1.0: DePaQ
Odontogenic pain versus all TMD pain

		Odontogenic pain Gold standard		
		Odontogenic pain	TMD pain (all)	Total
DePaQ	Positive	29	33	62
	Negative	5	4	9
	Total	34	37	71
Point estimate (95% CI)		Sensitivity= 85% (69% to 95%)		
		Specificity= 11% (3% to 25%)		
		Positive Predictive Value= 47% (34% to 60%)		
		Negative Predictive Value= 44% (14% to 79%)		

Table 7: AIM 1.1: DePaQ
Odontogenic pain versus TMD pain not referring to teeth only

		Odontogenic pain Gold standard		
		Odontogenic pain	TMD (not referring to teeth only)	Total
DePaQ	Positive	29	22	51
	Negative	5	3	8
	Total	34	25	59
Point estimate (95% CI)		Sensitivity= 85% (69% to 95%)		
		Specificity= 12% (3% to 31%)		
		Positive Predictive Value= 57% (42% to 71%)		
		Negative Predictive Value= 37% (9% to 75%)		

Table 8: AIM 1.2: DePaQ
Odontogenic pain versus TMD pain referring to teeth only

		Odontogenic pain Gold standard		
		Odontogenic pain	TMD (referring to teeth only)	Total
DePaQ	Positive	29	11	40
	Negative	5	1	6
	Total	34	12	46
Point estimate (95% CI)	Sensitivity= 85% (69% to 95%)			
	Specificity= 8% (0.2% to 38%)			
	Positive Predictive Value= 72% (56% to 85%)			
	Negative Predictive Value= 17% (0.4% to 64%)			

Table 9: AIM 2.0: TMD Screener
All TMD pain versus Odontogenic pain

		TMD pain Gold standard		
		TMD (all)	Odontogenic pain	Total
TMD Screener	Positive	34	14	48
	Negative	3	20	23
	Total	37	34	71
Point estimate (95% CI)	Sensitivity= 92% (78% to 98%)			
	Specificity= 59% (41% to 75%)			
	Positive Predictive Value= 71% (56% to 83%)			
	Negative Predictive Value= 87% (66% to 97%)			

Table 10: AIM 2.1: TMD Screener
TMD pain not referring to teeth only versus Odontogenic pain

		TMD pain Gold standard		
		TMD (Not referring to teeth only)	Odontogenic pain	Total
TMD Screener	Positive	23	14	37
	Negative	2	20	22
	Total	25	34	59
Point estimate		Sensitivity= 92% (74% to 99%)		
(95% CI)		Specificity= 59% (41% to 75%)		
		Positive Predictive Value= 62% (45% to 77%)		
		Negative Predictive Value= 91% (71% to 99%)		

Table 11: AIM 2.2: TMD Screener
TMD pain referring to teeth only versus Odontogenic pain

		TMD pain Gold standard		
		TMD (Referring to teeth only)	Odontogenic pain	Total
TMD Screener	Positive	11	14	25
	Negative	1	20	21
	Total	12	34	46
Point estimate		Sensitivity= 92% (61% to 100%)		
(95% CI)		Specificity= 59% (41% to 75%)		
		Positive Predictive Value= 44% (24% to 65%)		
		Negative Predictive Value= 95% (76% to 100%)		

Table 12: Comparison of the sample with other populations

	Nixdorf 2012	Schiffman 2010	Fonseca-Alonso	
	Odontogenic pain n=708	TMD pain n=141	Odontogenic pain n=34	TMD pain n=37
	Mean (SD) or % (n)			
Age in years	48 (13)	39 (15)	49 (12)	45 (18)
Gender: female	59	90	53 (18)	86 (32)
Ethnicity: non-Hispanic	96	-	100 (34)	97 (36)
Race: white	91	93	79 (27)	92 (34)
Income \geq \$30,000	84	59*	85 (29)	43 (16)
Level of education: college degree or more	81	81	53 (18)	46 (17)

