Viability of the quintessential 5 temporomandibular disorder symptoms as a TMD screener

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Objective. This study explored the viability of using the 5 temporomandibular disorder (TMD) symptoms (5Ts) of the Diagnostic Criteria for TMDs (DC/TMD) as a TMD screener.

Study Design. A total of 1039 adults (≥18 years old) with a mean age of 32.65 ± 12.95 years (77.4% women) from a tertiary dental hospital were enrolled. The 5Ts questionnaire (involving items on TMD/facial pain, headaches, temporomandibular joint noises, and closed- and open-locking) was administered, and TMD diagnoses were derived through clinical interviews and examinations, radiographic investigations, and the DC/TMD diagnostic algorithms and diagnostic tree. Diagnostic accuracy of the 5Ts was assessed using the area under the receiver operating characteristics curve and various measures, including sensitivity, specificity, predictive values, and likelihood ratios.

Results. Among the participants, 80.2% (n = 833) were 5Ts-positive, and 19.8% (n = 206) were 5Ts-negative, whereas 51.3% and 85.7% received at least 1 pain-related and intra-articular DC/TMD diagnosis, respectively. The 5Ts showed high accuracy for detecting all TMDs, pain-related and intra-articular, with area under the receiver operating characteristics curves of 0.98, 1.00, and 0.98, respectively. Sensitivity ranged from 96.1% to 99.2%, whereas specificity was 100.0%.

Conclusions. The 5Ts demonstrated high diagnostic accuracy for identifying pain-related and/or intra-articular disorders. (Oral Surg Oral Med Oral Pathol Oral Radiol 2022;133:643−649)

Temporomandibular disorders (TMDs) are a group of clinical conditions involving pain and dysfunction of the temporomandibular joints (TMJs), masticatory musculature, and contiguous tissues. They are the most common cause of chronic orofacial pain, affecting about 7% of adolescents and 15% of adults.[1,2] Women, especially those between 20 and 40 years, appear to be more susceptible to TMDs.[2,3] The multifactorial etiology of TMDs involves a myriad of biopsychosocial factors, including hormones, oral parafunctions, and emotional distress.[4] Although TMDs are known to lower patient quality of life, TMD interventions were shown to enhance it.[5,6] Based on the contemporary Diagnostic Criteria for TMDs (DC/TMD) standard, frequent TMD ailments can be dichotomized into pain-related (PT) and intra-articular (IT) disorders.[7] The DC/TMD diagnoses are derived from the Symptom Questionnaire (SQ), findings of physical examination, and the DC/TMD diagnostic algorithms and diagnostic tree. Despite its good reliability and validity,[8] use of the DC/TMD for clinical triage and population screening is impractical because of the arduous interview and examination procedures and complicated rule sets. TMD screeners need to be cheap, short, simple, accurate, and ideally self-administered. The deficits of earlier TMD screening tools had been reviewed,[9] and prevailing ones include the TMD Pain Screener (TPS), 3Q/TMD, and the Short-form Fonseca Anamnestic Index (SFAI).[9-11]

The TPS is part of the DC/TMD repertoire and comprises 3 (short version) or 6 (long version) items for assessing the presence of painful TMDs. Whereas the long version has adequate reliability for clinical use, the short version is appropriate for epidemiologic research.[7] Both versions have a sensitivity of 99% and specificity of 97% for correct identification of PT TMD. However, the TPS was not designed to screen for IT disorders. The 14-item SQ provides the required history for attaining the

Statement of Clinical Relevance

Considering its high accuracy, the 5Ts questionnaire could serve as an effective TMD screener for clinical triage and epidemiological research.

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DC/TMD diagnoses and involves 5 major TMD symptoms (5Ts), specifically TMD/facial pain, headaches, TMJ noises, and closed and open locking. Because these quintessential symptoms are central to the rendering of specific TMD diagnoses, it is logical to consider their use as a TMD screener.

The objective of this study was to establish the diagnostic accuracy of the 5Ts when used as a TMD screening tool. In addition, the sensitivity, specificity, predictive values, and likelihood ratios of the discrete and combined items of the 5Ts for identifying PT and IT disorders were explored. The null hypotheses were as follows: (1) the accuracy of the 5Ts is low when referenced to the DC/TMD benchmark, and (2) the 5Ts discrete and combined items' ability to detect participants with PT and IT disorders is poor.

