Development and Validation of a Screening Checklist for Temporomandibular Disorders

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Aims: *To develop and validate a short screening tool for temporomandibular disorders (TMD) from the comprehensive Research Diagnostic Criteria for TMD (RDC/TMD) assessment.* ***Methods:*** *Complete RDC/TMD assessments of four subject groups (96 TMD; 102 dental pain; 68 headache; 115 no-pain patients) were compared. Classification tree and multiple logistic regression analyses were utilized to develop the tool. To test external validity, a further 54 TMD and 51 non-TMD subjects whose diagnoses had been established by RDC/TMD assessment were reassessed with the new screening tool. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and likelihood ratios (LRs) were calculated for the screening tool in the validation set of subjects.* ***Results:*** *A short TMD checklist was developed. This screening instrument had sensitivity of 94.4% (95% confidence intervals [CI], 84.9% to 98.1%), specificity of 94.1% (95% CI, 84.1% to 98%), PPV of 94.4% (95% CI, 84.9% to 98.1%), NPV of 94.1% (95% CI, 84.1% to 98%), and positive and negative LRs of 16.056 (95% CI, 5.346 to 48.219) and 0.059 (95% CI, 0.02 to 0.178) in an independent validation set.* ***Conclusion:*** *A short TMD screening checklist with high validity has been developed. This checklist may have good utility in general practice as a primary screening tool for TMD.* J OROFAC PAIN 2011;25:210–222

Key words: Research Diagnostic Criteria for TMD, screening, temporomandibular disorders, validity

Signs and symptoms of temporomandibular disorders (TMD) have been reported in the literature. Of these signs and symptoms, clinicians are in general agreement that TMD has three clinical features: orofacial pain, temporomandibular joint sounds, and limitations in mandibular movement.[1] Nevertheless, it is still a challenge for clinicians to distinguish painful TMD from some other orofacial pain disorders such as primary headache and dental pain (pain from pulpal, periodontal, and oral mucosal diseases) because orofacial pain disorders often produce many similar or overlapping symptoms.[2,3]

The estimates of prevalence of TMD vary widely.[4–9] This is largely because of the variety of diagnostic criteria for TMD used in different studies. Another reason for the prevalence variation is bias due to the lack of appropriate study design, especially with the use of nonrepresentative groups from clinical populations.[4] Although the population prevalence of symptoms and signs of TMD has been

reported to range from 6% to 93%, only 3.6% to 7% of the general population have been estimated to be in need of treatment.[10] Therefore, to improve the quality and validity of diagnostic estimates, it is necessary to develop and apply a standardized diagnostic test that may be used for both epidemiologic purposes and as a clinical screening tool. In clinical practice, this would help to eliminate unnecessary examinations and possible unnecessary treatment.[11]

Over the years, many diagnostic tests have been developed for TMD. The diagnostic tools include self-report questionnaires,[12] clinical examination (muscle palpation, joint sound assessment, and mandibular movement measurement),[13–17] and imaging tests (panoramic radiographs, tomography, magnetic resonance imaging, arthrography, and ultrasonography).[18–29] For a screening test to be useful, it needs to have not only adequate sensitivity and specificity, but also should meet a set of criteria such as being short, valid, and inexpensive.[30]

The Research Diagnostic Criteria for TMD (RDC/TMD), which consist of a clinical physical examination and a self-report questionnaire, was developed for research purposes by an international consortium.[31] This diagnostic method has been translated into 18 languages and accepted by a 45-member consortium of RDC/TMD-based international researchers who continue to assess its reliability and validity.[32] Furthermore, it is being used clinically to assess TMD patients.[9,33–35] The most important advantage of this system is that it introduced a "dual axis" concept for the classification and assessment of TMD. It recognized that not only do physical conditions (ie, axis I factors) contribute to these disorders, but also psychosocial factors (axis II factors).[10] This system offers standardized diagnostic criteria for gathering relevant data and makes possible comparison of findings among diverse clinical investigators.[31] From a screening viewpoint, a rational reduction of the RDC/TMD diagnostic tool could potentially provide a reliable and valid screening assessment for TMD.

The comprehensive RDC/TMD assessment typically takes 20 to 30 minutes to complete and therefore is not suitable for screening patients for TMD in general dental and medical practices. Additionally, in recent studies, it was found that reliability and validity of the RDC/TMD was poor to marginally fair for some subgroup TMD diagnoses such as osteoarthrosis and disc displacement without reduction without limited opening.[36,37]

The aim of the present study was to develop and validate a short screening tool for TMD from the RDC/TMD assessment. To be of clinical use as a screening tool, such an instrument should discriminate TMD patients from common head and orofacial pain complaints such as headache, dental pain, and non-pain patients in general medical and dental practices.

Materials and Methods

Subject Selection for Screening Model Development

This study was approved by the Human Research Ethics Committee of the Sydney West Area Health Service and The University of Sydney, and informed consent was obtained from all participants. Of a total of 416 subjects who were invited and participated in this study, 35 were excluded (see below).

TMD Subjects. Ninety-six patients who had been diagnosed with TMD by completing the RDC/TMD at the Orofacial Pain Clinic, Centre for Oral Health, Westmead Hospital, during the period December 2006 to December 2007 were included. The examiners were calibrated and experienced in RDC/TMD assessments.

