

# Diagnostic Accuracy of Temporomandibular Disorder Pain Tests: A Multicenter Study

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***Aims:** To estimate the diagnostic accuracy of the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) clinical examination and of the dynamic/static tests for the recognition of TMD pain. Since the diagnosis of TMD pain is especially complicated in persistent orofacial pain patients, the test outcomes in persistent TMD pain patients were contrasted to those in two control groups: a group of persistent dental pain patients and a group of pain-free subjects. **Methods:** In 125 persistent TMD pain patients, 88 persistent dental pain patients, and 121 pain-free subjects, a blind and standardized clinical examination was performed. **Results:** For the RDC/TMD, sensitivity (88%) was high and specificity was low (pain-free group: 71%; dental pain group: 45%). For the dynamic/static tests, sensitivity was 65% and specificities were 91% and 84%, respectively. Comparing the outcomes of the two examinations showed higher positive likelihood ratios for dynamic/static tests ( $P < .001$ ), and lower negative likelihood ratios for the RDC/TMD examination ( $P < .01$ ). **Conclusion:** For the confirmation of a suspicion of TMD pain, it is better to rely on positive dynamic/static tests. To confirm the absence of TMD pain, it is better to rely on a negative RDC/TMD examination. J OROFAC PAIN 2009;23:108–114*

**Key words:** dental pain, diagnostic accuracy, dynamic/static tests, RDC, TMD

**T**emporomandibular disorders (TMD) is a collective term embracing pain and dysfunction of the muscles and joints of the masticatory system. The diagnosis of TMD, as for other musculoskeletal disorders such as low back pain and neck pain, is complicated, because objective signs to recognize the disorders are often lacking. Nowadays, for many musculoskeletal disorders, expert panels have introduced classification systems to standardize the diagnostic procedures.<sup>1–4</sup> These systems share the idea that the diagnosis mainly relies on the results of an oral history and a physical examination. In 1992, the Research Diagnostic Criteria (RDC) for TMD were introduced.<sup>1</sup> This system is unique in its detailed description of performing the clinical examination and in its classification of symptoms into TMD subtypes (for example, myofascial pain and arthralgia).

Validity of the RDC/TMD is so far based on consensus, reached by a team of recognized TMD specialists (“face-validity”). Further support for its diagnostic accuracy<sup>5</sup> is not available yet, as recently

**Table 1** Criteria for the Allocation of the Three Reference Groups

	Reference groups		
	Pain-free	TMD pain	Dental pain
Oral history			
Orofacial pain in the last month	No, not even tenderness or fatigue	Yes, an "aching, tender, or fluctuating" pain	Yes, an "aching, tender, fluctuating, or shooting" pain
Pain duration	-	> 3 months	> 3 months
Pain location	-	Orofacial region*	Orofacial region* (including teeth)
Pain intensity	-	Serious enough to seek help	Serious enough to seek help
Pain increase on temperature (eg, hot tea)	-	No	Yes
Comorbid conditions <sup>†</sup>	No	No	No
Dental examination			
Dental signs	-	No <sup>‡</sup>	Yes <sup>§</sup>

\*Jaw, temples, face, joint, preauricular area, or ear.

<sup>†</sup>Symptoms of any other orofacial pain disorder besides those of TMD or dental pain (eg, progressively more severe pain, paroxysmal neuralgias, characterized by sudden, shock-like pain that lasts only seconds to minutes, hemicrania, soreness in a "band-like" distribution, suggestive of tension-type headache, burning pain, neurologic signs or symptoms, such as paralysis, paresthesias, sensitivity to light and/or noise, vertigo, nausea, weight loss, or fever), systemic disease, general joint disorder, whiplash-associated disorder, treatment for psychiatric disorder, or overuse of pain killers.

<sup>‡</sup>No dental signs and no pathological pocket or fistula on intraoral inspection, and no periapical radiolucency on the Orthopantomogram (OPG).

<sup>§</sup>Increase of the patient's pain complaint on percussion, on temperature test or on bite test, a pathological pocket or fistula on intraoral inspection, and/or a periapical radiolucency on the OPG.

discussed.<sup>6-9</sup> In the RDC/TMD, palpation tests play an important role, but the relevance of palpation in recognizing a musculoskeletal pain is a matter of debate.<sup>10,11</sup> Moreover, for some intraoral muscle palpation sites, a poor reliability has been reported.<sup>12-14</sup> The consequences of these aspects for the accuracy of the RDC/TMD classification are unknown.