MATERIALS AND METHODS

Study population and TMD diagnoses

This investigation is part of project PKUSS-201732009 that was authorized by the Biomedical Institution Review Board of the Peking University Hospital and School of Stomatology. Consecutive adult patients (≥18 years old) seeking TMD and restorative dental care at a tertiary dental hospital were enlisted. Patients who had prior orofacial trauma/surgeries; uncontrolled autoimmune, metabolic, or psychiatric disorders; non-TMD muscle/joint diseases; and cognitive impairments were excluded, as were those who were illiterate. Involvement in the study was voluntary, and no financial reparation was offered for patients' participation. Information about the study was provided, and signed consent was obtained from all eligible patients. During their intake visit, the participants were instructed to complete a survey encompassing demographic data and the 5Ts questionnaire that was adapted from the SQ and appraised over 30 days (Table I). The participants were considered 5Ts-positive if they answered "yes" to any of the 5 symptoms and 5Ts-negative if they replied "no" to all 5 symptoms. Clinical interviews and examinations were subsequently carried out by a TMD specialist who was trained, calibrated, and proficient in the DC/TMD methodology[12] and blinded to the 5Ts outcomes. Panoramic radiographs were taken for all participants, and adjunctive diagnostic imaging, specifically cone beam computed tomography and magnetic resonance imaging, were performed to verify clinical observations when indicated. DC/TMD diagnoses were eventually made based on the DC/TMD algorithms and diagnostic tree.

Statistical analyses

Statistical analyses were accomplished with the SPSS statistical software Version 24.0 (IBM Corporation, Armonk, NY) with the significance level set at .05.

Table I. The 5 major TMD symptoms (5Ts) questionnaire

Item	*Questions (in the last 30 days)*	*Classification*
S1	Do you have pain in your jaw, temple, in the ear, or in front of the ear on either side?	Pain-related TMDs
S2	Do you have any headaches that include the temple areas of your head?	
S3	Do you have any jaw joint noise(s) when you move or use your jaw?	Intra-articular TMDs
S4	Does your jaw lock or catch, even for a moment, so that it would not open all the way?	
S5	When you open your mouth wide, does your jaw lock or catch, even for a moment, such that you could not close it from the wide-open position?	

TMD, temporomandibular disorder.

Categorical variables, namely TMD symptoms and diagnostic categories, were summarized as frequencies with proportions. Receiver operating characteristic curves were used to establish the accuracy (area under the curve [AUC]) of the 5Ts for all PT and IT TMDs. The AUCs were ordered as follows: coincidental (≤0.5), low (>0.5-0.7), moderate (>0.7-0.9), and high (>0.9-1.0) levels of accuracy.[13] Other measures of diagnostic accuracy, including sensitivity, specificity, positive and negative predictive values (PPVs and NPVs, respectively), and positive and negative likelihood ratios (PLRs and NLRs, respectively), were also calculated for the 5Ts and its pooled/discrete items.[14,15] Table II describes the different measures and details their equations. Whereas a screening test yielding a sensitivity/specificity >90%, PLR >10, and NLR <0.1 is deemed to have good diagnostic performance, a test that poses an ideal PPV or NPV of 100% will return no false positives or negatives, respectively.[13-15]

RESULTS

Of the 1229 patients evaluated for eligibility, 170 satisfied the exclusion criteria, and 20 declined participation, yielding a 98.1% response rate (Figure 1). The mean age of the study population (n = 1039), comprising 77.4% women, was 32.65 ± 12.95 years. Of these, 80.2% (n = 833) were 5Ts-positive and 19.8% (n = 206) were 5Ts-negative. Prevalence of the 5 major TMD symptoms was as follows: 64.8% TMJ sounds (n = 673); 52.3% TMD/facial pain (n = 543); 30.0% TMJ closed-locking (n = 312); 18.6% TMJ open-locking (n = 193); and 5.7% headaches (n = 59). Among the participants, 51.3% (n = 444) received at least 1 PT and 85.7% (n = 742) an IT DC/TMD diagnosis

Table II. Descriptors and equations for the different measures of diagnostic accuracy

Measure	*Description*	*Equation*
Sensitivity	Ability of the 5Ts to correctly identify participants with TMDs	True positives/(true positives + false negatives)
Specificity	Ability of the 5Ts to correctly identify participants without TMDs	True negatives/(true negatives + false positives)
Positive predictive value	Ability of the 5Ts to detect the presence of TMDs	True positives/(true positives + false positives)
Negative predictive value	Ability of the 5Ts to detect the absence of TMDs	True negatives/(true negatives + false negatives)
Positive likelihood ratio	Change in odds of having TMDs in participants with positive 5Ts	Sensitivity/(1 − specificity)
Negative likelihood ratio	Change in odds of having TMDs in participants with a negative 5Ts	(1 − sensitivity)/specificity

5Ts, 5 temporomandibular disorder symptoms; *TMD*, temporomandibular disorder.