Dental Pain, No TMD Subjects. One hundred twenty-five patients seeking emergency dental treatment between July 2007 and August 2007 at the Acute Care Clinic at the Centre for Oral Health completed the RDC/TMD assessment. Of the 125, 8 patients without a dental diagnosis and 15 patients with a concurrent TMD diagnosis established by the RDC/TMD assessment were excluded from the study.

Headache, No TMD Subjects. Seventy-two subjects were recruited from two sources. Current patients with neurologist-diagnosed headache were recruited from the Department of Neurology, Westmead Hospital, and staff and students of Westmead Hospital between October 2007 and December 2007. The subjects satisfied the International Headache Society criteria for primary headaches. Recruitment techniques included email and posting of flyers. All 72 headache patients completed the RDC/TMD assessment. Four individuals were excluded because they had a concurrent TMD diagnosis based on RDC/TMD assessment.

Non-pain, No TMD Subjects. One hundred twenty-three pain-free subjects were selected from staff and students of Westmead Hospital as well as patients who attended the general dental clinic at the Centre for Oral Health during July and August 2007. All the non-pain subjects completed the RDC/TMD assessment. Of the 123 subjects, eight subjects with a concurrent TMD diagnosis established by the RDC/TMD were excluded from the analysis.

Subject Selection for Validation of the Screening Model

The TMD Validation Set. This comprised the 54 additional patients who were diagnosed with TMD by the RDC/TMD in 2008 (19 males, 35 females, mean age ± SD was 45.8 ± 15.0 years).

The non-TMD Control Validation Set. This consisted of 51 patients randomly selected from three types of patients (dental pain, headache, and non-pain patients) who were also recruited from the above-mentioned sources between September and October 2008 and who were not TMD positive at RDC/TMD assessment (23 males, 28 females, mean age 44.8 ± 17.6 years).

Data Collection

All subjects underwent a complete assessment using the RDC/TMD, including a history questionnaire and clinical examination. The RDC/TMD was the gold standard in this experiment. All subjects in the control group were examined by a single calibrated examiner. The clinical examination of the TMD group was performed by calibrated clinicians in the Orofacial Pain Clinic. The data from the history questionnaire and clinical examination were manually transferred to a computer. Diagnoses were assigned according to the criteria of the RDC/TMD.

Data Preparation

A total of 151 variables were derived from the RDC/TMD history questionnaire and clinical examination (Table 1) as outlined by Dworkin and Le Resche.[31] The variables were sorted into nine functional groups as follows: *(1)* general health, oral health, and orofacial pain in last month (V1–V3, V74, V75); *(2)* pain related disability (V4–V13); *(3)* jaw function (V14, V16–V25, V27, V29–V41); *(4)* distress (V42-V73); *(5)* sociodemographic (V76–V79, V81, V82, V85, V86); *(6)* jaw movement measurements (V91, V92, V95, V98, V109, V112, V115, V119); *(7)* movement pain (V93, V94, V96, V97, V110, V111,V113, V114, V116, V117); *(8)* joint sounds (V99, V101, V103, V105, V120–V125; and *(9)* pain palpation (V126–V151).

The variables (V5–V13, V15, V26, V28, V80, V83, V84, V100, V102, V104, V106–V108, V118) that were generated from dependent questions were not used in constructing predictive models as they were not applicable for many subjects. For example, if subjects answered "no" to the question "Have you ever had your jaw lock or catch so that it won't open all the way?" then they don't need to answer the next question "Was this limitation in jaw opening severe enough to interfere with your ability to eat?" (V15). When no joint sound was detected in a subject, the measurements of mouth opening and closing were missing. Therefore, these variables (V100, V102, V104, and V106) were not used to construct any predictive models.

Statistical Analyses

Screening Tool Development. The statistical package SPSS version 17.0 for Windows (SPSS, IBM) was used to analyze the data. Two-tailed tests with a significance level of 5% were used throughout. S-PLUS version 8 was used to perform the classification tree analysis. Development of the screening tool proceeded in a series of steps that sought to exclude subjects as potential sufferers of TMD based on their responses to a minimal number of questions. The variables V1–V86 comprising the first five functional groups all come from the history questionnaire a subject completes without assistance from any clinician. The remaining variables V87–V151 that make up the final four functional groups all require clinical assessment and are therefore more "expensive" than the history variables in terms of time and cost.

Step 1 in the development of the screening tool was a classification tree analysis of TMD versus non-TMD based only on eligible variables from the history questionnaire (V1–V86). Inspection of the initial nodes in the tree identified a large subset of 126 subjects in whom TMD was not present. These non-TMD subjects were identified by their response to just two questions and were excluded from further analysis.

Step 2 of the screening tool development was a multiple logistic regression analysis of the remaining 255 potential TMD subjects. The candidate variables were again those eligible from the history questionnaire (V1–V86). Backward stepwise variable selection was used to identify the independent predictors of TMD among this set of variables, which did not require a clinical examination. A simple scoring system for predicting TMD was developed based on the six independent predictor variables in the best-fitting model. This score was used to assign further subjects to the predicted non-TMD group.