As an alternative for palpation tests, dynamic/static tests have been advocated.<sup>15</sup> These tests intend to provoke pain from the muscles and joints by performing mandibular movements and static muscle efforts. Recently, the dynamic and static tests are found to better discriminate between TMD pain patients and healthy subjects compared to palpation tests,<sup>16</sup> and their reliability is comparable to that of the RDC/TMD examination.<sup>17</sup>

The aim of this multicenter study was to estimate the diagnostic accuracy of the RDC/TMD clinical examination and of the dynamic/static tests for the recognition of TMD pain. Since the diagnosis of TMD pain is especially complicated in persistent orofacial pain patients, the test outcomes in persistent TMD pain patients were contrasted to those in two control groups: a group of persistent dental pain patients and a group of pain-free subjects. It was also examined whether the accuracy of the RDC/TMD examination could be improved by (1) changing the myofascial pain cutoff criterion or (2) by omitting unreliable palpation sites.

## Materials and Methods

### Allocation of Participants

Participants were recruited from four European dental faculties. At each faculty, it was aimed to recruit 30 patients with persistent TMD pain, 30 patients with persistent dental pain, and 30 pain-free subjects. The TMD and dental pain patients were recruited by the center's coordinator (a calibrated TMD specialist) from the patients referred to the TMD or endodontic clinics, respectively. The pain-free subjects were recruited by the coordinator from relatives and friends of the pain patients, or from those who reacted on an advertisement in the university building. Just prior to the blind TMD examination, the coordinator performed a standardized oral history, including questions regarding the inclusion criteria for the three study groups, and questions to exclude other causes of orofacial pain (eg, trigeminal neuralgia, migraine, intracranial neoplasm) and comorbid conditions (see Table 1). Based on the results of this oral history and of standard dental examinations (Table 1) that were performed by the treating dentist at intake, the coordinator allocated participants to one of the reference groups when they fulfilled the specific criteria for that group. Since in this study the accuracy of clinical TMD pain tests was determined, these tests were not used in the

allocation of the participants. For the dental pain patients, diagnoses were pulpitis, apical periodontitis, or occasionally a cracked tooth. In case of doubt of the pain origin (eg, when both a TMD pain and a dental pain were suspected), the patient was excluded from the study. The study was approved by the ethics committee of the Academic Medical Centre of the University of Amsterdam (MEC 04/056), and all participants signed an informed consent.

### TMD Examination

The participants were instructed not to provide the examiner any information regarding their background or complaints (if any). The examiners, a dentist or a physical therapist (one examiner per university), were blind to the results of the standardized oral history, the dental examination, and the participant's group allocation. The TMD examination included all clinical tests needed for a RDC/TMD pain diagnosis (ie, myofascial pain, arthralgia, or osteoarthritis): active mandibular movements, assisted opening, and palpation of 20 masticatory muscle sites and of four temporomandibular joint sites.<sup>1</sup> Following the RDC/TMD examination, the dynamic/static tests on opening, closing, and protrusion were performed.<sup>15,17</sup> During dynamic tests, the patient performed mandibular movements while the examiner applied a slight manual counterpressure to the movement. During static tests, the patient was instructed to hold the mandible motionless, while the examiner gradually increased a manual counterpressure, until either the patient or the examiner reached maximal effort. This effort was then maintained for about 3 seconds. After each dynamic or static test, the patient indicated whether any pain (yes/no) was provoked in the orofacial region. TMD pain was considered present when at least one of the six tests (three dynamic and three static tests) was painful.

Three of the examiners were already calibrated by the International RDC/TMD Consortium.<sup>13,18</sup> At the start of the study, the fourth examiner was carefully calibrated by the Dutch calibrated RDC/TMD examiners (CV and FL) and the other three examiners were recalibrated. All examiners were also carefully trained by the Dutch examiners in performing the dynamic/static tests.

### Analysis

Diagnostic accuracy of the RDC/TMD and the dynamic/static tests was expressed in terms of sensitivity, specificity, and positive and negative

likelihood ratio (LR). Ninety-five percent confidence intervals were calculated using the Wilson score method.<sup>19</sup> For the recognition of TMD, acceptable levels for sensitivity and specificity have been proposed to be at least 70% and 90%, respectively.<sup>1,20</sup> One-sample *t*-tests were used to evaluate differences between the diagnostic accuracies and their recommended levels. To evaluate potential confounding or effect modification of age, gender, or examiner on the ability of the examination under evaluation to predict TMD pain, logistic regression analysis was used with the reference groups as dependent variables. A variable was a confounder when the regression coefficient of the examination (ie, RDC/TMD or dynamic/static tests) changed over 10% upon adding that variable to the regression model.<sup>21</sup> Effect modification was present when there was a significant interaction between a possible confounder and the examination. Two-sample *t*-tests were used to test differences between LRs of the dynamic/static tests and the RDC/TMD examination.