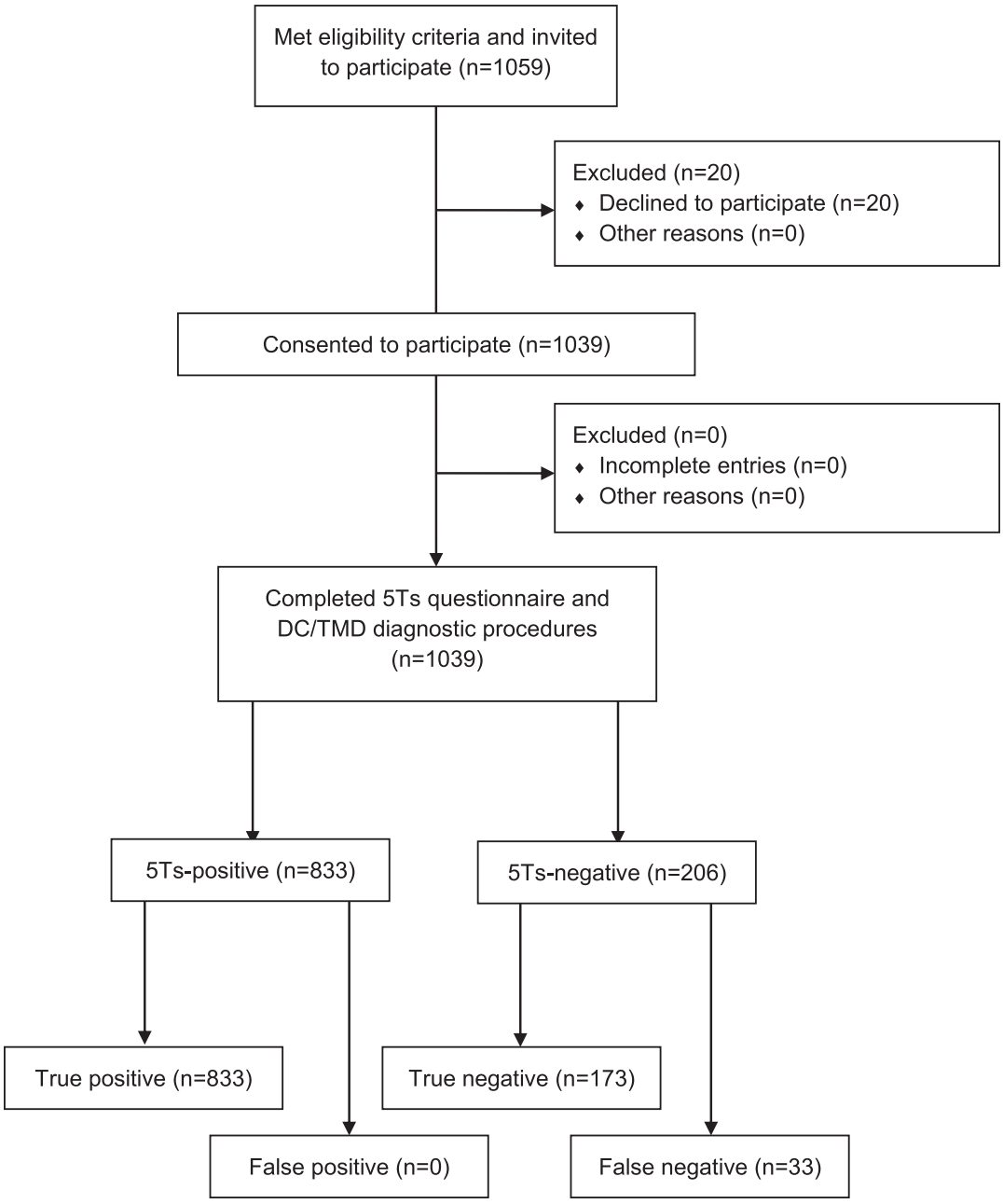

Fig. 1. Flow diagram detailing the enrollment and distribution of the participants.

