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International consensus on the most useful assessments used by physical therapists to evaluate patients with temporomandibular disorders: A Delphi study

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Abstract

Objective: To identify assessment tools used to evaluate patients with temporomandibular disorders (TMD) considered to be clinically most useful by a panel of international experts in TMD physical therapy (PT).

Methods: A Delphi survey method administered to a panel of international experts in TMD PT was conducted over three rounds from October 2017 to June 2018. The initial contact was made by email. Participation was voluntary. An e-survey, according to the Checklist for Reporting Results of Internet E-Surveys (CHERRIES), was posted using SurveyMonkey for each round. Percentages of responses were analysed for each question from each round of the Delphi survey administrations.

Results: Twenty-three experts (completion rate: 23/25) completed all three rounds of the survey for three clinical test categories: 1) questionnaires, 2) pain screening tools and 3) physical examination tests. The following was the consensus-based decision regarding the identification of the clinically most useful assessments. (1) Four of 9 questionnaires were identified: Jaw Functional Limitation (JFL-8), Mandibular Function Impairment Questionnaire (MFIQ), Tampa Scale for Kinesiophobia for Temporomandibular disorders (TSK/TMD) and the neck disability index (NDI). (2) Three of 8 identified pain screening tests: visual analog scale (VAS), numeric pain rating scale (NRS) and pain during mandibular movements. (3) Eight of 18 identified physical examination tests: physiological temporomandibular joint (TMJ) movements, trigger point (TrP) palpation of the masticatory muscles, TrP palpation away from the masticatory system, accessory movements, articular palpation, noise detection during movement, manual screening of the cervical spine and the Neck Flexor Muscle Endurance Test.

Conclusion: After three rounds in this Delphi survey, the results of the most used assessment tools by TMD PT experts were established. They proved to be founded on test construct, test psychometric properties (reliability/validity) and expert preference for test clusters. A concordance with the screening tools of the diagnostic criteria of TMD consortium was noted. Findings may be used to guide policymaking purposes and future diagnostic research.

KEYWORDS
assessments, delphi study, physical therapy, TMD

1 | INTRODUCTION

The diagnosis of temporomandibular disorders (TMD) represents a complex collection of clinical signs and symptoms in the craniofacial region, including masticatory muscles, temporomandibular joints and other related structures.[1-4] Several neuromuscular, neurobiological, biomechanical and biopsychosocial risk factors[5,6] have been associated with the development or perpetuation of TMD. TMD has a one-year prevalence of 19% with frequent myofascial complaints, a yearly incidence of 4%[4]and a broad peak prevalence between 20 and 40 years.[7] Females are affected at least twice as often as men.[8,9] The estimated annual medical cost for TMD treatment in the United States alone is $4 billion.[10]

Due to its complexity, TMD is an umbrella term for diverse clinical symptoms,[11] classified in the Diagnostic Criteria of Temporomandibular Disorders (DC/TMD).[12] The classification consists of two subscales, the physical (Axis I) and the psychosocial (Axis II) sections.[11,13] The DC/TMD Axis I is divided into painful TMD, intra-articular disorders, degenerative joint disease and joint subluxation. The Axis II classifies chronic facial pain into pain-related impairment of daily activities, depression and non-specific somatic symptoms.[11] Shiffman et al[12] within the DC/TMD validated the assessment of TMD with questionnaires and physical tests. Their results, although sometimes lacking a gold standard, led to the selection of valid diagnostic criteria for differentiating the most common pain-related TMDs, such as myofascial pain with referral (sensitivity 0.86; specificity 0.98), arthralgia (sensitivity 0.89; specificity 0.98), headache attributed to TMD (sensitivity 0.89; specificity 0.87) and disc displacement without reduction with limited opening (sensitivity of 0.80 and specificity of 0.97).

Physical therapists play an essential role in the multidisciplinary team working with patients with TMD and are primarily educated within the framework of the International Classification of Function and Disability (ICF).[14] Physical therapy outcome measurements often include questionnaires, clinical tests assessing pain and (neuro) musculoskeletal tests as well as collecting relevant contributing factors. These tests are the basis for physical therapy treatment and management decisions.[14]

In addition to the DC/TMD examination and questions, physical therapists may include additional questionnaires and tests in their process of developing a diagnosis such as the Neck Disability Index. These tests are generally used along with the DC/TMD instruments to determine the most appropriate treatment path for patients. That being said, what are the most common tests, instruments or tools used by physical therapists to evaluate patients with TMD? Besides, an inventory of the most common assessments tools, including tests and questionnaires, used by physical therapists to evaluate patients with TMD, has never been published. The aim of this Delphi survey was to reach a consensus-based decision by a panel of international experts in TMD PT regarding the identification of the most clinically useful questionnaires and clinical tests that evaluate pain and dysfunction in patients with TMD.

2 | METHODS

A Delphi survey was designed and conducted following established guidelines[15] and the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) and previously published Delphi surveys with similar research questions.[16-18] The survey was guided by a systematic evaluation of the literature of all clinical tools and assessments proposed for the assessment of musculoskeletal dysfunctions of patients with TMD. Ethical approval (wiso_BA_ELP_HP-SS-18-01—05) was granted by the local ethics authority (University of Applied Science of Osnabrück). The data collection time frame was from October 2017 to June 2018. There were three e-survey rounds sent out through email with an automatic method of capturing responses using SurveyMonkey. The completion rate was considered the ratio of users who finished the survey/users who agreed to participate. The survey was voluntary with a non-monetary incentive, that is an offer to provide the survey results at the end of the study.

2.1 | The experts

Experts were defined as physical therapists with a specialised education in musculoskeletal therapy in TMD, with at least 10 years of clinical experience or with a research background, including at least five publications in the area. They were contacted by email or phone and invited to participate in the study. For this purpose, the experts received a clear description of the study aims and procedures before informed consent was sought. Thirty-one international experts from 11 different countries were invited (by email) to participate in the first round of the Delphi study. Twenty-five experts responded and were required to state whether they were predominantly involved in research (n = 14), clinical practice (n = 2) or mixed (n = 9). They provided their responses anonymously to allow unbiased answers and to reduce the influence of potentially dominant personalities on the overall results. Experts were encouraged to revise, improve or add additional comments during each survey round.[19]

2.2 | Assessment tools

The assessment tools were divided into three test categories: a) questionnaires, b) pain screening tools and c) physical examination tests. Each test had the aim to both support TMD diagnosis and guide treatment choice. Before the first round of the survey, a list of assessment tools from the three categories described above was generated based on a systematic evaluation of the literature performed in the following databases: PubMed, Cinahl, EMBASE and PEDro, including the following search strategy:

> *temporomandibular disorder [MeSH Terms], OR temporomandibular joint disorder [MeSH Terms] OR further synonyms. AND (physiotherapy OR manual therapy OR physical therapy AND assessments OR examination OR test OR measurement).*

Synonyms of these words were also used. Based on this strategy, 150 studies identified to be potentially relevant. After full text screening, 36 studies were classified as relevant and formed the basis for the chosen assessment tools for the Round-1 in the Delphi survey (Table 1).

2.3 | Survey Round-1

The aim of the first round (Round-1) of the survey was to rate the clinical importance of the assessments identified in the literature and to collect additional suggestions of assessment tools considered clinically useful by the experts. Experts received a survey with questions on three clinical test categories: 1) questionnaires, 2) pain screening tools and 3) physical examination tests. The survey included a list of references supporting the tests used and comprised thirty two questions distributed over eight pages with between three to seven items per page. A summary of the responses was required to be verified as correct by the respondents, with a back button available to modify responses. Before each round, the survey was trialed for comprehensibility such as ambiguous questions or wording, unclear instructions or problems with the instrument and revised accordingly before widespread dissemination based on comments from three clinical and research experts of the Delphi team (HVP, KL and NB).