Step 3 of the screening tool development was a multiple logistic regression analysis of the remaining potential TMD subjects that used eligible variables from the clinical examination (V87–V151). Backward stepwise variable selection was used to identify the independent predictors of TMD among this set of clinical examination variables and a simple scoring system for predicted TMD developed for the final classification of the remaining subjects.

Table 1 Original Variables and No. of Subjects Responding

History questionnaire		
Variable		n
V1	Self perception of general health	381
V2	Self perception of oral health	381
V3	Orofacial pain experience in the past month	381
V4	The first time facial pain happened	191
V5	Frequency of pain	191
V6	Treatment sought	191
V7	Intensity of present pain	191
V8	Intensity of worst pain in the past 6 months	191
V9	Intensity of usual pain in the past 6 months	191
V10	Days of activity limitation due to the pain in the past 6 months	191
V11	Severity of pain interference with daily activity in the past 6 months	191
V12	Severity of recreational, social, and family activity–related disability in the past 6 months	191
V13	Severity of work-related disabilty in the past 6 months	191
V14	Jaw lock	381
V15	Ability interference to eat because of jaw lock	102
V16	Jaw click	381
V17	Jaw grating or grinding noise	381
V18	Grating or grinding teeth during sleep	381
V19	Grinding teeth or clench jaw during the day	381
V20	Jaw ache or feel stiff when wake up	381
V21	Noise or ring in the ear	381
V22	Bite uncomfortable	381
V23	Systemic arthritic disease	381
V24	Family member who has systemic arthritic disease	381
V25	Swollen and painful joint	381
V26	Persistent pain on joint at least one year	89
V27	Recent injury on face and jaw	381
V28	Jaw pain before injury	24
V29	Headaches and migraines	381
V30	Chewing limit because of jaw problem	381
V31	Drinking limit because of jaw problem	381
V32	Exercising limit because of jaw problem	381
V33	Eating hard food limit because of jaw problem	381
V34	Eating soft food limit because of jaw problem	381
V35	Smiling/laughing limit because of jaw problem	381
V36	Sexual activity limit because of jaw problem	381
V37	Cleaning teeth or face limit because of jaw problem	381
V38	Yawning limit because of jaw problem	381
V39	Swallowing limit because of jaw problem	381
V40	Talking limit because of jaw problem	381
V41	Having usual facial appearance	381

Table 1 *(continued)*

History questionnaire		
Variable		n
V42	In the last month, distress by headaches	381
V43	In the last month, distress by losing sexual interest	381
V44	In the last month, distress by faintness or dizziness	381
V45	In the last month, distress by pains in the heart or chest	381
V46	In the last month, distress by feeling low in energy or slowed down	381
V47	In the last month, distress by thoughts of death or dying	381
V48	In the last month, distress by poor appetites	381
V49	In the last month, distress by crying easily	381
V50	In the last month, distress by blaming yourself for things	381
V51	In the last month, distress by pains in the lower back	381
V52	In the last month, distress by feeling lonely	381
V53	In the last month, distress by feeling blue	381
V54	In the last month, distress by worrying too much about things	381
V55	In the last month, distress by feeling no interest in things	381
V56	In the last month, distress by nausea or upset stomach	381
V57	In the last month, distress by soreness of your muscles	381
V58	In the last month, distress by trouble falling asleep	381
V59	In the last month, distress by trouble getting breath	381
V60	In the last month, distress by hot or cold spells	381
V61	In the last month, distress by numbness or tingling in parts of body	381
V62	In the last month, distress by a lump in throat	381
V63	In the last month, distress by feeling hopeless about the future	381
V64	In the last month, distress by feeling weak in parts of body	381
V65	In the last month, distress by heavy feelings in arms or legs	381
V66	In the last month, distress by thoughts of ending life	381
V67	In the last month, distress by overeating	381
V68	In the last month, distress by awakening in the early morning	381
V69	In the last month, distress by restless or disturbed sleep	381
V70	In the last month, distress by feeling everything is an effort	381

Table 1 *(continued)*

History questionnaire		
Variable		n
V71	In the last month, distress by feelings of worthlessness	381
V72	In the last month, distress by feeling of being caught or trapped	381
V73	In the last month, distress by feelings of guilt	381
V74	Self care of general health	381
V75	Self care of oral health	381
V76	Age	381
V77	Gender	381
V78	Country of birth	381
V79	Does this country best represent your race, national origin, or ancestry	381
V80	Country of national origin or ancestry	57
V81	Education level	381
V82	Work in the past 2 weeks	381
V83	Have job or business	211
V84	Looking for a job or lay off	184
V85	Marital status	381
V86	Income	381
V87	Painful side of face	381
V88	Painful area on right side	381
V89	Painful area on left side	381
V90	Opening pattern	381
V91	Unassisted opening without pain	381
V92	Maximum unassisted opening	381
V93	Pain on muscle when doing maximum unassisted opening	381
V94	Pain on jaw joint when doing maximum unassisted opening	381
V95	Maximum assisted opening	381
V96	Pain on muscle when doing maximum assisted opening	381
V97	Pain on jaw joint when doing maximum assisted opening	381
V98	Vertical incisal overlap	381
V99	Right joint sound when opening	381
V100	Measurement of right side opening sound	49
V101	Left joint sound when opening	381
V102	Measurement of left side opening sound	47
V103	Right joint sound when closing	381
V104	Measurement of right side closing sound	21
V105	Left joint sound when closing	381
V106	Measurement of left side closing sound	22
V107	Reciprocal click eliminated on protrusive opening (right)	55
V108	Reciprocal click eliminated on protrusive opening (left)	57