Table III. Distribution of the DC/TMD diagnostic categories and subtypes

Diagnostic category	*TMD subtypes*	*Total n (%)*
Pain-related TMDs	Myalgia	104 (12.0)
	Arthralgia	385 (44.5)
	Headache attributed to TMDs	10 (1.2)
	Any pain-related disorders	444 (51.3)
Intra-articular TMDs	DD with reduction	192 (22.2)
	DD with reduction with intermittent locking	64 (7.4)
	DD without reduction with limited opening	166 (19.2)
	DD without reduction without limited opening	183 (21.1)
	Degenerative joint disease	329 (38.0)
	TMJ subluxation	2 (0.2)
	Any intra-articular disorders	742 (85.7)

DD, disk displacement; *TMD*, temporomandibular disorder.

(Table III). Arthralgia (44.5%; n = 385) and TMJ degenerative joint disease (38.0%; n = 329) were the most common specific TMD subtypes.

Table IV presents the AUCs and diagnostic accuracy measures for the 5Ts. The 5Ts showed high accuracy for detecting all TMDs, PT, and IT with AUCs of 0.98, 1.00, and 0.98, respectively. Sensitivity ranged from 96.1% to 99.2%, whereas specificity was 100.0%. Correspondingly, its PPV was 100%, and NPV ranged from 85.2% to 98.3%. NLRs varied from 0.01 to 0.04. Diagnostic performance was generally better for PT than for all TMDs and IT. Table V shows the frequencies of affirmative responses, sensitivity, specificity, PPV, NPV, PLR, and NLR for the discrete/combined items. Concerning PT, the best diagnostic performance was obtained by applying items "S1 or S2" (Table I). For this combination, specificity/specificity was 96.0%/100%, PPV/NPV was 100%/90.6%, and NLR was 0.04. Regarding IT, the best diagnostic performance was achieved using items "S3 or S4 or S5" (Table I). For this combination of items, specificity/specificity was 92.8%/100%, PPV/NPV was 100%/75.9%, and NLR was 0.07. When discrete items were considered, items S1 and S3 provided the best performance for PT and IT, respectively.

DISCUSSION

This study examined the diagnostic accuracy of the 5 major TMD symptoms (5Ts) of the DC/TMD when applied as a TMD screener. Furthermore, the diagnostic performance of the discrete and pooled items was also explored for identifying PT and IT conditions. The first null hypothesis was discarded because the 5Ts were found to have high diagnostic accuracy. However, the second null hypothesis was not rejected because some discrete or combination of items showed unsatisfactory diagnostic performance for recognizing PT and IT. The presence or absence of PT and IT TMDs was authenticated via operationalized TMD history, physical examination, imaging procedures, and validated algorithmic rules.[7,8] The high occurrence of TMJ arthralgia and degenerative joint disease was consistent with the high prevalence of TMJ disorders in adults and THE elderly (31.1%) and children or adolescents (11.3%) in the general population.[16]

Unlike the TPS, the 3Q/TMD and SFAI identifies both PT and IT TMD conditions.[9-11] The 3Q/TMD involves 2 items concerning facial/functional pain (jaw opening and chewing) and 1 item on TMJ closed/open locking. Likewise, the SFAI, a reduced version of the 10-item FAI,[17] consists of 2 items on TMJ/masticatory muscle pain and 3 items on TMJ noises, jaw opening, and side-movement difficulties. The 5Ts are more comprehensive and incorporate TMD-associated headaches as a symptom. The diagnostic accuracy of the 3Q/TMD and the SFAI had been evaluated with reference to the DC/TMD and will be considered hereafter.[10,18,19] The AUC reflects the discriminative ability of a test, with a perfect test having an AUC of 1.0 and an ineffective test having an AUC of $\leq$0.5.[13] The 5Ts exhibited high accuracy for differentiating individuals with and without all TMDs, PT, and IT. AUCs attained (0.98, 1.00, and 0.98, respectively) were marginally better than those of the SFAI, which were 0.97, 0.99, and 0.97 for all TMDs, PT, and IT, respectively. AUCs are statistical estimates and should be reported with confidence intervals (CIs). The 95% CIs specify the interval in which 95% of all AUC estimates will fall between should the study be replicated.