Whether the sensitivity and specificity of the RDC/TMD examination could be improved by changing the cutoff criterion for myofascial pain (pain on palpation of at least three out of 20 muscle sites, with at least one painful site on the same side as the patient's complaint) was also evaluated. The Receiver Operator Curve (ROC) was used for varying cutoffs for myofascial pain (varying from 0 to 20), and a cutoff was looked for that best met the recommended levels of sensitivity and specificity. It was also investigated whether omitting eight unreliable palpation sites (ie, lateral pterygoid area, tendon of the temporalis muscle, posterior mandibular region, and submandibular region<sup>12-14</sup>) would improve the accuracy of the RDC/TMD. Differences in accuracy between the RDC/TMD and its modified version were tested by comparing the areas under the curve (AUC) of their ROCs with a two-sample *t*-test. All analyses were performed with SPSS 14.0 software package, and  $\alpha$  was set at .05.

### Results

In the study, 334 subjects participated (mean age: 39 years; standard deviation: 15.0; 74% female). For the dental pain group, the number of participants was lower than the intended number of 120 (Tables 2 and 3). Age, gender, and examiner were not confounding factors for the diagnostic accuracy of the RDC/TMD examination and the dynamic/static tests (changes in

**Table 2** The RDC/TMD Clinical Examination\*

	Reference groups		
	Pain-free (n=121)	TMD pain (n=125)	Dental pain (n=88)
RDC/TMD examination			
TMD pain	35	110	48
No TMD pain	86	15	40
Diagnostic accuracy			
Sensitivity		88% (82–94%) <sup>†</sup>	
Specificity	71% (63–79%)		45% (35–55%)
Positive likelihood ratio	3.03 (2.58–3.68)	1.60 (1.45–1.78)	
Negative likelihood ratio	0.16 (0.11–0.21)	0.24 (0.18–0.30)	

\*Number of patients recognized with TMD pain or not in the three reference groups, and indicators of diagnostic accuracy (95% confidence intervals).

<sup>†</sup>Meets recommended minimal levels for TMD (ie, sensitivity  $\geq$  70%; specificity  $\geq$  90%).

**Table 3** The Dynamic/Static Tests\*

	Reference groups		
	Pain-free (n=121)	TMD pain (n=125)	Dental pain (n=88)
Dynamic/static tests			
TMD pain	11	81	14
No TMD pain	110	44	74
Diagnostic accuracy			
Sensitivity		65% (57–73%) <sup>†</sup>	
Specificity	91% (81–100%) <sup>†</sup>		84% (76–92%) <sup>†</sup>
Positive likelihood ratio	7.22 (5.45–10.31)	4.06 (3.36–5.46)	
Negative likelihood ratio	0.38 (0.32–0.44)	0.42 (0.35–0.49)	

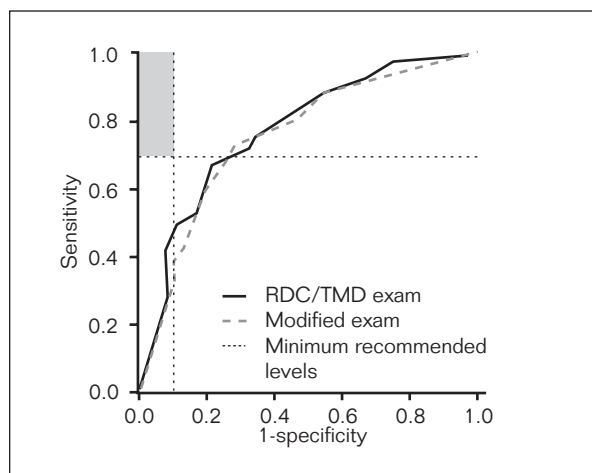
\*Number of patients recognized with TMD pain or not in the three reference groups, and indicators of diagnostic accuracy (95% confidence intervals).