Regarding the physical examination tests and the pain screening tools, experts were asked to classify the tests into the following disorder subcategories: myogenic, arthrogenic, mixed or chronic pain. Each test was evaluated for clinical usefulness on a scale from 0 (definitely not useful) to 4 (extremely useful). If the clinical usefulness of a test was considered "unclear," the expert could add an explanation in the response document. Experts were also asked to make further suggestions regarding additional questionnaires or assessment tools. These would be included in the next survey iteration or round. The survey questions used during the first and second survey round are described in Table 2.

TABLE 1 Assessment tools included for three categories in Round-1

	1. Questionnaires	2. Pain screening	3. Physical tests
1	PHQ-4[12,41,42]	Detailed screening of the pain in general[70]	Physiological TMJ movements [41,49-51]
2	PHQ-9 [12,47]	TMD-pain screener [12,61]	Accessory movements [12,53,76]
3	GAD-7 [8,12,44,47]	Pain drawing [12]	Noise registration during movement manual palpation [48,57]
4	DC/TMD demographics [12]	Graded chronic pain scale version 2 [12,53,62]	Noise registration during movement with stethoscope[53,55,76,77]
5	JFL scale 8 Item[12,45,51]	CAS[63,64]	Statistical tests[41,52,86]
6	JFL scale 20 Item[12,45,51]	VAS[64-66]	Myofascial Trp of masticatory m. [41,80-81,83]
7	Oral behaviors checklist[12,45,46]	Mouth movements pain[67-68,86]	Myofascial TrP outside the masticatory system[78,82]
8	PHQ-15 physical symptoms[12,47]		PPT of masticatory muscles[35,53,83,84]
9	MFIQ[48-50]		PPT of masticatory muscles outside the masticatory system[8,53,68,85]
10	CONTI questionnaire[52-55]		Dynamic and static load test of the TMJ[24,54]
11	Helkimo´s clinical dysfunction index[56-59]		Laterotrusion test[12,41,76,86]
12	Fonseca anamnestic index[60]		Dental stick test[69,76,81]
13			Neurodynamic test of the mandibular nerve[29,86]
14			Screenings test cervical spine[42,71,73-75,79]

Abbreviations: CAS, color analog scale; DC/TMD, diagnostic criteria for temporomandibular disorders; GAD-7, generalised anxiety disorder scale; JFL, jaw functional limitation; MFIQ, mandibular function impairment questionnaire; PHQ, patient health questionnaire; PPT, pain pressure threshold; PPT, pressure pain threshold; TMJ, temporomandibular joint; TrP, trigger point; VAS, visual analog scale.

TABLE 2 Protocol used during Round-1 and Round-2

	I consider this questionnaire … for TMD	I consider this assessment… for myogenic symptoms	I consider this assessment … for arthrogenic symptoms	I consider this assessment… for mixed symptoms	I consider this assessment… for chronic pain state
(4) extremely useful, (3) useful, (2) don't know, (1) probably not useful, (0) definitely not useful					
Questionnaires	*X				
Pain screening tools		*X	*X	*X	*X
Physical examination tests		*X	*X	*X	*X
I further suggest the use of the next assessment(s)	1) 2) 3)				

*X clinical usefulness on a score from 0 to 4.

A period of 8-weeks was given for Round-1. Experts were sent email reminders to answer the survey if no response was received within this time frame. If they did not respond after the reminder within 2-weeks, they were excluded from the analyses and from further rounds.

Results from Round-1 were presented to experts in Round-2, the second round, through a box plot diagram for each of the clinical test categories: 1) questionnaires, 2) pain screening tools and 3) physical examination tests. The specific test within each category was divided into three classifications: a) useful (2.5-4), b) not useful (0-1.5) and c) unclear results (1.5-2.5). Tests considered "unclear" by experts were included in the third round (Round-3) with more specific questions to add clarity to the classification. Additional details for the "unclear" tests, including available literature supporting them, were provided. A new response document was sent back to the experts who classified the tests as "unclear" in the test description.

2.4 | Survey Round-2

The aim of the second round (Round-2) was to rate the new tests, to clarify issues on the unclear tests and to formulate a preliminary consensus on the different statements from Round-1. Following completion of Round-1, experts received the Round-1 results as well as additional assessment tools suggested by the experts in Round-1. After the evaluation of the new tests by the experts, they were also invited to agree or disagree with the statements made by other experts during Round-1.

2.5 | Survey Round-3

The first two rounds were predominantly focused on the usefulness of the assessment tools. In the third round (Round-3), experts received the results from Round-2 as summarised feedback and a final response document. Experts further specified the clinical use of each clinical test (Table 3). The authors were informed that tests with a minimum rating of three ("useful") from at least 60% (n = 15) of expert participants would be included in the final list of useful tests. The consensus-based decision regarding the identification of the clinically most useful tests was formulated on this basis.[41] Experts were further asked to rate the newly suggested assessments from Round-2. During this round, experts also decided which test they considered most appropriate according to the DC/TMD classification. A period of 8 weeks was given to complete this round. An overview of the questions the experts received in Round-3 is provided in Table 3. Also, the classifications 1, 2, 3 and 4 are detailed in the results section of this manuscript.

TABLE 3 Questionnaire to specify the clinical use and purpose of the assessments

	Supporting a musculoskeletal diagnosis
1	A. Is this test sufficient as a stand-alone tool to support your diagnosis? B. Do you use it embedded in a cluster of tests with the same purpose? C. Can you use this test for the progress documentation or as a retest doing your treatment?
2	Supporting a specific treatment technique/approach
3	Supporting both a musculoskeletal diagnosis and the choice of a specific treatment technique/approach.
4	Other possible uses, like
	A. For the documentation B. Supporting prognosis C. Anything else, please mention in additions

3 | ANALYSIS

Only complete questionnaires were analysed. No statistical correction was required as there was no difference in weighting of items. Based on simple percentage comparisons, data were presented graphically. The questionnaires with the highest rankings were included in the subsequent round. To be included in Round-3, the assessment tool had to be rated at least 3-"useful" by at least 60% (n = 15) of all experts. In addition, for survey items with open-ended questions, we included qualitative descriptions for analysis.

4 | RESULTS

Twenty-three experts completed all rounds of the Delphi survey, and 34 assessment tools were considered clinically useful after the three rounds. Among them, nine were questionnaires, eight tests for pain screening and 18 for physical examination.

4.1 | Survey Round-1

Twenty-five participants responded the first round within 8-weeks. Based on the literature review, 33 assessment tools were suggested to be assessed by the experts. Among them, 12 were questionnaires, seven (7) were pain screening tools, and 14 were physical examination tests (Table 1). Three (3) questionnaires, one (1) assessments for the pain screening and four (4) physical examination tests were rated as unclear. Furthermore, 16 new assessments were suggested by the experts in this round: five (5) questionnaires, four (4) pain screening tools and seven (7) physical examination tests. An overview of the new assessment tools suggested by at least one expert after Round-1 is shown in Table 4.

Among the 33 initial assessment tools, the following were rated as "unclear" by nine (9) of the 25 experts and were clarified in detail in Round-2 using evidence-based literature:

- Questionnaires**:** patient health questionnaire (Physical Symptoms, PHQ-15), Fonseca Anamnestic Index.
- Pain screening tools: Color analog Scale (CAS), DC/TMD demographics.
- Physical examination tests: pressure pain thresholds of other body regions, dental stick test, mandibular neurodynamic test, noise detection during movement with a stethoscope.

4.2 | Survey Round-2

Twenty-five participants answered Round-2 within 8 weeks. After Round-2, 23 experts provided a ranking of the assessments rated as useful (see Figures 1-6). The questionnaires with the highest rankings were the TSK/TMD (84%, 21/25 experts), MFIQ (76%, 19/25 experts) and the JFL-8 (76%, 19/25 experts) (Figure 1).

