

Reliability and Validity of the Diagnostic Criteria for Temporomandibular Disorders Axis I in Clinical and Research Settings: A Critical Appraisal

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The recently published Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) Axis I, which is recommended for use in clinical and research settings, has provided an update of the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD). The authors of the DC/TMD based their publication on the results of a Validation Project (2001–2008) and consecutive workgroup sessions held between 2008 and 2013. The DC/TMD represents a major change in both content and procedures; nonetheless, earlier concerns and new insights have only partly been followed up when drafting the new recommendations. Moreover, the emphasis on immediate implementation in clinical and research settings is not in line with the provided external evidence on which the DC/TMD is based. This Focus Article describes these concerns with regard to several aspects of the DC/TMD: the additional classification categories; the high dependency on pressure-pain results from use of the recommended palpation technique; the TMD pain screening instrument; the test population characteristics; the utility of additional subgroups; the use of a reference standard; the dichotomy between pain and dysfunction; and the DC/TMD algorithms. Thus, although the DC/TMD represents an improvement over the RDC/TMD, its immediate implementation in research and clinical care does not yet appear to be adequately substantiated. *J Oral Facial Pain Headache 2018;32:7–18. doi: 10.11607/ofph.1704*

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Temporomandibular disorders (TMD) are musculoskeletal conditions that involve the masticatory musculature, the temporomandibular joints (TMJs), and associated structures. TMD is an umbrella term, not a diagnostic entity. Loading the affected muscular or articular structures during activities such as yawning, biting, or chewing hard/tough food will typically provoke the clinical signs and symptoms that the patients mention at consultation. The international TMD literature is unanimous in differentiating between muscular and articular subtypes of TMD. The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) has played a major role in allowing worldwide comparisons of research.¹ Axis I of the RDC/TMD deals with the physical characteristics of TMD, while Axis II is designed for evaluation of TMD-associated psychosocial aspects.

The RDC/TMD was conceptualized before 1992. New insights have suggested a need for changes to the original version; indeed, as early as in their original 1992 publication, the authors of the RDC/TMD had pointed out the need for its occasional revision. Various investigations, including study results on the reliability of clinical TMD diagnoses,² have indicated that the characteristics of the RDC/TMD have not met original expectations despite profound calibration of the researchers testing for Axis I reliability of symptoms and subgroup classifications.^{2–4} In fact, for most of the non-pain-related subgroups—and thereby for this classification system as a whole—both the reliability and the criterion validity have been found to be barely acceptable for use in investigations of the general population or in patients asking for therapy in clinics specialized in TMD diagnosis and management.^{4,5}

Table 1 Previous Suggestions for Updating the RDC/TMD^{11,12} and Their Endorsement for the DC/TMD⁷

Suggested changes	Endorsement	
	Yes	No
Reproduction of the main complaint	✓	
Additional clinical subgroups (eg, disc displacement with catching)	✓	
Update of disc displacement criteria	✓	
Inclusion of other clinical tests		✓
Fewer muscle palpation sites	✓	
Additional palpation techniques		✓
Exclusion of extra- and intraoral palpation sites		✓
Re-evaluation of group I, II, and III algorithms	✓	
Restriction to calibrated examiners and research purposes		✓
Identification of pathology or other sources of orofacial pain first, before applying RDC/TMD	✓	

In a Validation Project funded by the United States National Institutes of Health (NIH) and executed by several experienced TMD researchers from the International RDC/TMD Consortium Network and the Special Interest Group of the International Association for the Study of Pain (IASP), the RDC/TMD Axes I and II were evaluated between 2001 and 2008. The results were discussed in working groups around the world between 2008 and 2014, resulting in the revised RDC/TMD classifying algorithms in 2010⁶ and in a major revision termed the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) in 2014, with yet again readapted algorithms.⁷ The DC/TMD encompasses existing, new, and extended subgroups of TMD to support the claim for immediate implementation in clinical and research settings. The DC/TMD partly incorporates the American Academy of Orofacial Pain (AAOP) classification,⁸ and one DC/TMD muscular subgroup (headache attributed to TMD) originates from the International Headache Society (IHS) classification.⁹ The criterion validity of most of the TMD subgroups is now part of the DC/TMD based on sufficient data from the Validation Project.⁷ The inter-examiner reliability of the DC/TMD algorithms was tested in 46 patients by 6 examiners, implementing the TMJ Impact Project.⁷

The improvements, together with the meticulously executed and discussed methodology, do deserve compliments. Given the International RDC/TMD Consortium Network's request^{5,7,10} to the larger TMD community to provide input and discussion regarding the future of RDC/TMD research, the authors of the present Focus Article were motivated to critically assess the DC/TMD and to offer a positive contribution for improvement of its Axis I, as was the case for a previous publication.¹¹ Hence, the aim of this article is to discuss the DC/TMD from the perspective of the

RDC/TMD and the Validation Project, under consideration of the claim for immediate implementation in clinical and research settings.

This Focus Article only addresses the Axis I component of the (R)DC/TMD. Aspects of Axis II are discussed in the context of Axis I.

DC/TMD and RDC/TMD Axes I in Clinical and Research Settings

On two previous occasions, various aspects of the RDC/TMD were reviewed by two of the present authors, and suggestions for improvement were presented.^{11,12} The most important suggestions are summarized in Table 1. Some of these suggestions have been adopted in the revised RDC/TMD and in the DC/TMD, and others have been put aside. All operationalized changes from the RDC/TMD to the DC/TMD have been described in the DC/TMD publication.⁷ This Focus Article will focus on four aspects from the perspective of their clinical application: (1) familiar pain; (2) TMD categories; (3) palpation; and (4) diagnoses.