Table 1 *(continued)*

History questionnaire		
Variable		n
V109	Right lateral excursion	381
V110	Pain on muscle when doing right lateral excursion	381
V111	Pain on jaw joint when doing right lateral excursion	381
V112	Left lateral excursion	381
V113	Pain on muscles when doing left lateral excursion	381
V114	Pain on jaw joint when doing left lateral excursion	381
V115	Protrusion	381
V116	Pain on muscles when doing protrusion	381
V117	Pain on jaw joint when doing protrusion	381
V118	Midline deviation (side)	225
V119	Midline deviation (value)	381
V120	Right joint sound on right excursion	381
V121	Right joint sound on left excursion	381
V122	Right joint sound on protrusion	381
V123	Left joint sound on right excursion	381
V124	Left joint sound on left excursion	381
V125	Left joint sound on protrusion	381
V126	Right temporalis pain (posterior)	381
V127	Left temporalis pain (posterior)	381
V128	Right temporalis pain (middle)	381
V129	Left temporalis pain (middle)	381
V130	Right temporalis pain (anterior)	381
V131	Left temporalis pain (anterior)	381
V132	Right masseter pain (superior)	381
V133	Left masseter pain (superior)	381
V134	Right masseter pain (middle)	381
V135	Left masseter pain (middle)	381
V136	Right masseter pain (interior)	381
V137	Left masseter pain (interior)	381
V138	Right posterior mandibular region pain	381
V139	Left posterior mandibular region pain	381
V140	Right submandibular region pain	381
V141	Left submandibular region pain	381
V142	Right lateral pole pain	381
V143	Left lateral pole pain	381
V144	Right posterior attachment pain	381
V145	Left posterior attachment pain	381
V146	Right lateral pterygoid area	381
V147	Left lateral pterygoid area	381
V148	Right tendon of temporalis	381
V149	Left tendon of temporalis	381
V150	Right side of tongue	381
V151	Left side of tongue	381

Table 2 Demographic Characteristics of 381 Subjects Used to Develop Screening Tool; No. (%)

	TMD (n = 96)	Dental pain (n = 102)	Headache (n = 68)	Non-pain (n = 115)
Age (mean ± SD)	43.1 ± 16.8	43.2 ± 16.3	45.7 ± 14.7	27.4 ± 6.5
Gender				
Male	27 (28.1)	47 (46.1)	23 (33.8)	61 (53.0)
Female	69 (71.9)	55 (53.9)	45 (66.2)	54 (47.0)
Country of birth				
Australian born	51 (53.1)	51 (50.0)	35 (51.5)	50 (43.5)
Overseas	45 (46.9)	51 (50.0)	33 (48.5)	65 (56.5)
Education level				
None	1 (1.0)	4 (3.9)	4 (5.9)	0 (0.0)
Primary school	4 (4.2)	6 (5.9)	1 (1.5)	3 (2.6)
High school	72 (75.0)	77 (75.5)	32 (47.1)	16 (13.9)
University	19 (19.8)	15 (14.7)	31 (45.6)	96 (83.5)
Marital status				
Married, spouse in household	34 (35.4)	43 (42.2)	41 (60.3)	21 (18.3)
Married, spouse not in household	6 (6.3)	0 (0.0)	0 (0.0)	3 (2.6)
Widowed	8 (8.3)	3 (2.9)	2 (2.9)	2 (1.7)
Divorced	7 (7.3)	14 (13.7)	4 (5.9)	1 (0.9)
Separated	0 (0.0)	6 (5.9)	3 (4.4)	0 (0.0)
Never married	41 (42.7)	36 (35.3)	18 (26.5)	88 (76.5)
Income*				
0–14,999	44 (45.8)	62 (60.8)	10 (14.7)	55 (47.8)
15,000–24,999	18 (18.7)	19 (18.6)	10 (14.7)	8 (7.0)
25,000–34,999	11 (11.5)	12 (11.8)	7 (10.3)	11 (9.6)
35,000–49,999	6 (6.3)	4 (3.9)	14 (20.6)	5 (4.3)
50,000 or more	17 (17.7)	4 (3.9)	24 (35.3)	36 (31.3)
Missing	0 (0.0)	1 (1.0)	3 (4.4)	0 (0.0)

* = Australian dollars.

Finally, these results were synthesized to produce a screening tool comprising five simple questions for all subjects followed by clinical assessment of just four features in a subset of subjects. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and likelihood ratios (LRs) were calculated for this screening instrument.

External Validity

The external validity of the screening tool was assessed by applying it to an independent sample of 54 TMD and 51 non-TMD subjects whose diagnoses had been established by RDC/TMD assessment (gold standard).