Table IV. Area under receiver operating characteristic curve, sensitivity, specificity, predictive values, and likelihood ratios for the 5Ts

Diagnostic categories	*Area (95% CI)*	*Sensitivity*	*Specificity*	*Positive PV*	*Negative PV*	*Positive LR*	*Negative LR*
All TMDs	0.98 (0.97-0.99)	96.2%	100.0%	100.0%	85.2%	NA	0.04
Pain-related TMDs	1.00 (0.99-1.00)	99.3%	100.0%	100.0%	98.3%	NA	0.01
Intra-articular TMDs	0.98 (0.97-0.99)	96.1%	100.0%	100.0%	85.2%	NA	0.04

5Ts, 5 temporomandibular disorder symptoms; *CI*, confidence interval; *PV*, predictive value; *LR*, likelihood ratio; *NA*, not applicable; *TMD*, temporomandibular disorder.

Table V. Frequency of affirmative responses, sensitivity, specificity, predictive values, and likelihood ratios for S1 and S2 in relation to pain-related TMDs as well as for S3, S4, and S5 in relation to intra-articular TMDs

5Ts items	*Frequency n (%)*	*Sensitivity*	*Specificity*	*Positive PV*	*Negative PV*	*Positive LR*	*Negative LR*
Pain-related TMDs							
S1	543 (52.3)	95.7%	100.0%	100.0%	90.1%	NA	0.04
S2	59 (5.7)	12.3%	100.0%	100.0%	30.7%	NA	0.88
S1 or S2	547 (52.7)	96.0%	100.0%	100.0%	90.6%	NA	0.04
S1 and S2	55 (5.3)	12.1%	100.0%	100.0%	30.6%	NA	0.88
Intra-articular TMDs							
S3	673 (64.8)	81.0%	100.0%	100.0%	54.4%	NA	0.19
S4	312 (30.0)	36.2%	100.0%	100.0%	26.2%	NA	0.64
S5	193 (18.6)	24.6%	100.0%	100.0%	23.1%	NA	0.75
S3 or S4 or S5	779 (75.0)	92.8%	100.0%	100.0%	75.9%	NA	0.07
S3 and S4	208 (20.0)	24.6%	100.0%	100.0%	23.1%	NA	0.75
S3 and S5	188 (18.1)	24.0%	100.0%	100.0%	23.0%	NA	0.76
S4 and S5	48 (4.6)	5.9%	100.0%	100.0%	19.4%	NA	0.94
S3 and S4 and S5	45 (4.3)	5.5%	100.0%	100.0%	19.4%	NA	0.95

5Ts, 5 temporomandibular disorder symptoms; *PV*, predictive value; *LR*, likelihood ratio; *NA*, not applicable; *TMD*, temporomandibular disorder.

The CIs of the 5Ts for all TMDs, PT, and IT were all narrow, suggesting that the reported AUCs were indeed the true values.[13]

Whereas sensitivity indicates the true positive rate, specificity denotes the true negative rate. The 5Ts performed exceptionally well, with 99% sensitivity for PT, 96% sensitivity for all TMDs/IT, and 100% specificity for all TMDs/PT/IT. The highest sensitivities attained for PT by the 3Q/TMD and SFAI items were 96% and 97%, whereas the highest specificities were 63% and 96%. For IT, the highest sensitivities realized by the 3Q/TMD and SFAI items were 48% and 91%, whereas the highest specificities was 96% and 93%, respectively.[18,19] The 5Ts thus offered the best diagnostic performance among current TMD screeners including the TPS (which had a sensitivity/specificity of 99%/97% for PT). With its superior sensitivity and specificity, the 5Ts might be beneficial for both "ruling out" and "ruling in" TMDs. This is rare for most screening tests because sensitivity and specificity are often inversely related.[14]

The more specific a TMD screener, the less likely an individual with a positive test will be TMD-free and the greater the PPV (the probability that participants with positive tests truly have TMDs). Because the 5Ts yielded a 100% specificity (correctly identified all participants without TMDs), the PPV was correspondingly 100% for all TMDs, PT, and IT. The PPV of the 5Ts was greater than its NPV values (85.2% to 98.3%), suggesting that it was more adept at recognizing the presence than the absence of TMDs. A similar trend was also observed for the other TMD screening tools.[18,19] The PLR for the 5Ts could not be computed because specificity was 100%. NLRs were all <0.1, which indicates more than a 10-fold decrease in the odds of having all TMDs, PT, and IT in an individual with negative-5Ts. Diagnostic performance of the 5Ts, like the 3Q/TMD and SFAI, was generally better for PT than for IT.[18,19] The latter was anticipated, considering the poor correlations between TMJ noises and findings of diagnostic imaging[20] as well as the relatively lower frequency of acute TMJ closed/open locking. Furthermore, not all ITs are associated with functional TMJ noises, and individuals may also have difficulty differentiating pathologic joint sounds from normal ones.