Familiar Pain

One important suggestion for improvement of the RDC/TMD was related to reproduction of the main complaint.^{11,12} The principal challenge of making a diagnosis in patients with putative TMD signs and symptoms is to relate the complaints of the patient to the affected structures.^{13,14} Consequently, in the revised RDC/TMD as well as in the DC/TMD algorithms, the construct of "familiar pain" was introduced.^{15,21} Familiar pain is defined as "pain similar to or like what he/she had been experiencing from the target condition outside the examination setting."¹⁵ This distinction is critical because tenderness on palpation of the masticatory muscles or TMJs may also be elicited in individuals without TMD or in patients with other pain conditions; hence, a distinction is made between familiar pain and any other pains in the particular region being investigated. The original RDC/TMD myofascial pain algorithm made a classification in the presence of any pain with a minimum of 3 out of 20 painful sites and at least 1 painful palpation site on the same side as the ongoing pain, but without the condition for familiar pain. With such criteria, a reliable myofascial pain or TMJ arthralgia classification cannot be established, and overdiagnosis of myofascial pain may instead be the result. In fact, the prevalence of group I diagnoses was about 45% lower when the number of painful palpation sites on the side of the ongoing pain was at least three as opposed to at least one (76% vs 31.4%, respectively).¹⁶

The introduction of the construct of familiar pain has significantly improved the reliability of the test results for the revised RDC/TMD myofascial pain algorithm.⁶ It may be discussed, however, whether familiar pain provoked by palpation—in the RDC/TMD, revised RDC/TMD, and DC/TMD (operationalized as pressure)—is equivalent to pain provoked by functional loading of the masticatory structures, as is the case during muscular stretching or mastication of hard or tough foods. Hence, the presence of both conditions (pain on palpation and during mandibular function) seems more adequate as a criterion to apply in the confirmation of TMD.

TMD Categories

Additional categories were proposed by the authors of the DC/TMD to meet the objective of using this classification system in clinical settings. The most important previously missing category, which had been formerly suggested as an addition to the RDC/TMD, is “disc displacement with catching,”¹¹ now identified as “disc displacement with reduction with intermittent locking.” The categories “subluxation,” “headache attributed to TMD,” and three subcategories of myalgia have been supplemented. The utility of the three myalgia subgroups has been questioned elsewhere by some authors of the DC/TMD,^{17,18} and the categories “subluxation” and “headache attributed to TMD” will be discussed below. The RDC/TMD diagnosis “myofascial pain with limited opening” was eliminated as a separate category, but the RDC/TMD Validation Project provided no explanation for this decision. This latter RDC/TMD diagnosis should be re-introduced for the reasons outlined below.

Disc displacement criteria were also revised. Criteria that are widely used clinically for disc displacement with reduction (ie, the elimination of a click while opening and closing with the mandible in protrusion; loudness of a closing click with counterforce on the mandible^{19,20}) have been abandoned. TMJ clicking on either opening or closing the jaw now qualifies for disc displacement with reduction.

Palpation

The number of muscles to be palpated in the DC/TMD has been reduced compared to the RDC/TMD. Both the temporalis and masseter muscles seem logical sites to palpate because these muscles are the most clinically relevant and are the only jaw muscles accessible to extraoral palpation. Palpation in its original (and broad) sense is an examination for the purpose of diagnosing disease or illness; it provides information about the areas of pain, wind-up phenomena, hypersensitivity, and tender spots that may provoke symptoms. During muscle palpation, the clinician assesses stiffness, tissue texture, the contrast

of the muscle tone between contraction and relaxation, symptoms provoked by muscle palpation, and the reaction to palpation during muscle stretch and muscle contraction. The relevant tissues should be palpated not only for tenderness, but also for tissue changes, such as induration.

In the DC/TMD, the technique mandated for muscle palpation does not fully comply with the original description in the RDC/TMD, as it is restricted to assessing the intensity of pain originating from a muscle site after pressing for a certain amount of time with a defined amount of force (1 kp). In order to classify three muscle pain-related conditions, the elicited pain is further evaluated as to its location and distribution on the basis of palpations of 2 and 5 seconds, respectively. The rationale for choosing 2 and 5 seconds has not been explained, nor has the time period between these two palpations been specified. Furthermore, palpation to obtain an insight into tissue characteristics or to detect pathology is still not an issue; instead, pain provocation is the only characteristic assessed, albeit supplemented by confirmation of its location and by the construct of familiar pain. In order to use the information gained from this palpation methodology in clinical practice, other clinical conditions and diagnoses need to be excluded beforehand.