Results

The total number of subjects for model development across the four groups was 381. Demographic information, including age, gender, country of birth, education, marital status, and income of subjects within each group, is provided in Table 2.

Screening Model

Inspection of the initial nodes in the classification tree (Step 1; Fig 1) revealed that the absence of orofacial pain in the past month combined with being ≤ 36 years of age identified 126 subjects, all of whom were non-TMD. The TMD status of nearly half (ie,

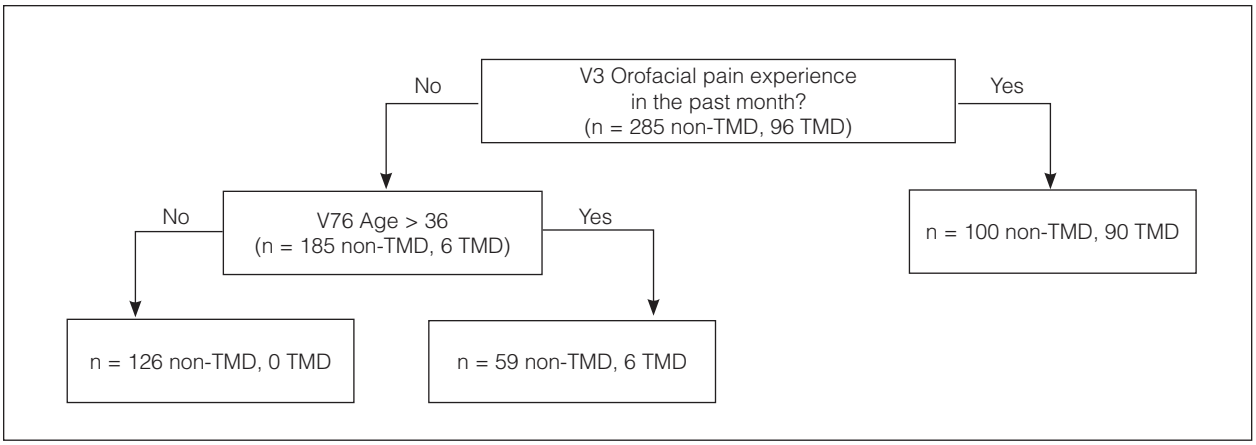

Fig 1 Classification tree analysis of TMD vs non-TMD based only on eligible variables from the history questionnaire (V1–V86).

Table 3 The Best-Fitting Multiple Logistic Regression Model for TMD Based on Only the History Questionnaire in the Remaining 255 Subjects Who Had Experienced Pain in the Past Month or Were Over 36 Years

					95% CI	
	B	SE	*P*	OR	Lower	Upper
V3 orofaial pain in the past month	1.19	0.544	.029	3.287	1.131	9.556
V16 jaw click	1.109	0.361	.002	3.031	1.495	6.147
V29 headache and migraines	–1.24	0.415	.003	0.289	0.128	0.653
V30 chewing limit because of jaw problem	0.975	0.383	.011	2.651	1.25	5.621
V38 yawning limit because of jaw problem	1.524	0.384	.0	4.593	2.165	9.743
V41 having usual facial appearance	1.057	0.501	.035	2.879	1.079	7.683
Constant	–2.452	0.509	.0	0.086		

B = Coefficient for the constant (also called the "intercept") in the null model; SE = standard error; OR = odds ratio; CI = confidence interval.

44%) of the non-TMD patients in the model development sample was correctly identified by means of two questions alone (ie, "Do you have pain in the face, jaw, temple, in front of the ear or in the ear in the past month?" and "Are you older than 36?"). The best-fitting multiple logistic regression model for TMD based on only the history questionnaire in the remaining 255 subjects who had experienced pain in the past month or were over 36 years of age is shown in Table 3. The following independent predictors of TMD were identified in this Step 2:

- V3 = orofacial pain in the past month (positive association)
- V16 = jaw click (positive association)
- V29 = headache and migraines (negative association)
- V30 = chewing limit because of jaw problem (positive association)
- V38 = yawning limit because of jaw problem (positive association)
- V41 = having usual facial appearance (positive association)

Based on responses to these six self-report variables, another 31 subjects were not predicted to have TMD, although two of them were, in fact, TMD positive. In those not ruled out as potential TMD at Steps 1 and 2 (n = 224), the best-fitting multiple logistic regression model for TMD based on the clinical examination identified five independent predictors at Step 3 (Table 4 and Fig 2).

A flow diagram illustrates the three-step development of this screening tool (Fig 3).

Table 4 The Best-Fitting Multiple Logistic Regression Model for TMD Based on the Clinical Examination Identified Five Independent Predictors

							95% CI	
	B	SE	Wald	*df*	*P*	OR	Lower	Upper
Joint pain on opening	3.576	0.770	21.593	1	.0	35.727	7.906	161.448
Muscle pain on protrusive jaw movement	3.219	1.076	8.950	1	.003	24.999	3.035	205.942
Joint sound on closing	4.123	0.968	18.146	1	.0	61.770	9.265	411.833
Masseter pain palpation	1.526	0.551	7.672	1	.006	4.600	1.562	13.541
TMJ pain palpation	3.352	0.633	28.039	1	.0	28.549	8.257	98.710
Constant	–3.982	0.588	45.893	1	.0	0.019		

Wald = Wald chi-square test that tests the null hypothesis that the constant equals 0; *df* = degree of freedom.