When discrete/combined items were evaluated, the permutations of "S1 or S2" and "S3 or S4 or S5" (Table I) gave the best diagnostic performance for detecting PT and IT, respectively. These item combinations yielded 96.0% specificity for PT, 92.8% specificity for IT, and 100% sensitivity for both conditions and hence can be used to screen for the presence or absence of PT and IT disorders. When discrete items were appraised, item S1 (TMD/facial pain) offered the best diagnostic performance for PT and item S3 (TMJ noises) for IT. Although specificity was good, the sensitivities of items S2 (headaches), S4 (TMJ closed locking), and S5 (TMJ open locking) were poor and could be attributed partly to their relatively lower occurrence in the study population. Therefore, these items should not be used independently for the identification of PT and IT.

This study has limitations. First, the exceptional specificity observed could be a result of the higher proportion of participants with more complex or advanced TMDs, because they were recruited from a tertiary dental hospital. Furthermore, there was a higher percentage of female participants, who are at greater risk of experiencing TMDs.[3] The diagnostic accuracy of the 5Ts must therefore be reassessed in the general population to validate the findings of this

study. The inclusion of headaches as a major TMD symptom may be of concern. Headaches affect about 46% of the general population, and primary causes include migraine, tension-type, cluster, and hypnic headaches.[21,22] Possible secondary causes encompass cervicogenic headache, occipital neuralgias, temporal/giant cell arteritis, subdural hematomas, strokes, central nervous system tumors, and infections.[22,23] The associations between TMDs, particularly muscle disorders, and primary headaches were explained by peripheral/central sensitization, shared neuronal pathways, and referred pain, despite the lack of evidence supporting a cause-and-effect relationship.[24] Providentially, the occurrence of headaches was low in our study cohort and consistent with the estimated 1-year prevalence of migraine (9.3%) and tension-type headaches (10.8%) in China.[25] The low headache prevalence might have also influenced the specificity of the 5Ts and warrants further research in other patient samples. Second, the TMD symptoms were assessed over 30 days because the 5Ts were referenced against the DC/TMD, which applied this recall timeframe. Given the fluctuating nature of TMD symptoms, recurrent TMDs might be overlooked.[26] The duration of TMD symptom evaluation should be extended to $\geq$3 months, which is the minimum period for defining chronic musculoskeletal pain.[27] Third, partial verification bias can occur because the symptoms of the 5Ts are also considered when rendering the TMD diagnoses.[28] Nevertheless, items of the 5Ts constituted only a third of DC/TMD SQ, and the 5Ts questionnaire was administered independently of the DC/TMD diagnostic process that also involved clinical and radiographic assessments in this study. Furthermore, the DC/TMD is the sole internationally accepted "reference test" for TMD diagnosis and is essential for classifying TMD subtypes. More recently, a checklist user interface for the DC/TMD, which appears to improve diagnostic accuracy and reduce the time needed to render diagnoses, was introduced.[29] Lastly, only the Chinese version of the 5Ts was scrutinized. The English and other language versions of the 5Ts need investigation in disparate racial groups with differing TMD prevalence because the sensitivity and specificity of a diagnostic test might vary with disease prevalence. Even so, Leeflang et al.,[30] in their evaluation of meta-analyses, determined that specificity tended to be lower with higher disease prevalence, but sensitivity was not affected. Future TMD screeners could consider incorporating the appraisal of the frequency, duration, and intensity of TMD symptoms as well as the disability/activity interference they produce. The symptoms and impacts should ideally be scored on an ordinal scale to facilitate review and statistical analyses.

CONCLUSIONS

This study determined the diagnostic accuracy of the 5Ts for identifying DC/TMD-defined PT and/or IT TMDs. The 5Ts exhibited high accuracy for screening all TMDs, PT, and IT, with AUCs of 0.98, 1.00, and 0.98, respectively. Their diagnostic performance was good, with 96.1% to 99.2% sensitivity, 100.0% specificity, and NLRs of <0.1. With their high sensitivity and specificity, the 5Ts are suitable for both "ruling out" and "ruling in" TMDs. The 5Ts were better at recognizing the presence (100% PPVs) than the absence (85.2%-98.3% NPVs) of TMDs. Items "S1 or S2" and "S3 or S4 or S5" can be employed for screening PT and IT disorders accordingly. The 5Ts questionnaire could serve as an effective TMD screener for clinical triage and epidemiologic research.

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