For pain screening tools, clinical experts reported using pain screening in general (88%, 22/25), pain drawings (84%, 21/25) and VAS (80%, 20/25) (See Figure 2). The choice of pain screening tools used varied by TMD sub-classification (Axis I DC/TMD). Specific to myogenic TMD, experts found pain drawings (88%, 22/25 experts), the VAS (88%, 20/25 experts) and the NRS (88%, 22/25 experts) to be particularly useful while for arthrogenic TMD, the VAS (92%, 23/25 experts) and the NRS (92%, 23/25 experts) were rated as highly useful, followed by pain drawings (88%, 23/25 experts). For mixed TMD, experts considered the VAS (92%, 23/25 experts), pain drawings (88%, 22/25 experts), NDI, NRS and pain provoked by mandibular movements (each 84%, 21/25 experts) to be useful. For chronic oro-facial pain, experts considered pain drawings, VAS

TABLE 4 An overview of the new assessments based on consensus of the experts after Round-1

	1. Questionnaires	2. Pain screening	3. Physical tests
1	The central sensitisation inventory (CSI)[87]	NDI[96,97]	Evaluation of the mobilisation of the hyoid bone [112]
2	Pain localisation in CMD patients with modified pain questionnaire [88]	TMD Disability Index [98]	Articular palpation [103]
3	The Brief Illness Perception Questionnaire [89]	Mc Gill questionnaire [99]	Intra-oral examination for signs of parafunctional habits[104,105]
4	TSK/TMD[90,91]	Numeric Pain Rating Scale[100-102]	Evaluation of the Head and neck posture[106-108]
5	LDF-TMDQ/JFS [92-95]		Mobilisation with movement of the TMJ [109]
6			Dynamic/static tests As Assessment of pain [110]
7			Neck flexor muscle endurance test [111]

Abbreviations: CSI, central sensitisation inventory; LDF-TMDQ-JFS, limitations of daily functions in TMD questionnaire; NDI, neck disability index; TMJ, temporomandibular joint; TSK/TMD, Tampa scale for kinesiophobia for temporomandibular disorders.

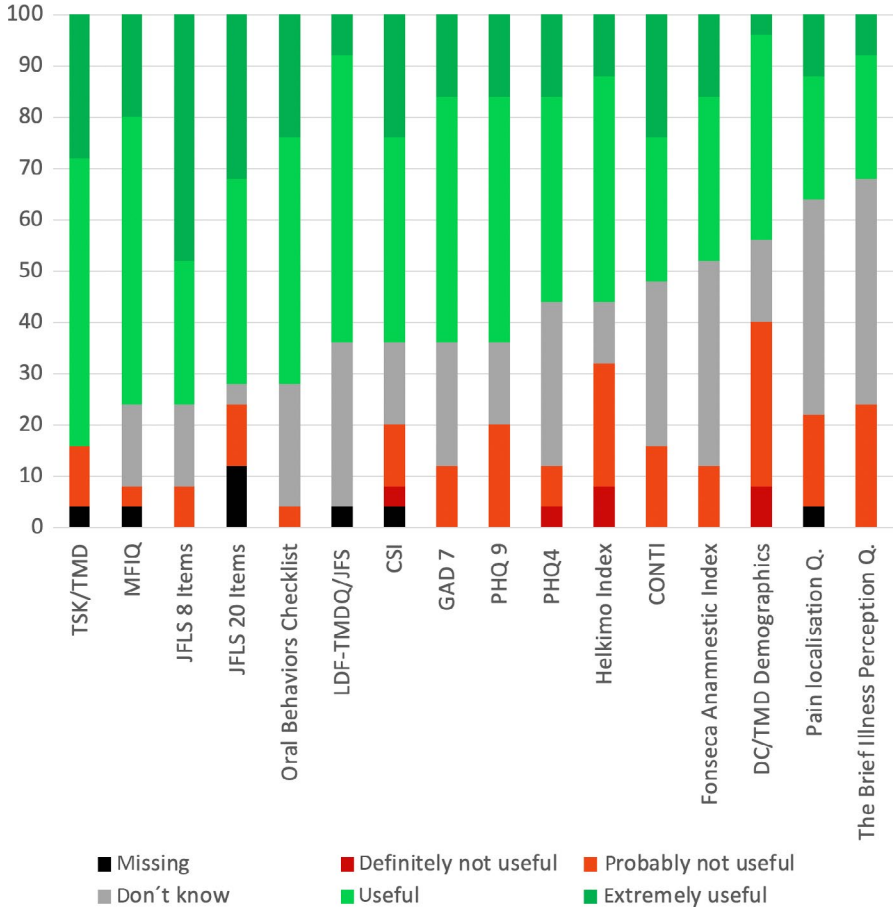

FIGURE 1 Distribution of answers for the questionnaires category after Round-1 and Round-2 for all TMD

and NDI as relevant to evaluate the condition with 80% each (20/25 experts).

The most useful physical tests identified for 1) arthrogenic TMD were physiological TMJ movements (100%, 25/25 experts), and accessory movements and articular palpation (96%, 24/25 experts) (Figures 2 and 3) myogenic TMD were physiological TMJ movements (96%, 24/25 experts), TrP palpation of the facial muscles (92%, 23/25 experts) and TrP palpation outside the masticatory system (96%, 24/25 experts) (Figure 3). In contrast, for mixed TMD, the clinical experts rated the assessment of physiological movements as the most appropriate test (100%, 25/25 experts), followed by accessory movements (96%, 24/25 experts) and TrP palpation outside the masticatory system (92%, 23/25 experts) (Figure 3). If a chronic oro-facial pain state was associated with Axis II, the screening of physiological movements (100%, 25/25 experts), muscle/TrP assessment outside the masticatory system (92%, 23/25 experts) and screening of the cervical spine were stated as the most appropriate clinical tests (88%, 22/25 experts) (Figure 3).

To be included in subsequent rounds (Round-3), the assessment tool should have been rated at least 3-"useful" by at least 60% (n = 15) of all experts. The following 12 tests did not reach this minimum requirement: 1) PHQ-4, 2) Helkimo's Clinical Dysfunction, 3) CAS, 4) Conti Anamnestic Questionnaire, 5) DC/TMD demographics, 6) PHQ-15 physical symptoms, 7) Fonseca anamnestic index, 8) the Letter illness perception questionnaire, 9) pain localisation in TMD patients with modified pain questionnaire, 10) pressure pain thresholds of the masticatory muscles, 11) neurodynamic test of the mandibular nerve and 12) the accessory movement of the hyoid bone.

4.3 | Survey Round-3

In the third round (Round-3), two experts dropped out due to lack of time; therefore, 23 experts returned the responses within the time frame. An overview of the results related to the use of the tests and assessment tools is reported in Table 3 and depicted in Table 5.