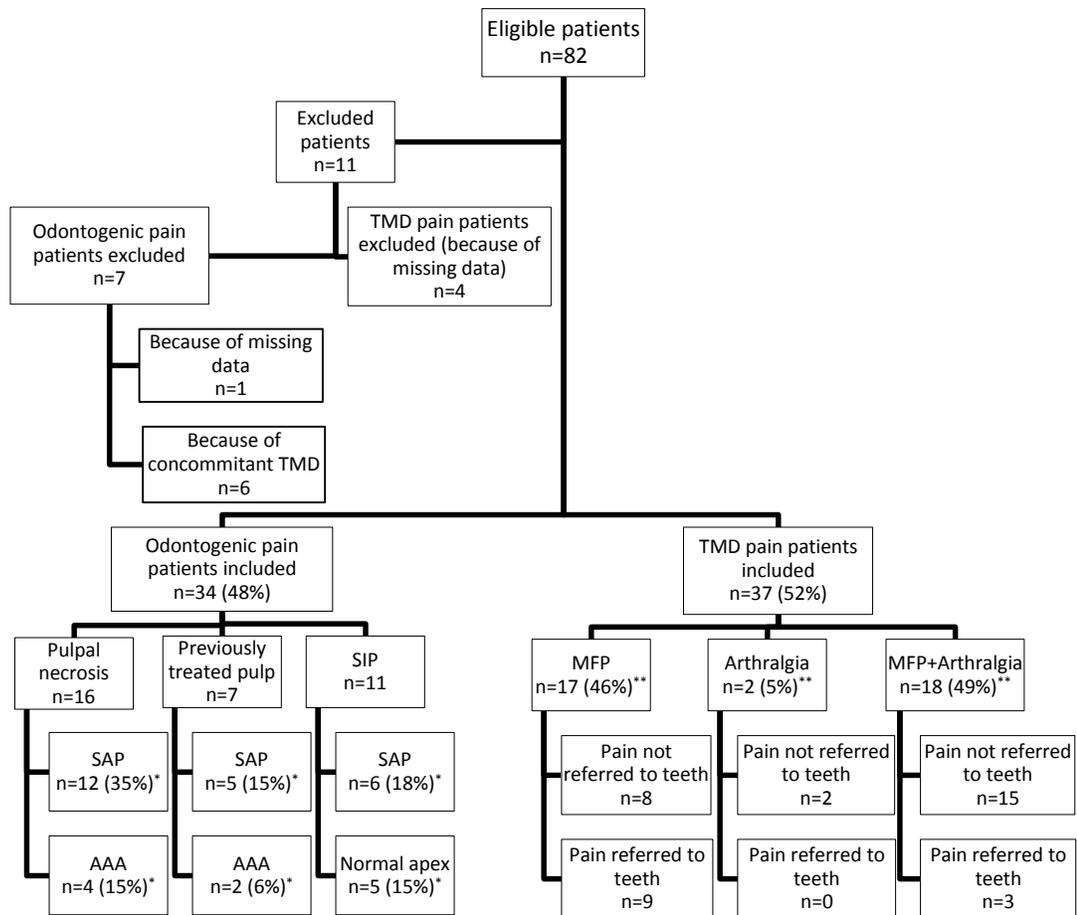
*Income \geq \$50,000

Table 13: DePaQ and TMD screener item analysis

<i>Question number: topic of the question</i>	<i>Fischer's coefficient</i>	<i>Score in the questionnaire</i>	<i>Odontogenic pain</i>	<i>TMD pain Not ref. to teeth</i>	<i>TMD pain Referring to teeth</i>
		Min-Max	Mean (SD)		
<i>DePaQ</i>					
Question 1: Location	7.72	0-2	1.3 (0.5)	0.2 (0.5)	1.3 (0.6)
Question 2: Duration	3.79	1-5	2.3 (1)	4.2 (0.9)	4.2 (1.1)
Question 3: Intensity	4.28	1-5	3 (1.2)	3.2 (1.2)	3.2 (1.1)
Question 4: Periodicity	3.79	1-2	1.3 (0.5)	1.4 (0.5)	1.5 (0.5)
Question 5: Radiation	0.64	1-4	2.6 (0.9)	3 (0.9)	2.8 (0.8)
Question 6: Chewing on side	1.13	1-5	4 (1)	3.2 (1.2)	3.4 (1.2)
Question 7: Cold sensitivity	3.34	1-5	3.8 (0.8)	3.4 (0.7)	3.6 (0.9)
Question 8: Gum swelling	0.29	1-5	2 (1.2)	1.2 (0.5)	1.7 (1)
Question 9: Loose tooth	0.23	1-4	1.2 (0.7)	1.1 (0.4)	1.4 (1)
Question 10: Difficulty to swallow	-0.72	1-5	1 (0)	1.2 (0.6)	1.7 (1)
Question 11: Sticking out	0.05	1-5	1.6 (1.1)	1 (0)	1.3 (0.9)
Question 12: Difficulty sleeping	2.72	1-5	2.6 (1.2)	2.3 (1.4)	2.2 (1.3)
Question 13a: Exhausting	0.03	0-1	0.3 (0.5)	0.4 (0.5)	0.7 (0.5)
Question 13b: Electric	-4.44	0-1	0.2 (0.4)	0.1 (0.3)	0.2 (0.4)
Question 13c: Pulling	-5.28	0-1	0.2 (0.4)	0.3 (0.5)	0.3 (0.5)
Question 13d: Numb	4.88	0-1	0.3 (0.5)	0.2 (0.4)	0.3 (0.5)
<i>TMD screener</i>					
Question 1: Pain duration	-	0-2	1.1 (0.8)	1.4 (0.5)	1.3 (0.6)
Question 2: Jaw stiffness	-	0-1	0.3 (0.5)	0.8 (0.4)	0.9 (0.3)
Question 3: Chewing food	-	0-1	0.8 (0.4)	1 (0.2)	1 (0)
Question 4: Opening mouth	-	0-1	0.1 (0.3)	0.9 (0.3)	0.7 (0.4)
Question 5: Clenching	-	0-1	0.4 (0.5)	0.9 (0.3)	0.9 (0.3)
Question 6: Talking	-	0-1	0.1 (0.3)	0.8 (0.4)	0.4 (0.5)

Figures

Figure 1: Patients enrolled



SAP: Symptomatic apical periodontitis, SIP: Symptomatic irreversible pulpitis, AAA: Acute apical abscess, MFP: Myofascial pain.