Surprisingly, palpation of supplemental muscle sites that are anatomically not accessible is still endorsed in the DC/TMD protocol and includes the amount of palpation pressure²¹ despite the evidence for the inaccessibility of these muscles, as is the case for the lateral pterygoid muscle²² and the posterior digastric muscle.²³ In the new protocol, pressure in the posterior mandibular region is now carried out medially at the posterior aspect of the mandibular angle and at the medial wall of the mandible, probably aiming at the attachment of the medial pterygoid muscle. Yet, the region behind the posterior aspect of the mandibular ramus contains many structures that may easily produce pain when pressure is applied even among symptom-free individuals, which may include non-TMD patients. The tendon of the temporalis muscle is the only clinically relevant and accessible intraoral palpation site in the DC/TMD; however, pressure on this structure is usually unpleasant, even in healthy individuals. Hence, instructions for palpation of supplemental muscle sites (ie, the lateral pterygoid, posterior digastric, and posterior mandibular region) should be omitted from the clinical protocol.²¹

Palpation of the TMJs in the DC/TMD differs from the RDC/TMD description. The rationale behind palpation “around the lateral pole of the condyle”¹⁵ is not mentioned. This method has neither been described nor used in other TMD protocols, thereby

lacking content validity. Well-established methods to assess pain originating from the TMJ, in particular from its posterior structures,²⁴ have been abandoned, but “can be used when indicated.”⁷ Yet, the corresponding indication has not been provided. More importantly, when following the pain-related TMD algorithms, palpation of the lateral pole of the condyle during jaw opening is now critical in the distinction between articular and muscular pain (arthralgia vs myalgia), as the location of the pain has become a major criterion in the DC/TMD protocol. However, overlap of articular and muscular structures (the deep portion of the masseter muscle with the anterior part of the joint capsule) makes such a distinction sometimes difficult, especially in a protruded mandibular position mandated for palpation of the posterior part of the TMJs as part of palpation around the lateral pole.²¹ Since protrusion by itself may provoke pain, palpation without protrusion via the external auditory meatus needs to be carried out as well. The rationale behind these proposed procedures is unclear. In how many cases will anterior, superior, and/or inferior palpation be positive when posterior palpation is negative? In addition, one should always recall that the site of the pain may not always be the source of the pain, especially in the distinction between articular and muscular pain when the pain-related TMD and headache algorithm is used.

Besides these aspects, correlation between digital examination of the lateral pole of the TMJ and the range of mandibular motion to assess condylar sliding during opening and closing of the jaw and in excursive mandibular movements is lacking in the DC/TMD. Again, the focus is on pain provocation, not on other qualities.

Clinicians typically use a systematic approach in their assessment and continuously match the obtained information with other findings. Taking a history is more than asking questions and documenting the patient's answers. While taking the history, aspects such as general appearance, state of nutrition, symmetry, head posture, speech, skin condition, and engagement in oral habits can be observed. Pain provocation through pressure only contributes a small amount to the diagnostic process. Pressure to establish pain intensity receives too much emphasis in the DC/TMD over other aspects of the physical examination, such as pain provocation by mandibular movements or palpation as a tool for detecting pathologies.

Diagnoses

In clinical practice, patients with pain and dysfunction of the masticatory system may have all kinds of alternative or additional conditions. The following two citations from the RDC/TMD Validation Project⁴ and the DC/TMD⁶ may serve as examples:

The study attempted to exclude subjects with other forms of regional pain including odontogenic pain, any specific craniofacial neuralgia, nonspecific neuropathic pain, and pain arising from recent trauma in addition to pain associated with fibromyalgia, rheumatoid arthritis...these findings should be viewed as preliminary data to be taken into consideration for future study designs.⁴

The reader is advised that before applying the revised algorithms, it is necessary to assess for and rule out other pathology, including the conditions that are listed in the exclusion criteria for the RDC/TMD Validation Project.⁶

In this sense, the DC/TMD is an improvement compared to the RDC/TMD. Nonetheless, it would have been beneficial to cite this latter remark in the Introduction or to position it as a disclaimer at the beginning of the DC/TMD publication and in the assessment instruments on the RDC/TMD website with a specific reference to the different types of odontalgia, as they represent the most frequent orofacial pains. This would also reflect the necessity of beginning any examination with an open mind. The assumption at the beginning of a clinical assessment that a non-specific TMD is playing a role in a particular patient suggests that many clinicians may not consider other sources of pain and dysfunction of the masticatory system. The possible flaws that may result from such a strategy are illustrated in case reports published in the dental literature.²⁵⁻⁴⁰ The scope of the DC/TMD is much narrower than the open mind that clinicians should have when confronted with patients with putative TMD signs and symptoms. As the DC/TMD authors themselves indicate, the values for diagnostic sensitivity and specificity need to be looked at with great care, because “the study was not designed to provide estimates in patients with comorbidities.”¹⁵

The DC/TMD may serve as an adjunct to other existing protocols aiming to exclude other pathologies.^{4,6} As soon as all other pathologies (not only pain-related) have been excluded, including the different forms of odontalgia⁴¹ and systemic diseases (eg, fibromyalgia, rheumatoid arthritis), the resultant potential “nonspecific” TMD may be classified following (an updated version of) the DC/TMD or any other validated protocol that a clinician is using or is familiar with.⁴²

It should also be noted that in clinical practice the reliability of classification of subcategories is expected to be lower than that of the DC/TMD, which was developed by highly calibrated examiners with ongoing training.

In summary, the DC/TMD has undoubtedly improved upon the original RDC/TMD. However, this new classification and diagnostic scheme is highly pain oriented, and (dys)function does not receive much attention. Palpation, operationalized as pressure on tissues of the masticatory muscles and the TMJs, still plays a dominant role in classification. Finally, the statement that the RDC/TMD has served the community well does not agree with the outcome of the Validation Project.⁵ Overdiagnosis (eg, myofascial pain) and overtreatment may well have resulted from this classification. On the other hand, underdiagnosis may also have been a consequence of the strict application of the RDC/TMD criteria, for instance in individuals with (deep) temporomandibular pain in the absence of relevant findings during the clinical examination.