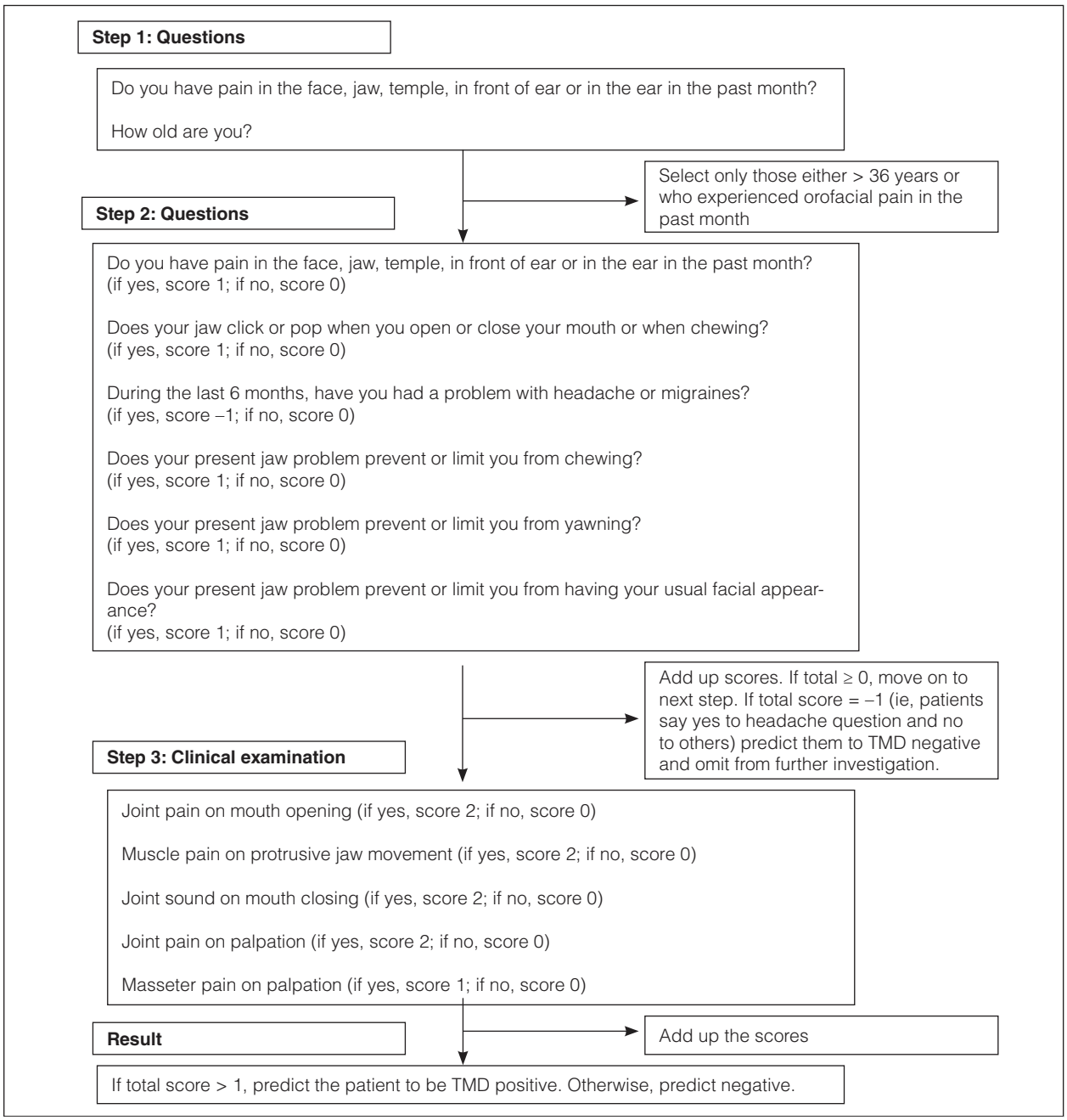

Fig 2 The three-step screening procedure.