4.3.1 | Questionnaires

The TSK/TMD reached the highest rate as a stand-alone test (one test which confirms the diagnosis) (Question - Q1A) to make a musculoskeletal diagnosis (Q1) with only 17.4%. When experts were asked which tests they would use within a cluster (a collection of tests which increases the accuracy of the suspected diagnosis) of assessments to support a musculoskeletal diagnosis and for documentation (Q1B), or as a retest of a musculoskeletal treatment (Q1C), the JFL-8 and the Oral Behavior Checklist received the highest scores with 82.6% (19/23 experts) and 78.3% (18/23), respectively. The experts did not consider the GAD-7 as a stand-alone tool (Q1A) 69.6% (16/23 experts) or

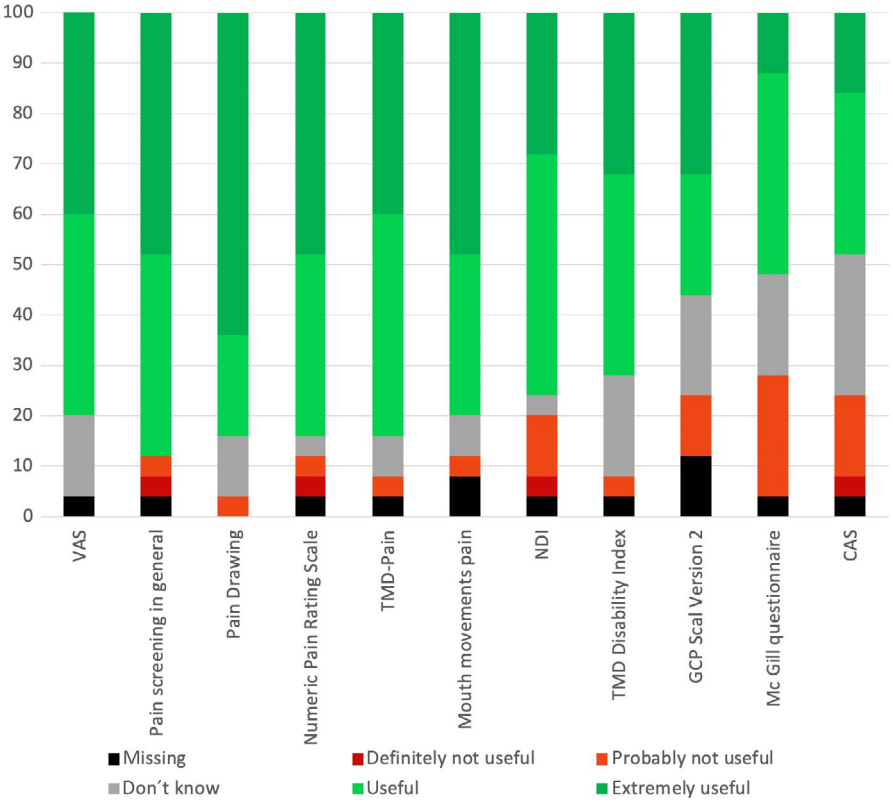

FIGURE 2 Mean of pain assessment tool in myogenic, arthrogenic, mixed TMD or chronic oro-facial pain after Round-1 and Round-2

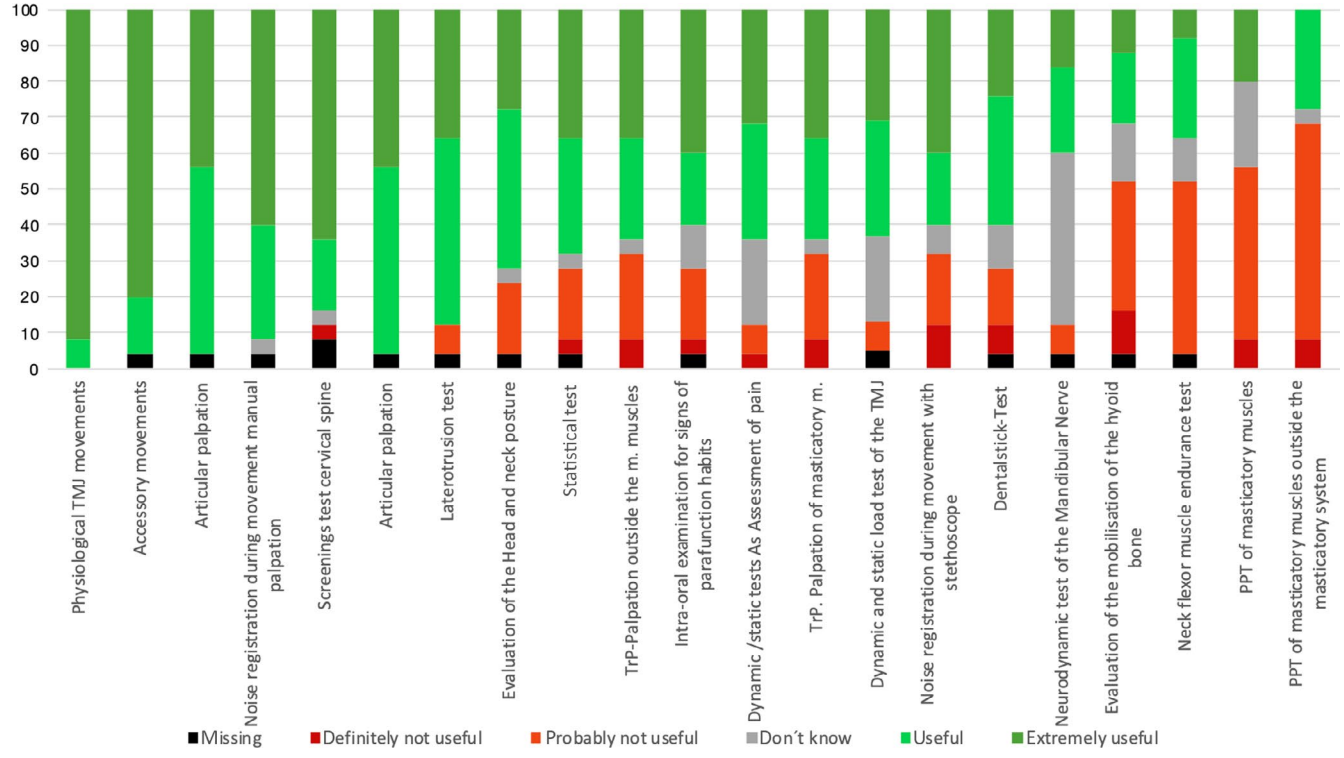

FIGURE 3 Distribution of answers after Round-1 and 2 in the physical tests category for arthrogenic TMD

imbedded (Q1B) in with other assessments (56.5%, 13/23) supporting a musculoskeletal diagnosis. Also, the GAD-7 and the JFL-8 achieved only 4.3% (1/23 experts) as sufficient stand-alone assessments (Q1A). Regarding the clustering of tests (Q1B) and as assessment for the documentation or reassessment test (Q1C), the LDF-TMDQ/JFS (Q1B: 30.4%, 7/23) and the GAD-7 (Q1C: 30.4%, 7/23) scored the lowest. For other uses of the questionnaires (Q4), the highest values were achieved by the GAD-7 (69.6%, 16/23) for the documentation process (Q4A), the JFL-20 (60.9%, 14/23) for prognosis (Q4B) and the Oral Behaviors Checklist (78.3%, 18/23) for anything else (Q4C).

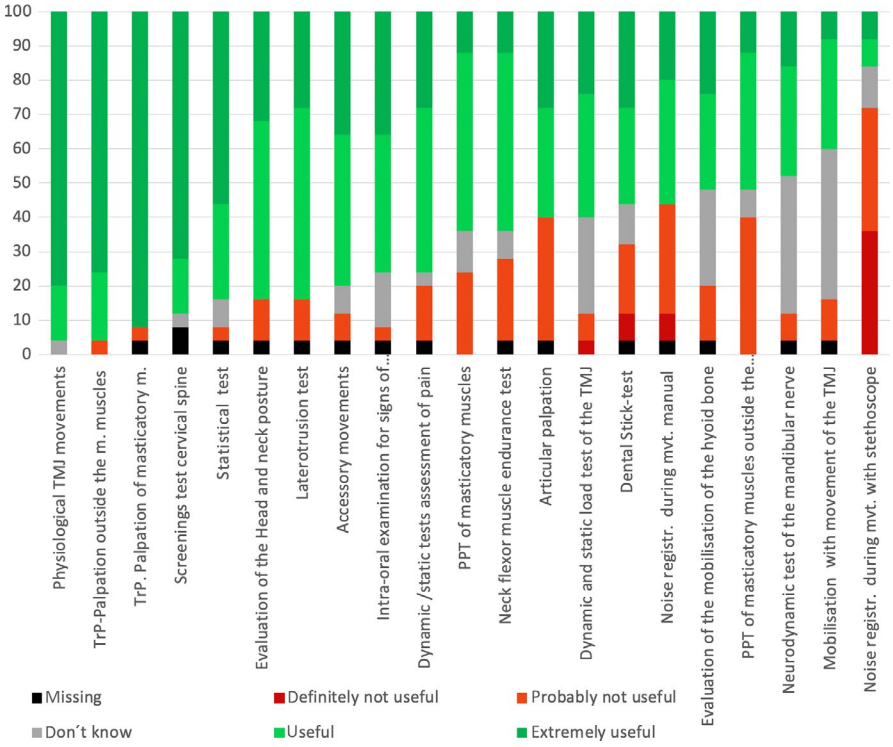

FIGURE 4 Distribution of the answers after Round-1 and Round-2 in the physical tests category for myogenic TMD