DC/TMD Axis I and the Validation Project

In addition to the general concerns regarding the DC/TMD proper, the Validation Project—which was the basis for the DC/TMD—also merits discussion. The following discussion will focus on six relevant aspects: (1) the Axis I TMD pain screener; (2) the test population characteristics; (3) the utility of additional subgroups; (4) the reference standard; (5) pain and (dys)function; and (6) the algorithms.

Axis I TMD Pain Screener

An Axis I pain screener was introduced by Gonzalez et al⁴³ as a simple, reliable, and valid self-report instrument in the DC/TMD that “. . . will allow clinicians to identify more readily—and cost-effectively—most patients with painful TMD conditions for whom early and reliable identification would have a significant effect on the diagnosis, treatment, and prognosis.”⁴³ Pain and stiffness in the jaw in the morning and pain-related changes in the jaw during certain activities (such as chewing hard or tough food), mandibular movements (such as yawning), and parafunctions (such as jaw clenching) are included in the TMD pain screener, but these functional activities may provoke non-TMD-related pain as well. Therefore, although the screener can be important in patient care in general dental practice (for instance, when a patient has to be referred to a TMD specialist or is a likely candidate for intervention⁴³), it is crucial to be cautious with this module. Still, the study population used to provide test characteristics of the screener was a selection of cases and controls originating from the Validation Project. This is a selected TMD population, not an open population in which screening is indicated. Because of this, the groups to be

compared are restricted to painful TMD patients (as established by the criterion examiners) and healthy controls, nonpainful TMD patients, and TMD patients with headache (pain vs no pain and pain vs headache). The high values for diagnostic sensitivity and specificity are based on these obvious aspects. Any consultation with patients encompasses and starts with questions like those included in the screening evaluation, so its additional value is questionable. It will certainly not select or triage patients for being candidates for intervention or select TMD patients in a nonselected population with similar high positive and negative predictive values, as found in the study that resulted from circularity in the design (ie, the questions in the screener are similar to those in the reference standard examination). The results of the investigation by Gonzalez et al⁴³ on the reliability and validity of the pain-screening questionnaire are too positive as well, because an optimized prediction model will reach a certain level of correctness solely due to the number of random variables as predictors. A part of the model performance is “for free,” but also meaningless. This phenomenon is known as the optimism of a prediction model.⁴⁴ Hence, the TMD pain screener should not be used in clinical settings as proposed.⁷ Any additional pain conditions need to be ruled out first. The patient group in the investigation by Gonzalez et al also consisted of a subgroup with odontalgia, and the logistics of this investigation did not allow the inclusion of values for sensitivity, specificity, negative predictive value, and positive predictive value for this subgroup in comparison to TMD pain or headache or to patients without pain.⁴³ Other authors have suggested the inclusion of a dental pain group as well in order to “discriminate dental pain patients from TMD pain patients.”⁴⁵ The use of clinical tests for TMD pain in such a context is not compliant with clinical practice because in patients presenting with orofacial pain, the dentist will evaluate the presence of odontalgia first by using primarily dental tests. TMD pain tests are not relevant for this purpose. Because toothache is the most prevalent source of pain in the face and jaw, the discrimination between TMD pain and odontalgia (as well as other possible sources of pain) belongs to the very first phase of the diagnostic process. It is advised, therefore, to specifically mention odontalgia in the disclaimer because this condition needs other tests for confirmation (also see below).

Test Population Characteristics

In selecting the study population, the procedures⁶ followed the Standards for Reporting of Diagnostic Accuracy (STARD) requirements,⁴⁶ beginning with: “Are the test results in patients with the target condition different from the results in healthy people?”⁶

If so, a second question needs to be answered: "Are patients with specific results more likely to have the target condition than similar patients with other test results?"⁶ Due to the relatively large number of individuals who were invited to participate in the investigation by telephone, advertisement, or flyer (thus qualifying as community cases [n = 359, 72%]¹⁵ as opposed to clinic cases [n = 141, 28%]¹⁵), too few comorbid conditions were prevalent in the study sample to answer this question.⁶ This challenges the generalizability of the study results. Patients with pain and dysfunction of the masticatory system due to other pathologies were excluded from the study population because their sample size was too small. The sensitivity and specificity presented in the RDC/TMD Validation Project are expected to be less favorable in other settings, for instance, in a dental practice.

The population characteristics also differ from a clinical setting with respect to the duration of the pain complaints (averages range from 100 to 126 months), suggesting an exaggeration in the number of patients diagnosed with persistent temporomandibular pain. Chronicity and its associated comorbidity are more prevalent in dental clinics focused on special needs than in a general dental practice, thus jeopardizing the generalizability of the reported results.

Another selection bias may be the low threshold for having at least one of the three cardinal TMD symptoms; ie, jaw pain, limited mandibular movement (in most cases, restricted jaw opening), and TMJ noise.¹⁵ This is important, since in recent studies high prevalence rates of TMD-related pain conditions were found when the RDC/TMD was used. For example, in an investigation analyzing factors associated with TMD pain in adolescents, group I and group III RDC/TMD diagnoses were selected to detect TMD pain, and a prevalence of 25.5% was found.⁴⁷ Apart from using a global system to classify patients, it would be mandatory to define having TMD in epidemiologic studies similarly, relying on similar operationalized criteria worldwide. However, when the criteria result in such high prevalence values, the RDC/TMD may not be representative for patients in general dentistry. A statement about low treatment need for most TMD cases is necessary when using other criteria that unveil all TMD cases, including those without a treatment need.