<sup>†</sup>Meets recommended minimal levels for TMD (ie, sensitivity  $\geq$  70%; specificity  $\geq$  90%).

regression coefficients:  $\leq$  7%). Only in the comparison of pain-free subjects and TMD patients in the RDC/TMD examination was effect modification by age found ( $P < .05$ ). Stratification into two age groups (cutoff at the median value of 35 years) showed that the diagnostic accuracy for the younger subjects was higher than for the older subjects.

For the RDC/TMD, sensitivity (88%) was higher and specificities (pain-free group: 71%; dental pain group: 45%) were lower than the recommended minimal levels (Table 2;  $P < .001$ ). For the dynamic/static tests, sensitivity (65%) and specificities (91% and 84%, respectively) were not different from their recommended minimal levels (Table 3). Comparing the outcomes of the RDC/TMD examination and the dynamic/static tests showed higher positive LR for the dynamic/static tests ( $P < .001$ ) and lower negative LR for the RDC/TMD examination ( $P < .01$ ).

When the cutoff for the TMD subdiagnosis of myofascial pain was varied, the recommended levels of sensitivity and specificity for the RDC/TMD



**Fig 1** ROC showing the sensitivity and (1-specificity) of the RDC/TMD examination (solid line) and of the modified RDC/TMD examination (ie, without the unreliable muscle palpation sites; broken line), in the sample contrasting the TMD pain patients and the dental pain patients. The dotted lines represent the minimal recommended levels of sensitivity and specificity (see Tables 2 and 3), with the gray area representing that part of the graph in which both recommended levels would be fulfilled.

examination could not simultaneously be met (Fig 1: the ROC curve of the RDC/TMD examination did not enter the area in which both recommendations would be fulfilled). The same was true for the modified RDC/TMD examination. The AUC of the original RDC/TMD examination was 0.77 (95% confidence interval: 0.71–0.84), and that of the modified RDC/TMD examination was 0.76 (0.70–0.82): there was no difference in diagnostic accuracy.

## Discussion

In this multicenter study, the diagnostic accuracy of the RDC/TMD clinical examination and of the dynamic/static pain tests for the recognition of TMD pain was evaluated. A strong point of this study was the inclusion of two control groups; ie, a “traditional” group of pain-free participants and a group of persistent dental pain patients. Dental pathology is the primary cause of orofacial pain.<sup>22</sup> Therefore, clinical tests for TMD pain should especially be able to discriminate dental pain patients from TMD pain patients, which makes the inclusion of a dental pain control group essential in validity studies of TMD pain.

Ideally, in a validity study of musculoskeletal pain, the outcomes of the clinical tests are compared to a reference standard that confirms the presence of the pain. For some musculoskeletal pain disorders, such a reference standard is available. For example, the presence of sacroiliac joint pain was confirmed by intra-articular anesthetic block injections as a reference.<sup>23</sup> However, for other musculoskeletal disorders, such as myofascial TMD pain and fibromyalgia, objective data to recognize the disorder are lacking, and classification is usually based on expert opinion.<sup>1,4</sup> When the clinical tests that are being validated are also used in the allocation of the participants in validity studies to such disorders, there is a problem of circularity. This problem is discussed by Cohen and Quintner<sup>24</sup> in a critique on the diagnostic criteria for fibromyalgia, where it was stated that “diagnostic criteria...have been ‘validated’ via a circular argument in which the evidence on which the construct is based is taken as proof of its veracity.” To avoid such circular arguments, information from the clinical tests under study (ie, the RDC/TMD examination and the dynamic/static tests) was not used in the assignment of participants to their specific reference group. Instead, allocation was based on the outcomes of a standardized oral history, including questions regarding typical orofacial

pain symptoms, and a dental examination. The allocation of participants into the two control groups was straightforward. The pain-free participants did not report any orofacial pain complaints at rest or during function. In analogy to the RDC/TMD<sup>1</sup> and the guidelines of the American Academy of Orofacial Pain,<sup>25</sup> these patients are free of TMD pain. The dental origin of the orofacial pain in the dental pain group was confirmed by clinical signs and/or radiographic findings. For the TMD-pain group, several precautions were undertaken to assure that the orofacial pain complaint originated from the musculoskeletal structures of the masticatory system: the participants were recruited from those who were referred for TMD pain, the primary cause of orofacial pain (being dental pain) was excluded by the dental examination, and the report of pain was typical for TMD pain (in terms of location, description, influencing factors). Since other causes for orofacial pain are rare, and are commonly described in quite different terms (eg, burning or shock-like pain), it is likely that the allocation of TMD pain patients was in most, if not all, cases correct. Ultimately, it turned out to be difficult to recruit sufficient persistent dental pain patients in the settings of the university clinics. In most cases, patients were referred to the endodontic clinics of the dental faculties because they developed a persistent pain after a failed primary-care treatment. Comparison of the confidence intervals (Tables 2 and 3), however, suggests that the lower number of dental pain patients had no influence on the estimations of diagnostic accuracy.