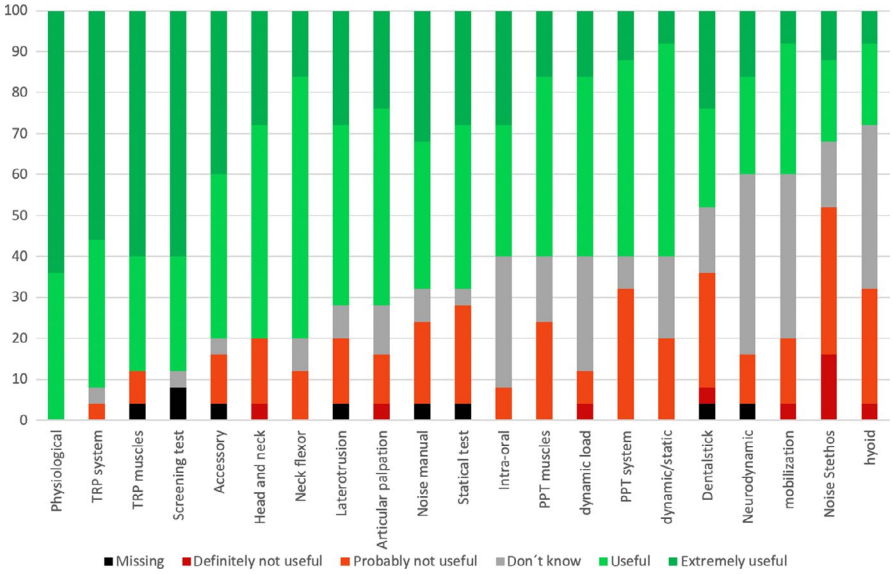

FIGURE 5 Distribution of the answers after Round-1 and Round-2 in the physical tests category for mixed TMD

4.3.2 | Pain screening

For the assessment of pain, both VAS and TMD Disability Index achieved the highest scores (95.7%, 22/23, Q1B). The results showed that 78.3% (18/23) of the experts rated the TMD Disability Index and the NRS as a useful pain assessment tool for documentation or retest (Q1C). The McGill Pain Questionnaire (8.7%, 2/23, Q1A) was rated as a sufficient independent assessment but was better during clustering (69.6%, 16/23). Besides, the GCPS scale (version-2) achieved the lowest score to support a neuromusculoskeletal diagnosis in a cluster with other tests (56.5%, 13/23, Q1B).

Regarding the question of whether a test supports a specific treatment technique/approach (Q2), "pain triggered by mandibular movements" achieved the highest expert support (52.2%, 12/23). To support both, a neuromusculoskeletal diagnosis and the choice of a particular treatment technique or approach (Q3), the TMD Disability Index and NDI (69.6%, 16/23) were both rated as the most useful assessment of the experts. The pain drawing (30.4%, 7/23), together with the VAS (34.8%, 8/23), scored the lowest. When asking whether there were any other uses for the pain assessment (Q4), the pain drawing and the TMD disability index both reached the highest level (73.9%,17/23) supporting the documentation process (Q4A), and the TMD disability index and NDI both (73.9%, 17/23)

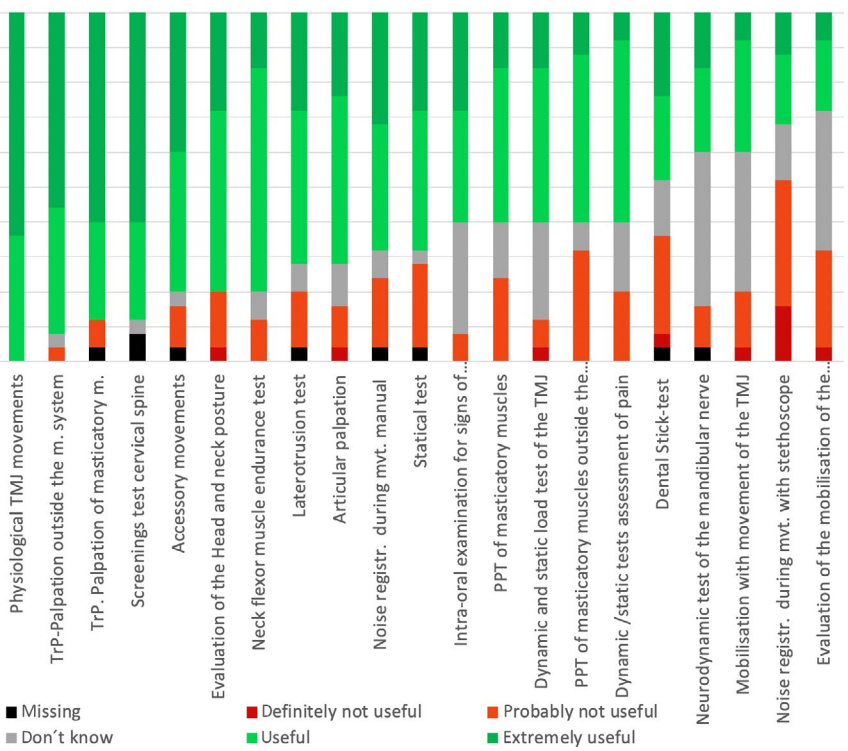

FIGURE 6 Distribution of answers after Round-1 and Round-2 in the physical tests category for chronic oro-facial pain state

supported prognosis (Q4B). The McGill Pain Questionnaire reached the highest value in Q4C, with 21.7% (5/23) of the experts considering the McGill Pain Questionnaire.

Furthermore, the experts were asked whether the assessment tool could help to classify TMD according to the International Classification of the DC/TMD in the following categories: “painful TMD”; “intra-articular disorders”; “degenerative joint diseases”; and “joint subluxation”. In the category "painful TMD," the VAS and pain drawing reached 87% (20/23), and in combination with the examination of mandibular movements, the best results were for "intra-articular disorders" (69.6%, 16/23) and "degenerative joint disease" (60.9% 14/23). The NDI scored the worst (43.5%, 10/23) result in the category “painful TMD.” The NDI together with the CGPS-2 and the McGill Pain Questionnaire were also rated the least useful (21.7%, 5/23) for the assessment of pain in the category “degenerative joint disease.” The CGPS-2 had the lowest score (26.1%, 6/23) in the category “intra-articular disorders,” and together with the NDI also the lowest score (13%, 3/23) in the category “joint subluxation.” These results are not depicted in Table 5.