It is well known that in the general population, treatment need for TMD is much lower than its prevalence.⁴⁸ In the RDC/TMD Validation Project population, 40% of the community cases received five diagnoses, and almost 50% of the community were non-pain-related TMD individuals with two diagnoses.¹⁵ Considering that nonpatients did not demand therapy, the number of subgroup categories is unexpectedly high. In an earlier study, 30% of a pain-free population received a TMD pain diagnosis accord-

ing to the RDC/TMD.⁴⁵ It seems that the RDC/TMD criteria and the associated multiple diagnosis system render too many diagnoses, thereby raising doubt as to the validity of the RDC/TMD and probably the DC/TMD, given the major role of pain on palpation in both classifications. Yet, it is still the patient report about her/his perception of pain during mandibular function that is the first requirement for making a (R)DC/TMD diagnosis; tenderness on palpation alone does not qualify for a (R)DC/TMD pain diagnosis.

Due to the low threshold for being a case, the study group in the Validation Project contained many community cases without a treatment demand. In future study groups, the reliability of classified conditions needs to be tested in TMD patients with a concomitant demand for therapy in order to better simulate clinical patients.

Utility of Additional Subgroups

In the DC/TMD, pain-related TMD include the subgroup "headache attributed to TMD."⁷ Unfortunately, the relevance of the distinction between headache and myalgia is not explained. Headache in the region of the anterior portions of the temporalis muscle(s) can result from various pain sources. The DC/TMD unambiguously states that "a diagnosis of pain-related TMD (eg, myalgia or TMJ arthralgia) must be present and is established using valid diagnostic criteria."⁷ But what is the need for the separate subgroup for headache attributed to TMD when the pain has already been classified as TMD-related pain? Should a subgroup "otalgia attributed to TMD" be supplemented as well? Pain in the temporalis region may present in conjunction with arthralgia; is it then tension-type headache or myalgia in the temporalis region in conjunction with arthralgia? It seems more appropriate to use "myalgia (in the temporalis region)" in such cases. In the IHS classification this subgroup makes sense, but not in the DC/TMD.

Subluxation is an additional DC/TMD category. In the literature, the term "subluxation" has raised much confusion because it has been defined in a highly variable way.⁴⁹ Other conditions, such as mandibular hypermobility and disc dislocation, have been described similarly. In 87% of the general population (in some individuals more expressed than in others), the condyle moves beyond the inferior crest of the articular eminence during maximum jaw opening without any hindrance in jaw closure or any other TMJ-related symptomatology.⁵⁰ This phenomenon is neither a hypermobility disorder nor is it known to be a predictor of dislocation. Conversely, clinically relevant conditions are (habitual) dislocations (luxation, open lock) with condylar sliding beyond the lower crest of the eminence and with the mandible in an elastic fixation in the wide-open position.

Perceived clicking or popping at the end of jaw opening requires further evaluation by the clinician in order to assess whether the symptom is related to the condyle moving beyond the crest or to clicking in the final phase of jaw opening due to a disc displacement. Therapeutically, neither condition needs more than explanation and advice for the patient; therefore, it would be better to eliminate the subgroup “subluxation” and to use “luxation” instead when it relates to a single event. The term “habitual luxation,” on the other hand, should be used in cases in which dislocations occur more frequently, regardless of whether the patient or the examiner needs to maneuver the jaw. In sum, it is suggested to omit the myalgia subgroups, the subluxation subgroup, and the headache attributed to TMD subgroup.

Reliance on the DC/TMD in patients with restricted jaw opening in association with myalgia apparently does not result in a correct diagnosis. In contrast to the RDC/TMD, the DC/TMD no longer includes this condition, although it is a prevalent clinical entity. A more than 5-mm difference between assisted and unassisted jaw opening (“soft endfeel”) in combination with familiar pain, as well as a jaw opening of less than 40 mm and normal range of motion values for the horizontal movements, are indicative for the group “myofascial pain with limited mouth opening.” These considerations support the need for the former diagnostic RDC/TMD group to be re-introduced.

Regarding the expanded TMD taxonomy, which was published separately from the DC/TMD,⁵¹ the DC/TMD is oscillating between two thoughts. On the one hand, a diagnosis is only made after excluding all other pain-related and non-pain-related pathologies. On the other hand, it has been suggested to include in the DC/TMD (at a later stage) specific but less common TMD conditions, which have been listed in the expanded taxonomy.⁵¹ However, when the DC/TMD is used at the initial consultation, the history, physical examination, and presented algorithms are inadequate to diagnose these specific conditions. Besides, inspection as part of the physical examination is lacking, which is very important for conditions mentioned in the expanded taxonomy, such as neoplasms or growth disturbances. Simple algorithms like those used in the DC/TMD will never yield any of the conditions mentioned in the expanded taxonomy. Therefore, it is advised that the DC/TMD be restricted to the most common pain-related and intra-articular manifestations of TMD.