Since TMD pain is a condition of low morbidity, it is important that healthy individuals are not subjected to unnecessary treatments. Therefore, the specificity of TMD tests should be high (at least 90%), while their sensitivity may be lower (at least 70%).<sup>1,20</sup> Sensitivity and specificities of the dynamic/static tests were not different from these recommended minimal levels. For the RDC/TMD, sensitivity was above, but specificities were below these levels. These findings were found irrespective of the dental faculty where the examinations were performed (no interaction with the examiner). The lower specificity in the dental pain patients as compared to the pain-free subjects, confirms that diagnostic accuracy can be overestimated when clinical tests are evaluated using healthy controls only.<sup>26</sup> The accuracy of the evaluated tests can probably be further improved by taking only those pain responses into account which resemble the pain complaints of the patient.

The RDC/TMD pain diagnosis strongly relies on palpation tests. In the fibromyalgia literature, the relevance of palpation in the recognition of musculoskeletal pain is a matter of debate. Although the number of tender points on palpation is used for the diagnosis of fibromyalgia,<sup>4</sup> low specificity of this criterion has been reported. Pain on palpation is suggested to be more a measure of general distress than of muscle pain,<sup>10,27,28</sup> while others have argued it to be indicative of a generalized heightened pain perception.<sup>11</sup> The often inflammatory origin of persistent dental pain (pulpitis or apical periodontitis) may have led to peripheral sensitization and hyperalgesia in the tissues surrounding the inflammation. The present outcomes suggest that hyperalgetic tissues are more susceptible to palpation pressure than to resisted mandibular movements, arguing in favor of the use of dynamic and static tests to discriminate between TMD pain and its most important differential diagnosis, ie, dental pain. Since the dynamic and static tests are not yet generally used to recognize TMD pain, some training in the specific techniques and in the verbal instructions to the patient will be necessary.

In an attempt to see whether diagnostic accuracy of the RDC/TMD examination could be improved by using another cutoff for the number of painful palpation sites necessary for the recognition of myofascial pain, a ROC analysis was performed. A change in cutoff for myofascial pain affected most diagnoses of TMD pain: 99% of the participants with a RDC/TMD pain diagnosis (also) had myofascial pain. When this cutoff was varied, the recommended minimal levels for sensitivity and specificity could never be simultaneously met. The same was true for the modified RDC/TMD examination, in which eight unreliable palpation sites were omitted. Since both versions of the RDC/TMD examination had the same diagnostic accuracy, and to avoid unnecessary burdening of patients, omission of the unreliable palpation sites from the examination is recommended.

The interpretation of test results is best illustrated by the use of LRs. Dynamic/static tests showed higher positive LRs than the RDC/TMD examination. This indicates that the odds of having TMD pain are higher after a positive dynamic/static outcome than after a positive RDC/TMD outcome. The smaller negative LRs of the RDC/TMD examination, on the other hand, showed that the odds of not having TMD pain are higher after a negative RDC/TMD outcome. Since the dynamic/static tests and the RDC/TMD examination seem to have their specific strengths and weaknesses, it seems challenging to combine their

outcomes to further improve diagnostic accuracy. This can be evaluated by simply multiplying the LRs, or by using more sophisticated strategies which result in adjusted LRs which are corrected for possible interdependence of the tests under evaluation.<sup>29</sup> This will be a matter of further study.

No attempts were made to estimate the diagnostic accuracy of subdiagnoses of TMD pain (ie, muscle or joint pain). Pain in the region of the temporomandibular joint can also originate from the muscular structures and, especially in persistent TMD patients, both structures are often affected simultaneously.<sup>30</sup> Therefore, it was regarded as impossible to come to a trustworthy reference standard of subdiagnoses of TMD pain without also using the information from the clinical examinations. In the latter case, problems of circular arguments would arise, which cannot easily be solved.

Within the limits of this study, it is concluded that confirmation of a suspicion of TMD pain better relies on a positive dynamic/static test outcome. Confirmation of the absence of TMD pain better relies on a negative RDC/TMD examination outcome. Intraoral and submandibular palpation sites can be omitted from the RDC/TMD examination, without losing diagnostic accuracy.

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