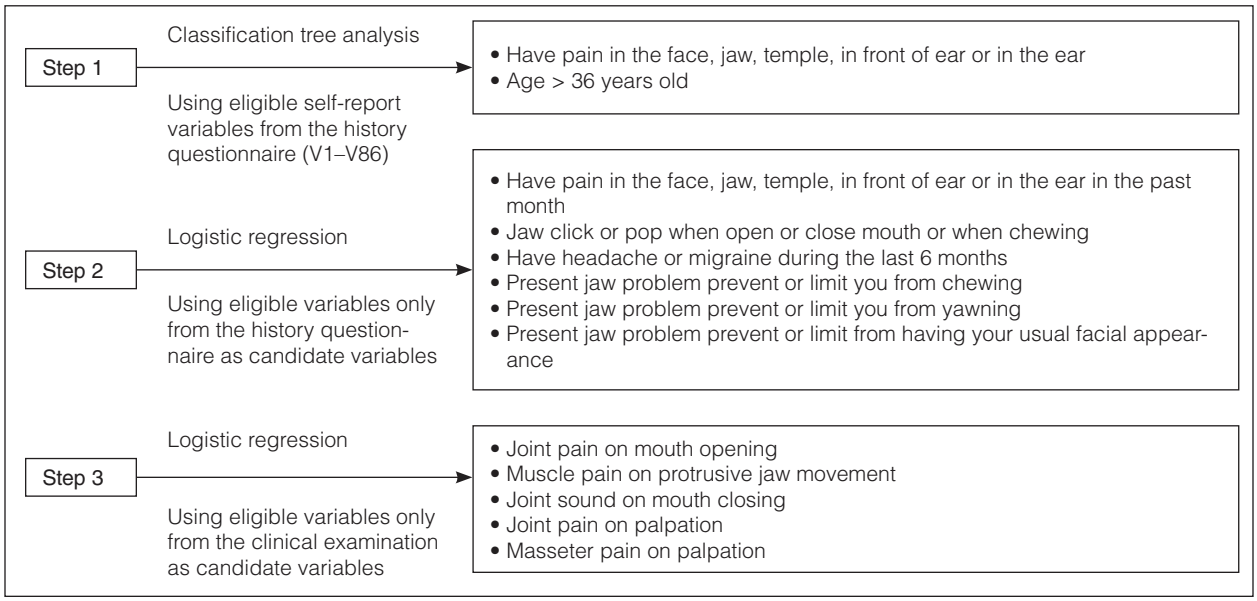

Fig 3 The process for developing the screening tool.

The internal validity of this instrument is shown in Table 5. The sensitivity, specificity, PPV, and NPV for this particular training sample were 93.8%, 92.6%, 81.1%, and 97.8%, respectively.

For ease of use in clinical practice, the original screening procedure and score methods of this screening tool (Fig 2) have been reduced to a TMD checklist, and this is shown in Table 6.

External Validity of Screening Tool

A total of 105 independent subjects were used to assess external validity. Table 7 outlines the age, gender, and subject type composition of the TMD and non-TMD groups. Table 8 shows that the screening tool ruled out 51 subjects as having a TMD, although 3 of them actually had a TMD. It also shows 51 TMD patients were correctly diagnosed, although another 3 subjects who had no TMD were predicted to be TMD positive. According to their RDC/TMD clinical forms, 2 of these 3 false negative cases had pain in more than 3 muscle sites and all those 3 false positive cases had unilateral joint palpation pain. The sensitivity, specificity, PPVs, and NPVs were 94.4% (95% confidence intervals [CI]: 84.9% to 98.1%), 94.1% (95% CI: 84.1% to 98%), 94.4% (95% CI: 84.9% to 98.1%), and 94.1% (95% CI: 84.1% to 98%), respectively. The positive likelihood ratio was 16.056 (95% CI: 5.346 to 48.219). The negative likelihood ratio was 0.059 (95% CI: 0.02 to 0.178).

Table 5 Internal Validity of Screening Tool

	RDC/TMD		
Screening tool	Positive (+)	Negative (–)	Total
Positive (+)	90	21	111
Negative (–)	6	264	270
Total	96	285	381

Sensitivity (90/96, 93.8%); specificity (264/285, 92.6%); PPV (90/111, 81.1%); NPV (264/270, 97.8%).

Discussion

Study Findings

The main finding of the present study was that it was possible to reliably distinguish TMD patients from dental pain, headache, and non-pain patients by means of a few simple questions and brief clinical examination. Indeed, the TMD status of nearly half (ie, 44%) of the non-TMD patients in the model development sample was correctly identified by means of two questions alone (ie, "Do you have pain in the face, jaw, temple, in front of ear or in the ear in the past month?" and "Are you older than 36?"). This is in agreement with previous studies indicating that questionnaires can be used as reliable primary or supplementary screening tools in general practice.[38–40] An advantage of the current screening tool over earlier screening tools is the high sensitivity and specificity demonstrated for this new tool.

Table 6 TMD Checklist

Questionnaire	Tick if "yes"	Clinician use: If yes, score
1. Do you have pain in the face, jaw, temple, in front of ear or in the ear in the past month?	☐	4
2. Are you older than 36?	☐	3
3. During the last 6 months have you had a problem with headache or migraine?	☐	–1
4. Does your present jaw problem prevent or limit you from chewing or yawning or having your usual facial appearance?	☐	1
5. Does your jaw click or pop when you open or close your mouth or when chewing?	☐	1
	Total	

If total score < 3, prediction is TMD negative. If total score ≥ 3, patient needs following exam.

Exam
1. Joint pain on mouth opening
2. Muscle pain on protrusive jaw movement
3. Joint sound on mouth closing
4. Joint pain on palpation

If none of the above exam items is positive, prediction is TMD negative. Otherwise, TMD is predicted.