Reference Standard

In assessments of patients, the validity of an instrument is as important as its reliability. An instrument can be highly reliable, but not valid. The DC/TMD

publication has stated that “validity of diagnostic criteria revolves around the use of reliable clinical tests.”⁷ Undoubtedly, the validity critically depends on the reliability of the clinical tests when using criterion examiners as a reference standard and test examiners for evaluation of the criterion validity of the index tests.¹⁵ Using this method, the tables presented in the DC/TMD publications⁵⁻⁷ in fact represent calculations of reliability. Circularity has been avoided as much as possible¹⁵; nevertheless, the test examiners and the criterion examiners, by knowing and using the algorithms, are not independent, thus leading to a certain degree of circularity. In conditions such as TMD, it is impossible to use an independent reference standard when biomarkers are not available. The help of imaging techniques for the criterion examiners is not useful, since the association between symptoms and imaging results is low.⁵² While the method of using two random samples of one specific population under study is a proper validation procedure, the strength of the model in another population (external validity) is still unknown. A reference standard for TMD does not exist, and so values for diagnostic characteristics—such as sensitivity, specificity, positive predictive value, and negative predictive value—should not be used. Therefore, it is advisable to limit the presented data to the concept of reliability of clinical entities.

The reliability of the assessment of various TMD symptoms and classification of subgroups following the RDC/TMD has been found to be unacceptable. In a multicenter study, major differences in clinical TMD subgroups existed even among highly calibrated examiners, despite broad categories.^{2,3} Percent agreement, heavily inflated through agreement by chance and clustering into myofascial pain, disc displacement, and degenerative joint disorder, was able to yield positive results leading to the authors' conclusion that the results supported the use in clinical research and decision-making (clinical practice).² However, only categories such as (muscle- or joint-associated) pain and no pain (intraclass coefficient [ICC] 0.72) and diagnosis vs no diagnosis (ICC 0.78) reached sufficiently acceptable values to have clinical utility.²

Similar results were obtained in the Validation Project of the RDC/TMD³: The reliability of the revised RDC/TMD Axis I diagnoses was found to be excellent, with κ values > 0.75 only for all myofascial pain subgroups. Considerable uncertainty existed for the other groups. Compared with the RDC/TMD Validation Project, the DC/TMD reliability values were based on a relatively small sample of 46 individuals (92 TMJs).⁷ Considering this limited data, immediate implementation of the DC/TMD procedures in clinical practice is not advised.

Pain and Dysfunction

In both the DC/TMD and the RDC/TMD, pain and dysfunction are evaluated separately. This nonclinical dichotomy is necessary to be able to compose the simple classification algorithms. However, just as Axis I and Axis II are constructs in the same patient, both pain and dysfunction need to be assessed in their mutual relation. The concept of replication of the main complaint is based on this principle, among others. The number of the resultant multiple diagnoses is high after pain and dysfunction are assessed separately in cases and controls (see above); nonetheless, patients may not be sufficiently characterized through the summation of the maximum of five Axis I classifications permitted for a single patient. Moreover, the management plan does not always differ among subgroups.

In contrast, assessing pain and dysfunction in their mutual relation provides additional information about the underlying substrate (eg, myofascial pain with limited jaw opening), as opposed to assessment of pain and dysfunction as separate entities. Multiple diagnoses are still possible when assessed together in the same patient, but the clinician is better able to grade the identified signs and symptoms and thereby to determine the patient-specific therapeutic need than with the mere use of multiple independent diagnoses.

The construct "familiar" (as used in the term "familiar pain") can be used for any symptom that is part of the patient's complaint. In the case of a painful click during jaw opening as reported by the patient, it is necessary to ensure a clear communication between the patient and the examiner; in particular, it should be assessed whether the click is due to an anterior disc displacement or to the condyle popping beyond the inferior crest of the articular eminence, as well as whether pain is elicited at the moment of the phenomenon (eg, pain-free clicking vs painful clicking). It is not adequate to assess pain and clicking separately.

The nonclinical dichotomy of assessing pain and function separately has yet other consequences. In the DC/TMD, pain drawings indicating the location(s) of a patient's pain are used. The drawings show a full body (front and back) template, a head and neck (left and right, but not the shoulders) template, and an intraoral template. The drawings and the assessment of impairments of mandibular function are part of Axis II, but this is in fact Axis I physical information. It is crucial for the treatment provider in clinical settings to assess all pain locations as Axis I information because this information is relevant for prognosis and therapy.⁵³ Other consequences of assessing pain and dysfunction separately are that palpation is restricted to one dimension: pain on pressure. Joint

locking is assessed for reduction and unlocking; however, whether a pain report is linked to mandibular function is not evaluated.

Patterns of signs and symptoms mandatory for defining TMD subgroups that are absent in patients are likely to disturb diagnostic accuracy. One example is the pattern of deflexion of the mandible to the affected side upon mandibular opening movement; this is highly predictable for an acute unilateral disc displacement without reduction, while a clinical finding not fitting this pattern raises doubt with regard to this diagnosis. Another example is a jaw opening of less than 20 mm, which is atypical for nonspecific TMD, but not part of a disclaimer. Hence, clinically relevant pattern recognition is absent in the DC/TMD.