4.3.3 | Physical examination tests

The 18 clinical tests integrated into the physical examination questionnaire in Round-3 achieved the following results defining TMD in the DC/TMD categories. Palpation of the masticatory muscles achieved the highest value in the category "painful TMD" with 91.3% (21/23). In all the three categories (Q1A-C), physiological TMJ movements achieved the highest score (100%, 23/23), especially in combination with other tests (Q1B). The lowest result (21.7%, 5/23) was for noise detection during movement with a stethoscope (Q1A). In addition, pain pressure threshold (PPT) of the masticatory muscles reached the lowest value (4.3%, 1/23) in the two categories "intra-articular disorders" and "joint subluxation." To support a neuromusculoskeletal diagnosis (Q1B), dynamic and static load test of the TMJ achieved the highest rating (95.7%, 22/23). The following five tests, 1) static test, 2) dynamic and static load test of the TMJ, 3) dental stick test, 4) articular palpation and 5) dynamic/static load tests, were all used by 91.3% (21/23) of the experts as a cluster of tests (Q1B). Physiological movements of the TMJ were rated as the most useful assessment for the follow-up documentation (87%, 20/23, Q1C). Evaluation of the head and neck posture was rated as useful by 4.3% (1/23) of the experts as a stand-alone tool (Q1A).

Regarding the question, if some tests supported a specific treatment approach (item 2, Table 5), extra-oral TrP palpation of the masticatory system achieved the best results (78.3%, 18/23), and the stethoscope noise detection during movement test reached the lowest (47.8%, 11/23). To support both, a neuromusculoskeletal diagnosis and a specific treatment approach (Q3), 87% (20/23) of the experts considered the screening test of the cervical spine together with palpation of the masticatory system as the most useful test battery. Articular palpation received the lowest score (34.8%, 8/23). Up to 74% (17/23) of the participants agreed about the benefit of intra-oral examination as an additional procedure to confirm the clinical neuromusculoskeletal diagnosis (Q4A) and 73.9% (17/23) indicated the benefit of PPT of the masticatory muscles to support the prognosis (Q4B). In addition, 21.7% (5/23) of the participants also used PPT of the masticatory system

TABLE 5 Overview of the most useful test according the clinical experts

	1. Supporting neuromusculoskeletal diagnosis			2. Supporting a specific treatment technique/ approach	3. Supporting both a neuromusculoskeletal diagnosis and the choice of a specific treatment technique/ approach	4. Other possible uses		
	A) **sufficient as a stand-alone tool to support the diagnosis**	B) **imbedded in a cluster of tests with the same purpose**	C) **Can be used for the progress documentation or as a retest**			A) **sufficient as a stand-alone tool to support the diagnosis**	B) **imbedded in a cluster of tests with the same purpose**	C) **Can be used for the progress documentation or as a retest**
Questionnaires (%, numbers/total numbers)								
1. JFLS-8	4.3 (1/23)	**82.6 (19/23)**	78.3 (18/23)	43.5 (10/23)	47.8 (11/23)	30.4 (7/23)	39.1 (9/23)	4.3 (1/23)
2. MFIQ	13.0 (3/23)	60.9 (14/23)	69.6 (16/23)	43.5 (10/23)	47.8 (11/23)	60.9 (14/23)	52.2 (12/23)	4.3 (1/23)
3.TSK/TMD	**17.4 (4/23)**	47.8 (11/23)	60.9 (14/23)	60.9 (14/23)	47.8 (11/23)	60.9 (14/23)	56.5 (13/23)	13.0 (3/23)
4. JFLS-20	8.7 (2/23)	65.2 (15/23)	78.3 (18/23)	43.5 (10/23)	43.5 (10/23)	52.2 (12/23)	**60.9 (14/23)**	4.3 (1/23)
5. Oral Beh.	13.0 (3/23)	78.3 (18/23)	60.9 (14/23)	52.2 (12/23)	30.4 (7/23)	65.2 (15/23)	8.7 (2/23)	**78.3 (18/23)**
6. LDF-TMDQ/JFS	13.0 (3/23)	30.4 (7/23)	65.2 (15/23)	43.5 (10/23)	52.2 (12/23)	69.6 (16/23)	39.1 (9/23)	4.3 (1/23)
7. PHQ 9	13.0 (3/23)	43.5 (10/23)	43.5 (10/23)	30.4 (7/23)	26.1 (6/23)	65.2 (15/23)	52.2 (12/23)	26.1 (6/23)
8. GAD 7	4.3 (1/23)	39.1 (9/23)	30.4 (7/23)	34.8 (8/23)	17.4 (4/23)	**69.6 (16/23)**	56.5 (13/23)	8.7 (2/23)
Pain screening (%, numbers/total numbers)								
1. VAS	34.8 (8/23)	**95.7 (22/23)**	56.5 (13/23)	34.8 (8/23)	39.1 (9/23)	69.6 (16/23)	56.5 (13/23)	13.0 (3/23)
2. NDI	8.7 (2/23)	82.6 (19/23)	60.9 (14/23)	47.8 (11/23)	**69.6 (16/23)**	65.2 (15/23)	**73.9 (17/23)**	8.7 (2/23)
3. NPRS	17.4 (4/23)	82.6 (19/23)	**78.3 (18/23)**	39.1 (9/23)	39.1 (9/23)	65.2 (15/23)	52.2 (12/23)	13.0 (3/23)
4. Mouth Mvt.	21.7 (5/23)	91.3 (21/23)	60.9 (14/23)	52.2 (12/23)	60.9 (14/23)	69.6 (16/23)	52.2 (12/23)	8.7 (2/23)
5. Pain Drawing	17.4 (4/23)	78.3 (18/23)	56.5 (13/23)	**30.4 (7/23)**	47.8 (11/23)	**73.9 (17/23)**	56.5 (13/23)	8.7 (2/23)
6. TMD Dis.Ind.	13.0 (3/23)	**95.7 (22/23)**	**78.3 (18/23)**	47.8 (11/23)	**69.6 (16/23)**	**73.9 (17/23)**	**73.9 (17/23)**	8.7 (2/23)
7. TMD Pain S.	21.7 (5/23)	60.9 (14/23)	56.5 (13/23)	52.2 (12/23)	43.5 (10/23)	56.5 (13/23)	34.8 (8/23)	4.3 (1/23)
8. GCPS 2	17.4 (4/23)	**56.5 (13/23)**	65.2 (15/23)	30.4 (7/23)	43.5 (10/23)	65.2 (15/23)	56.2 (13/23)	13.0 (3/23)
9. Mc Gill Q.	8.7 (2/23)	**69.6 (16/23)**	47.8 (11/23)	47.8 (11/23)	52.2 (12/23)	65.2 (15/23)	69.6 (16/23)	**21.7 (5/23)**
Physical examination tests (%, numbers/total numbers)								
1. Phys.Mvt TMJ	**56.5(13/23)**	**100 (23/23)**	**87.0 (20/23)**	69.6 (16/23)	78.3 (18/23)	65.2 (15/23)	69.6 (16/23)	8.7 (2/23)
2. Palp mastic. M	34.8 (8/23)	**91.3 (21/23)**	60.9 (14/23)	69.6 (16/23)	**87.0 (20/23)**	60.9 (14/23)	39.1 (9/23)	8.7 (2/23)
3. Art palp	21.7 (5/23)	91.3 (21/23)	69.6 (16/23)	65.2 (15/23)	**34.8 (8/23)**	**74.0(17/23)**	47.8 (11/23)	13.0 (3/23)
4. Screen. Cerv.	21.7 (5/23)	78.3 (18/23)	60.9 (14/23)	56.5 (13/23)	**87.0 (20/23)**	60.9 (14/23)	56.5 (13/23)	8.7 (2/23)
5. Acc Mvt TMJ	13.0 (3/23)	87.0 (20/23)	60.9 (14/23)	73.9 (17/23)	78.3 (18/23)	56.5 (13/23)	34.8 (8/23)	4.3 (1/23)
6. Noise Reg.	**21.7 (5/23)**	78.3 (18/23)	60.9 (14/23)	56.5 (13/23)	47.8 (11/23)	69.6 (16/23)	56.5 (13/23)	13.0 (3/23)
7. Load Tests	21.7 (5/23)	91.3 (21/23)	56.5 (13/23)	65.2 (15/23)	73.9 (17/23)	56.5 (13/23)	39.1 (9/23)	8.7 (2/23)
8. Trp. Outside	17.4 (4/23)	82.6 (19/23)	60.9 (14/23)	**78.3 (18/23)**	78.3 (18/23)	69.6 (16/23)	52.2 (12/23)	8.7 (2/23)
9. Lat.Test	17.4 (4/23)	87.0 (20/23)	56.5 (13/23)	60.9 (14/23)	65.2 (15/23)	65.2 (15/23)	34.8 (8/23)	4.3 (1/23)