Table 7 Distributions by Age, Gentder, and Subject Types for External Validity Test Set of Screening Tool; No. (%)

	TMD	Control
Age (mean ± SD)	45.8 ± 15.0	44.8 ± 17.6
Gender		
Male	19 (35.2)	23 (45.1)
Female	35 (64.8)	28 (54.9)
Subject types		
TMD	54 (100.0)	
Dental pain		19 (37.3)
Headache		12 (23.5)
No pain		20 (39.2)
Total	54	51

Table 8 External Validity of Screening Tool

	RDC/TMD		
Screening tool	Positive (+)	Negative (–)	Total
Positive (+)	51	3	54
Negative (–)	3	48	51
Total	54	51	105

Interestingly, those ≤ 36 years of age and without a history of face pain in the past month were predicted by this method at Step 1 as having no TMD. In the TMD group, there were six subjects with a non-painful TMD diagnosis (disc displacements or osteoarthrosis). This low prevalence of non-painful TMD is likely one reason for Step 1 questions ruling out subjects < 36 years with non-painful TMD. Although the sample may not be representative of non-painful TMD prevalence in the community,[35,41,42] the focus of the screen is to identify painful TMD since this is the group that demonstrates more disability and distress.[43,44]

The relationship between age and TMD is still controversial. Pow and his colleagues reported that the prevalence of TMD symptoms increased with age,[8] whereas other studies reported an opposite trend.[4,5] In the present study, age < 36 years in those with no history of face pain in the past month was identified as a predictor of no TMD. Although this result differs from the findings of some previous studies that showed TMD was more prevalent among people under 45 years,[4,5] the overlap of the age group (36~45 years) between the present and previous findings warrants further investigation.

The question "Do you have pain in the face, jaw, temple, in front of ear or in the ear in the past month?" was identified as a good predictor for TMD in this study and was included in both the Step 1 primary selection and the Step 2 score of the above model. This result was supported by a previous study,[40] which used a similar question for de-

tecting TMD pain in an adolescent population. The reliability and validity were found to be very good for this previous study (Kappa value: 0.83; test sensitivity and specificity: 98% and 90%; retest sensitivity and specificity: 96% and 83%).[40]

The relationship between psychological factors and TMD has been well documented in many studies.[10,45] Previous studies have indicated that psychological distress was a good predictor for TMD-related pain.[44,45] However, the inclusion of such variables in the present model failed to distinguish those with TMD from those with other orofacial and head pains. This suggests that subjects with dental pain and headache may suffer similar emotional distress as TMD patients. In addition, the recruitment of control pain-free subjects from a hospital environment may have affected the psychological state of these pain-free subjects (eg, level of stress) and therefore may have influenced the inclusion of psychological variables as predictive variables.

Joint sounds have been frequently reported in TMD patients as well as the general population.[5–9,46] However, the diagnostic value of joint sounds for TMD is not clear.[47] A previous screening tool development study indicated that the presence of reciprocal clicking of the temporomandibular joint can distinguish headache patients from TMD patients.[48] In the present study, joint sounds on mouth closing were considered a predictor for TMD. This supports the above studies[5–9,46] that suggested joint noise is a common finding in TMD.

Inconsistent Cases Analysis

In the external validity test, there were three false negative cases (ie, RDC/TMD test positive, but screening model test negative) and three false positive cases (ie, RDC/TMD test negative, but screening model test positive). Two of these false negative cases had pain in more than three muscle sites. Their pain-free openings were less than 40 mm, and passive stretch increased this by more than 5 mm. According to the RDC/TMD diagnostic criteria, they had myofascial pain with limited opening. However, the screening model only assigns numerical values for particular positive assessment findings. For example, subjects were only assigned a score of 1 if they had pain in their masseter irrespective of how many sites of this muscle were painful. Therefore, the final scores for these individuals were insufficient to be predictive of TMD according to the screening model.

All three of the false positive cases had unilateral joint palpation pain. According to the screening model, their final scores were all 2; therefore, they were predicted TMD positive. However, under the RDC/TMD diagnostic criteria, there was insufficient evidence to assign them a specific TMD diagnosis.

Limitations and Advantages of This Study

There are three main shortcomings in the current study. First, the study was based on a small sample size. Whether the model is applicable for the general population is unknown. Second, the clinical examination for the control subject group was performed by a single calibrated examiner while the TMD group was examined by calibrated clinicians in the Orofacial Pain Clinic. Although all examiners had been calibrated, variability between the examiners is inevitable. Third, the mean ages of the non-pain and pain groups were not closely matched. However, if the "age" factor (question 2, Table 6) was omitted in the short checklist, only one TMD patient was missclassified; therefore, this age discrepancy was not considered a major issue.

The screening model does have advantages as a screening tool for TMD. First, it can reliably distinguish TMD from dental pain, headache, and non-pain subjects by means of a few simple questions and a brief clinical examination. This meets the criterion of cost-effectiveness of a screening tool. Second, its score rules can be easily mastered and utilized in clinical practice, which fits the criterion of simplicity of a screening tool. Finally, since the clinical examination components of this model were generated from the highly standardized clinical examination variables of the RDC/TMD, it allows for the comparison of findings among diverse clinical investigators.

This screening tool can be useful for two purposes. First, it would be useful for all patients attending a dental clinic as a basic assessment before carrying out any dental treatment that could potentially worsen a preexisting TMD. Second, the TMD patients who are identified may benefit from early intervention, including preventive intervention.

Conclusions

High validity has been found for a simple TMD screening checklist. The results indicate that this checklist has good utility in general practice as a primary screening tool for TMD.

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