Teaching clinicians to think of pain and dysfunction as separate entities provides them with a false start in the process of clinical reasoning. Clinicians tend to stick to a first impression and often forget to keep an open mind at the first consultation, as well as during the subsequent management of their patients. Diagnostic error is defined as "the failure to (a) establish an accurate and timely explanation of the patient's health problem(s) or (b) communicate that explanation to the patient."⁵⁴ Anchoring (the tendency to lock onto salient features in the patient's initial presentation and to fail to adjust this initial impression in light of subsequent information) and premature closure (the tendency to accept the first answer that explains the facts at hand without considering whether there might be a different or better solution) are frequent biases in clinical practice.⁵³ Using the oversimplified TMD pain screener and examining the patient from the viewpoint of the separate entities pain and dysfunction in general dental practice are bound to increase this type of diagnostic error.

Algorithms

The evolution of the original 1992 RDC/TMD algorithms was tested in the Validation Project. The results led to the revised RDC/TMD algorithms presented in 2010. Workshops held in different parts of the world and involving members of the International RDC/TMD Consortium Network and the IASP Orofacial Pain Special Interest Group produced the current DC/TMD algorithms. It is beyond the scope of this Focus Article to identify all differences among the three versions; however, due to the additional myalgia subgroups and the arthralgia subgroup, modifications of the pain-related DC/TMD algorithms are larger than those between the original and revised RDC/TMD algorithms. The same holds true for the disc displacement and degenerative joint disease algorithms.

In the DC/TMD, several subgroups still lack values for diagnostic accuracy. This is due to major changes in the transition of the revised RDC/TMD to the DC/

TMD. The process for providing subgroup diagnostic accuracy has been less clearly described than the process of transition to the revised RDC/TMD. It was stated that “sufficient data from the Validation Project existed to provide a credible estimate of the criterion validity.”⁷ This concerned the validity of the newly recommended DC/TMD Axis I diagnostic algorithms⁷; however, it is not clear which “sufficient data” were used. With so many of its components still being developed, the prompt implementation of the DC/TMD should not be based on this limited information.

Another aspect that deserves attention is the number of positive test results in the case of repetitive diagnostic procedures: In the DC/TMD this is one out of three, whereas in the original RDC/TMD this was two out of three. Probabilistic (Bayesian) reasoning implies that the presence (or absence) of findings (ie, positive vs negative tests) can raise the likelihood of a condition.⁵³ A symptom is more stable when it is tested positively in three out of three tests. In this strict interpretation, a two out of three outcome would be interpreted as a negative overall test result. Hence, the reliability of the subgroup classification based on a set of positive tests will increase in proportion to the percent of positive responses. Would it, therefore, not be preferable to require at least two out of three positive test results, as in the RDC/TMD, or even three out of three positive test results for research purposes, which would be a better indication of homogenous patient groups? In research a patient can be excluded for a test or a trial, but in the clinic, patients need to be accommodated. Using one out of three positive test results may be sufficient in a clinical setting, particularly to avoid too many patients finding themselves undiagnosed.

The DC/TMD algorithms need to be simple in order to generate the classified TMD conditions, but at the cost of a limited scope regarding clinical reality. For example, in the history level (Symptom Questionnaire item 3), replacement of regional pain with wisdom tooth pain (representing regional pain modified by jaw opening) would lead to the category “myalgia” in the pain-related TMD algorithm. Although the muscles may be sore, they certainly do not require therapy in such a case, and the necessarily simple DC/TMD algorithm may lead the clinician’s reasoning in the wrong direction. More “AND” statements in the pain-related algorithms may result in increased diagnostic accuracy. In the myalgia subgroup, “familiar pain from jaw opening” (exam item 4) during examination is expected to be accompanied by the similar “familiar pain on masticatory muscle palpation, 2 secs” (exam item 9). In the context of probabilistic reasoning, “AND” is more appropriate than “OR.” Similarly, it seems more appropriate to connect “arthralgia on jaw opening” (exam item 4) to “jaw horizontal movements” (exam item 5) with

“AND” instead of “OR.” Other “AND/OR” statements in these algorithms need further consideration as well. Likewise, “pain modified with mandibular function” is preferred over “pain modified with jaw movement, function, or parafunction,” because it is questionable whether patients can reproduce parafunction on command. Since mandibular function includes jaw movement, the latter term can be eliminated from the phrase. Furthermore, at the history and examination levels for intra-articular disorders, prior jaw locking at closed jaw does not really describe the actual condition; “jaw locking with limited opening” is preferred. A “maneuver required to open the mouth” in disc displacement with intermittent locking could preferably be stated as a “maneuver required to unlock the joint.”

Crepitus in conjunction with putative degenerative joint disease may be confirmed by computer tomography²¹ (CT) or by cone beam computed tomography (CBCT); a reference to the specific indication is necessary. However, the need for imaging when the only symptoms and signs are TMJ noise is highly questionable. Exclusion of clinically relevant pathologies is the main indication for TMJ imaging.

In the body of the text of the DC/TMD, pain modification in a patient report is described as “pain made better or worse” by loading the masticatory system (ie, through function, movement, or parafunction).⁷ However, pain modification also relates to pain that was previously absent but is induced by diagnostic manipulations, as indicated in the legend of Table 2 in the DC/TMD. Both descriptions should receive equal emphasis.

Neck pain is frequently part of the history in patients with TMD. Following the DC/TMD, the examiner considers pain referral from the neck and shoulder region as TMD pain because these regions do not otherwise receive diagnostic attention. Moreover, due to the overlap in symptom profiles of TMD and cervical spine disorders and its consequences with regard to sensitization, the examiner may not be aware of manifestations of malignancies, fracture, or rheumatic disease in the neck and shoulder area.