(Continues)

TABLE 5 (Continued)

	1. Supporting neuromusculoskeletal diagnosis			2. Supporting a specific treatment technique/ approach	3. Supporting both a neuromusculoskeletal diagnosis and the choice of a specific treatment technique/ approach	4. Other possible uses		
	A) **sufficient as a stand-alone tool to support the diagnosis**	B) **imbedded in a cluster of tests with the same purpose**	C) **Can be used for the progress documentation or as a retest**			A) **sufficient as a stand-alone tool to support the diagnosis**	B) **imbedded in a cluster of tests with the same purpose**	C) **Can be used for the progress documentation or as a retest**
10. statistical	17.4 (4/23)	91.3 (21/23)	56.5 (13/23)	65.2 (15/23)	78.3 (18/23)	52.2 (12/23)	34.8 (8/23)	8.7 (2/23)
11. Head and neck posture	4.3 (1/23)	82.6 (19/23)	52.2 (12/23)	69.6 (16/23)	60.9 (14/23)	69.6 (16/23)	30.4 (7/23)	8.7 (2/23)
12. load tests	21.7 (5/23)	**95.7 (22/23)**	65.2 (15/23)	56.5 (13/23)	60.9 (14/23)	65.2 (15/23)	43.5 (10/23)	8.7 (2/23)
13. Intra-oral tech.	13.0 (3/23)	78.3 (18/23)	47.8 (11/23)	56.5 (13/23)	65.2 (15/23)	73.9 (17/23)	47.8 (11/23)	8.7 (2/23)
14. dentalstick	21.7 (5/23)	91.3 (21/23)	56.5 (13/23)	65.2 (15/23)	73.9 (17/23)	56.5 (13/23)	39.1 (9/23)	8.7 (2/23)
15. mob with mvt.	13.0 (3/23)	69.6 (16/23)	39.1 (9/23)	52.2 (12/23)	47.8 (11/23)	47.8 (11/23)	34.8 (8/23)	8.7 (2/23)
16. Neck flexor	30.4 (7/23)	73.9 (17/23)	56.5 (13/23)	69.6 (16/23)	82.6 (19/23)	52.2 (12/23)	43.5 (10/23)	8.7 (2/23)
17. Noise reg. with mvt.	21.7 (5/23)	73.9 (17/23)	56.5 (13/23)	**47.8 (11/23)**	69.6 (16/23)	60.9 (14/23)	47.8 (11/23)	13.0 (3/23)
18. PPT mast.	13.0 (3/23)	78.3 (18/23)	43.5 (10/23)	52.2 (12/23)	65.2 (15/23)	60.9 (14/23)	73.9 (17/23)	21.7 (5/23)

Note: Numbers in bold; highest or lowest values discussed during results in Round-3.

Abbreviations: Acc Mvt TMJ, accessory movements; Art palp, articular palpation; Dentalstick, Dentalstick-Test; GAD 7, Generalisied Anxiety Disorder Scale-7; GCPS 2, Graded Chronic Pain Scale Version 2; Intra-oral, Intra-oral examination for signs of parafunction habits; JFLS-20, Jaw Function Limitations Scale 20-item,Oral Beh., Oral Behaviors Checklist; JFLS-8, Jaw Function Limitations Scale 8-item; Lat.Test, laterotrusion Test,Statical, statical tests,Head and neck, evaluation of the Head and neck posture; LDF-TMDQ/JFS, Limitations of Daily Functions in TMD Questionnaire (LDF-TMDQ/JFS); Load tests, dynamic/static tests; Mc Gill Q., Mc Gill questionnaire; MFIQ, Mandibular Function Impairment Questionnaire (MFIQ); Mob.with mvt., Mobilisation with movement of the TMJ; Mouth Mvt., Mouth movements pain; NDI, Neck Disability Index; Neck flexor, neck flexor muscle endurance test; Noise Reg., noise registration during movement Load tests, Dynamic and static load test of the TMJ; Noise stethoscope, noise registration during movement with stethoscope; NPRS, Numeric Pain Rating Scale; Pain Drawing, Pain Drawing; Palp mastic. M., triggerpoint; palpation of masticatory muscles; PHQ 9, Patient Health Questionnaire 9; Phys.Mvt TMJ, physiological TMJ movements; PPT mast., pressure pain thresholds of masticatory muscles outside the masticatory system;Screen. Cerv., screenings Test cervical spine; TMD Dis.Ind., TMD Disability Index; TMD Pain S., TMD-Pain Screener; Trp.outside, triggerpoint-Palpation outside the masticatory system; TSK/TMD, The Tampa Scale for Kinesiophobia for Temporomandibular Disorders (TSK/TMD); VAS, visual analog scale.

*The physical examination tests are the sum for all subcategories of the Axis I of the DC/TMD.

for other uses such as including or excluding myofascial tissue dysfunction in the diagnosis (Q4C).

5 | DISCUSSION

This Delphi study obtained a consensus regarding the most useful tools to evaluate pain and dysfunction in patients with TMD by an international group of physical therapy experts in TMD. During three survey rounds, 23 international clinical or research experts in TMD from 11 different countries evaluated three categories of assessment tools, including 1) questionnaires, 2) pain screening tools and 3) physical examination tests. After the three rounds, nine questionnaires, eight pain screening tests and 18 physical examination tests were considered clinically useful by the international experts. The most useful tests considered by the experts included the following questionnaires: JFL-8, MFIQ, TSK/TMD and the NDI. The useful assessments for pain screening were the VAS, the NRS and pain provoked by mandibular movements. The recommended physical examination tests included physiological TMJ movements, TrP palpation of the masticatory muscles, TrP palpation outside the masticatory system, accessory movements, articular palpation, noise detection during movement, manual screening of the cervical spine and the Neck Flexor Muscle Endurance Test.

5.1 | Questionnaires

Experts agreed that from the available questionnaires, a musculoskeletal diagnosis was best supported by the TSK/TMD, followed by JFL-8 and MFIG. All three questionnaires are focused on oro-facial daily functions such as eating, chewing, talking and (non)verbal functions of the mandible. The TSK/TMD also measures the dimension of fear associated with TMD (ie related to pain, joint sounds and limited jaw movements) and may provide information about future management strategies. The majority of experts (96%) rated the JFL-8 as an appropriate test when used in combination with physical tests to confirm the TMD diagnosis. Interestingly, the TSK/TMD reached higher scores than the LDF-TMDQ/JFS and MFIG, suggesting that clinical experts are frequently confronted with patients with TMD and kinesiophobia. This is particularly frequent in chronic patients, such as those with TMD and often associated with psychosocial factors, such as depression and anxiety.[20,21]

5.2 | Pain assessment tools

The experts recommended two ways to screen pain in subjects with TMD. The first was the VAS during mandibular excursions to determine whether pain is triggered by mandibular movements. The second, the TMD Disability Index, may give an overall assessment of the function, pain intensity and also regarding other symptoms associated with TMD, such as tinnitus and dizziness. However, the authors of the present study found no validation studies on these two assessment tools. An explanation could be that the TMD Disability Index has only been used in case studies with the purpose to reassess patients individually.[22] The TMD Disability Index was preferably clustered with pain drawings and with the NDI, suggesting that physical therapists use this tool in combination with other tools during their search to recognise clinical patterns, along with general measurements for pain such as the NRS, GCPS and the McGill Pain Questionnaire. It may be assumed that during this study, the experts claimed to use pain assessments in combination with other valid measurements to support the hypothesis of TMD and to find an indicator for a promising treatment approach.