*Percentage from the Odontogenic pain group only. **Percentage from the TMD pain group only

Appendix 1: Dental Pain Questionnaire

You may tick more than 1 answer in the list below

1. Where in the mouth and/or face region do you feel the pain you currently have?	tooth/teeth	<input type="checkbox"/>
	gums	<input type="checkbox"/>
	tongue	<input type="checkbox"/>
	palate	<input type="checkbox"/>
	floor of mouth	<input type="checkbox"/>
	inside of cheek	<input type="checkbox"/>
	jaw	<input type="checkbox"/>
	jaw joint	<input type="checkbox"/>
	others - please specify:	

Please tick only one answer for questions 2 to 12

Chose one word from the list below and make a tick in one box only		
2. How long have you had your current pain?	less than 1 week	<input type="checkbox"/>
	1 week or longer, but less than 4 weeks	<input type="checkbox"/>
	4 weeks or longer, but less than 6 months	<input type="checkbox"/>
	6 months or longer, but less than 1 year	<input type="checkbox"/>
	1 year or longer	<input type="checkbox"/>

Chose one word from the list below and make a tick in one box only		
3. How would you describe the intensity of your current pain AT ITS WORST ?	Mild	<input type="checkbox"/>
	Discomforting	<input type="checkbox"/>
	Distressing	<input type="checkbox"/>
	Horrible	<input type="checkbox"/>
	Excruciating	<input type="checkbox"/>

Choose either episodic or continuous and place one tick		
4. Thinking about your current pain, how would you describe its pattern of occurrence?	Episodic: It comes and goes	<input type="checkbox"/>
	Continuous: It's constant	<input type="checkbox"/>

	Tick one box only				
	Not at all	A small extent	Moderate extent	A large extent	Complete extent
5. Please indicate the extent to which your pain radiates to the surrounding area:	<input type="checkbox"/>				

	Tick one box only				
	Complete extent	A large extent	Moderate extent	A small extent	Not at all
6. Please indicate the extent to which it is worse when you chew or eat on the side of your mouth with the pain:	<input type="checkbox"/>				

	Tick one box only				
	Makes it a lot more painful	Makes it a little more painful	No effect	Makes it a little better	Makes it a lot better
7. Please indicate the effect of eating or drinking something COLD:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

	Only tick one box in each row				
Please indicate the extent to which	Not at all	A small extent	Moderate extent	A large extent	Complete extent
8. your gums have been swollen now or have been swollen recently:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. the tooth where you have the pain from feels loose:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. it is difficult to swallow now or has been difficult to swallow recently:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. the tooth where you have the pain from feels like it is sticking out a little:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

	Tick one box only				
	Full extent	A large extent	Moderate extent	A small extent	Not at all
12. Please indicate the extent to which you have had difficulties with sleeping:	<input type="checkbox"/>				

	Tick either yes or no in each row	
	Yes	No
13. Which of the following word(s), if any, would you use to describe your current pain?		
Exhausting	<input type="checkbox"/>	<input type="checkbox"/>
Electric shocks	<input type="checkbox"/>	<input type="checkbox"/>
Pulling	<input type="checkbox"/>	<input type="checkbox"/>
Numb	<input type="checkbox"/>	<input type="checkbox"/>

14. What other word(s), if any, would you use to describe your current pain? Please write in the space below:

Appendix 2: TMD screener

Question 1. In the last 30 days, on average, how long did any pain last in your jaw or temple area on either side?

a) No pain	b) From very brief to more than a week but it does stop	c) Continuous
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Question 2. In the last 30 days, have you had pain or stiffness in your jaw on awakening?

a) No	b) Yes
<input type="checkbox"/>	<input type="checkbox"/>

Questions 3-6.

In the last 30 days, did the following activities change any pain (that is, make it better OR make it worse) in your jaw or temple region on either side?

	a) No	b) Yes
3. Chewing hard or tough food	<input type="checkbox"/>	<input type="checkbox"/>
4. Opening your mouth or moving your jaw forward or to the side	<input type="checkbox"/>	<input type="checkbox"/>
5. Jaw habits such as holding teeth together, clenching/grinding, or chewing gum	<input type="checkbox"/>	<input type="checkbox"/>
6. Other jaw activities such as talking, kissing, or yawning	<input type="checkbox"/>	<input type="checkbox"/>