Suggestions

The DC/TMD offers much perspective for future development in research settings and represents a distinct improvement over the RDC/TMD; however, the remarks made here and previously¹¹ lead to the conclusion that the DC/TMD is not yet adequate for use in clinical settings. Therefore, suggestions for improvement are offered in Table 2. Theoretically, research can be directed toward determining proper reliability and validity and to studies using the DC/TMD in clinical TMD research. More advanced versions of a better validated Axis I system may be used for TMD

Table 2 Suggestions for Improvement of the DC/TMD

Avoid using pain screener to select patients with TMD or candidates for intervention.
Include individuals with treatment demand in Axis I validation studies.
Use the construct "familiar" for all signs and symptoms in the assessment of putative TMD.
Include extra- and intra-oral inspections in the protocol.
Include clinical tests on neck and shoulder girdle.
Include a list of atypical signs and symptoms for nonspecific TMD.
Include a disclaimer for excluding other pain-related conditions first before considering nonspecific TMD.
Abandon nonaccessible muscle palpation sites.
Do not use pain location as a critical decision for subgroup allocation.
Use additional palpation techniques for assessment of tissue characteristics.
Include more robust algorithms for determination of subgroups (more "AND" statements; three out of three criteria met).
Include correlation of condylar sliding and incisal measurement of jaw opening.
Include the subgroup "myofascial pain with limited opening" (use difference of assisted and unassisted jaw opening > 5 mm).
Exclude subluxation subgroup and the need for maneuvering the mandible by the patient.
Exclude palpation around the lateral pole.
Do not differentiate temporalis myalgia and headache attributed to TMD.
Assess pain and dysfunction in their mutual relation.
Consider pain locations and limitation in function as Axis I information.
Provide information for dealing with patients not exhibiting all requirements of the DC/TMD classification (eg, patients reporting TMJ or masticatory muscle pain in the absence of tenderness on palpation) and provide a list of signs and symptoms occurring in patients with TMD/orofacial pain.

research on clinical care. The latest research agenda proposed in a commentary⁵⁵ drafted by a subgroup of the authors of the DC/TMD, in combination with the present suggestions, may serve as recommendations. The contents of this commentary also underpin the lack of urgency to implement the DC/TMD in clinical practice. DC/TMD projects that are executed in a stepped order of research before research on its clinical application will provide the best possible evidence for the TMD community. TMD patients will also benefit most when this stepped strategy is used.

One may wonder, though, whether a one-size-fits-all strategy (one system for both research and clinical care) is desirable, since research and management of patients are different processes. The statement that the core of the DC/TMD can be supplemented by any other desired examination is correct, but also somewhat misleading. The presented diagnostic accuracy is no longer valid when other tests are used in the decision-making process of subgroup classification next to the core algorithms; for example, a cut-off value for limited jaw opening may be relevant as a research question, but may not be relevant in clinical care at all. Separating pain and dysfunction is probably acceptable for research, but not in clinical practice.

Figures on reliability of the DC/TMD in a larger test population are also needed. In future Axis I reliability studies, patients with TMD but without a treatment demand should not be included. As long as the DC/TMD is advocated to be used in clinical settings, a disclaimer should be added indicating that before

applying the revised algorithms it is necessary to assess for and rule out all other pathologies.

More certainty can be expected from three out of three positive tests in research settings. One out of three is the very minimum in clinical measurement. Assessing condylar sliding by palpation and correlating this information with the degree of jaw opening better informs the clinician about the source of a jaw-opening limitation than measuring only the inter-incisal distance (plus the vertical overbite). Palpation should include examination of the tissues with the fingertips by touch and not only by the pain pressure procedure, and nonaccessible muscles should no longer be a part of the protocol. Several DC/TMD subgroups need to be evaluated for retention, reconsideration, or omission.

Because of overlap between signs and symptoms of TMD and cervical spine disorders, clinicians should be advised to include within their diagnostic scheme the probability of a cervical spine disorder as an additional condition in patients with pain and dysfunction of the masticatory system. Both the RDC/TMD and the DC/TMD ignore this aspect. Studies have shown that both questionnaires and orthopedic tests of the masticatory system may be used to distinguish between TMD and cervical spine disorders, while orthopedic testing of the cervical spine is of minor importance.^{56,57} Hence, the questions, drawings, and tests in the DC/TMD protocol should include the neck and shoulder girdle region in order to provide an orientation needed for proper referral of the patient to a specialist competent in

dealing with problems involving the head, neck, and shoulder girdle. Patients and clinicians may expect a more mature DC/TMD version before immediate implementation is proclaimed. Researchers have an even broader responsibility in exposing patients and subjects to the DC/TMD, which are presently not yet ready for clinical application.

Conclusions

The DC/TMD represents an improvement over the RDC/TMD; however, there is a need to consider further aspects of the DC/TMD before its immediate and general implementation in clinical settings. Suggestions for improvement are made in this Focus Article. It is difficult to support the DC/TMD Axis I as long as several of its components are still being developed. It would be wise to focus research efforts on further development of the system itself. Given the vast number of pathologies mimicking nonspecific TMD and the necessity to exclude other pathologies first, expanding the DC/TMD to include less common TMD conditions and disorders appears to be too ambitious to be credible and clinically appropriate.

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