5.3 | Physical examination tests

After Round-2, an overview of all physical tests considered as useful for the evaluation of patients with suspected TMD was provided to the clinical experts (see Figure 7). Among the 14 tests described in the literature, the following were not familiar to all experts, such as the dental stick test, hyoid movement, mandibular nerve test and ten new tests suggested by individual experts. These 13 tests are not regularly imbedded in research studies and have not been reviewed for reliability and validity.[23]

Nearly, all experts perform physiological mandibular movements and rated them as important for the reassessment during the treatment process and also to distinguish between intra-articular disorders, degenerative joint disease and myogenic disorders. Experts sometimes used them as stand-alone tests to confirm their hypothesis. For the assessment of painful myofascial TMD, manual palpation was the preferred assessment for almost all experts in comparison to the use of an algometer (PPT), which was comparable with the proposal of the DC/TMD consortium published in 2014 and illustrated in Figure 7, where different clinical physical tests are applied along with the clinical diagnosis as described in the DC/TMD. Interestingly, most physical therapy experts did not believe in an isolated physical test to support the clinical diagnosis. They preferred "cluster of tests" including inspection for posture, myofascial examination, physiological examination and mandibular movements. Recent studies highlighted that clinicians should look at a combination of assessment tests and functional tests for the diagnosis of musculoskeletal conditions such as patellofemoral pain syndrome,[25] cervicogenic headache[26,39]or shoulder pain.[27]This was in accordance with the literature, where combinations of symptoms and a clinical test were considered to have a moderate to high reliability (*k*-values >0.4). This combination of tests assisted the clinician to sub-classify the patients' presentation into arthrogenic, myogenic or neurogenic TMD.[24,28]For example, when assessing cervical impairment, experts preferred the craniocervical flexion test (endurance) and cervical spine screening with manual techniques. The craniocervical flexion

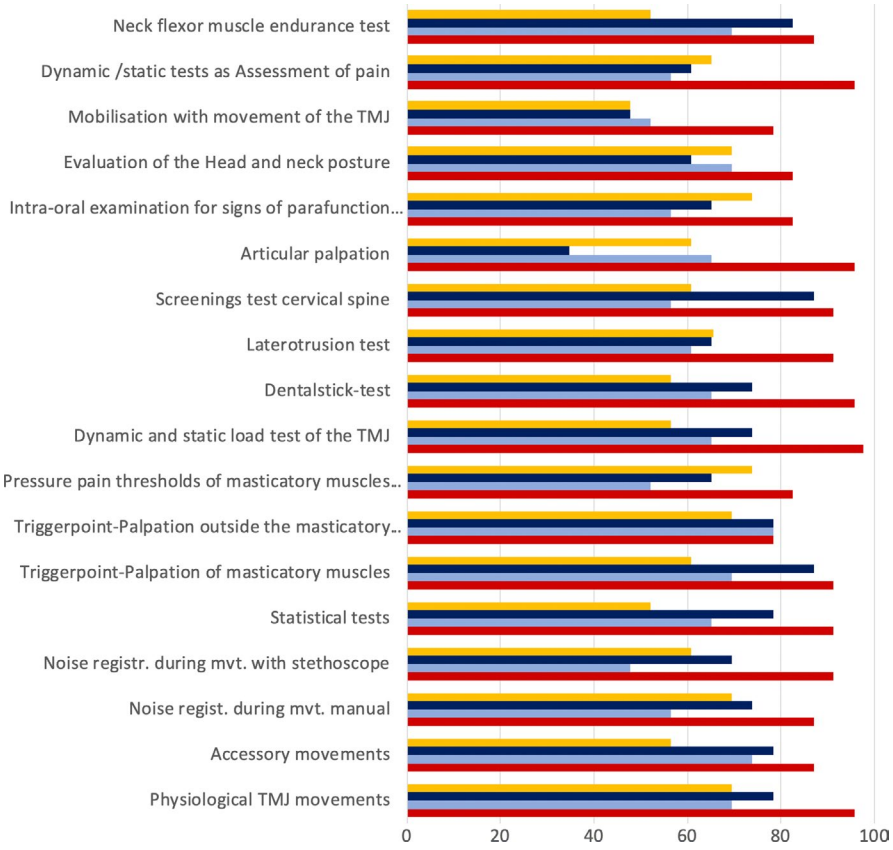

FIGURE 7 Differentiation in the choice of physical tests in percentages during the main clinical diagnosis after Round-3. Axis 1 within the DC/TMD Axis 1 consortium 2014; myogenic TMD, atherogenic TMD, degenerative TMD and subluxation

test is a clinical test of neuromotor control of the deep flexors of the cervical spine. This test may be strongly associated with chronic neck pain[25-26,30,31] and cervicogenic headache.[32] Experts suggested it should to be used to evaluate myogenic (64%) and mixed (74%) TMD Axis 1, as well as for chronic oro-facial pain (Axis II). Screening of the cervical spine requires the use of valid cervical physical tests with the aim of finding cervical impairments. These impairments can play a role in determining the patients' TMD complaints. It was noted by the experts that in those with TMD, cervical manual screening in Axis I (82.6%, 19/23) and Axis II (87.0%, 20/23) was useful. Most physical therapist experts were familiar with the clinical patterns classified in the DC/TMD and the strong association of cervical impairments[29] and TMD.[36,37]

6 | STRENGTHS AND LIMITATIONS

Our study had some limitations. A Delphi study is based on a qualitative analysis and does not have the sampling requirements of a randomised design.[38,39,40] We included 23 motivated experts from around the world who were known (personally or through the publications) by the Delphi team. The number of participants in comparison with other Delphi studies in the physical therapy area was small. This was probably due to the number of physical therapy experts in the TMD field being small in comparison with other areas such as the lumbar spine, cervical spine and shoulder.[30] Although we tried to represent different areas of specialty and geographical regions with our experts, our findings may have limited generalisability.

Despite the limitations, the results of this study demonstrated that the proposed Delphi process was a useful method for reaching consensus in the physical therapy related to TMD assessment tools. From a clinical and research perspective, our study succeeded in demonstrating an agreement of about 60% within the experts. There was a large overlap of the assessment tools used by physical therapists to assess the TMD. Additionally, this study may promote collaboration and research with other disciplines that use the DC/TMD consortium.

7 | CONCLUSION

This study was an international consensus of 23 clinical physical therapy TMD experts from 11 countries on questionnaires, pain screening tools and physical examination tests for the evaluation of TMD. The chosen assessments of the Delphi panel were based on a comprehensive evaluation of the literature before the first survey round and on the opinion of international experts after the second round. The most used questionnaires by the panel of experts were TSK/TMD followed by JFL-8 and the MFIG. For pain screening assessment, the VAS and the TMD Disability Index were considered relevant by the panel of experts. For physical examination tests, physiological mandibular movement assessment, muscle palpation and cervical manual

screening were the preferred tests. Most experts were familiar with the DC/TMD classification and believe that physical examination tests need to be clustered to confirm subgroups in TMD (DC/TMD). This consensus may facilitate ideas for a useful combination of assessments designed for the different subgroups of TMD, which can be used in clinical research, clinical practice and could allow collaboration with other disciplines utilising the DC/TMD.

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CONFLICT OF INTEREST

The authors have stated explicitly that there is no conflict of interests in connection with this article.

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