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# Temporomandibular disorders – validity of clinical diagnostics compared to magnetic resonance imaging

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**Abbreviations:**
DD – disc displacement
MFA – manual functional analysis
MRI – magnetic resonance imaging
TMD – temporomandibular disorder
TMJ – temporomandibular joint
VAS – visual –analogue scale

**Key words:** temporomandibular disorders, magnetic resonance imaging, validity, manual functional analysis

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## Abstract

***Background and Purpose:*** *Orthopedic examination techniques of the musculoskeletal system contribute to the successful diagnostics of temporomandibular disorders (TMD). The purpose of this study is to determine the validity of TMD clinical diagnostics by comparing the findings of manual functional analysis (MFA) and the results of MRI of temporomandibular joint (TMJ). The diagnostic significance of limited mouth opening and pain upon passive mouth opening were taken into consideration.*

***Materials and Methods:*** *59 patients with clinical signs and symptoms of TMD were examined consecutively. There was a subgroup comprising 40 patients diagnosed with DD. Clinical diagnoses were made by means of MFA. MRI was the gold standard in the assessment of clinical diagnostics validity, in certain diagnoses of DD (partial with reduction, complete with reduction, complete without reduction), as well as in the diagnostic significance of limited mouth opening (<40 mm) and pain upon passive mouth opening.*

***Results and Conclusion:*** *Validity of MFA in diagnostics of TMD showed maximal sensitivity of 100% and specificity of 57%. Matching of TMD diagnoses between findings of MFA and MRI was 95%. Sensitivity of MFA for certain diagnoses of DD was from 67 to 78%. Lower values were determined for active mouth opening (<40 mm) for certain diagnoses of DD (from 25 to 35%), while the sensitivity for findings of pain in the TMJ on passive mouth opening was 86%. By using compression and joint play technique, the existing clinical diagnostics for specific diagnostics of subgroups as well as for various TMD diagnoses was enhanced.*

## INTRODUCTION

Within the stomatognathic system, musculoskeletal disorders are grouped as temporomandibular disorders (TMDs), which imply painful conditions of the temporomandibular joints (TMJs) and/or masticatory muscles. Clinical diagnostics based on the main symptoms and clinical signs of TMDs is important in identifying the real cause of pain and in differentiation between pains in articular and muscular structures *(1–4)*. Research Diagnostic Criteria (RDC) for TMD is the best known diagnostic system *(5–9)*.

The purpose of introducing specific methods of examination from the fields of orthopedics, rheumatology and manual medicine into TMD diagnostics was to separate diagnostically nonspecific symptoms from the important symptoms and clinical signs accompanied by pain, which is equally important to patients and clinicians *(10, 11)*. Namely,

epidemiologic data reveal a high prevalence of TMD symptoms (such as clicking in the TMJ up to 75–90%) and a relatively low prevalence of pain (from 2.7 to 6.1%) in general population *(12)*.

Manual functional analysis (MFA) is a group of methods of manual examination and of pain and other clinical symptoms differentiation within arthrogenic and/or myogenic forms of TMD *(13)*. Numerous authors have implemented orthopedic and specific manual examinations in order to improve clinical diagnostics. However, despite the inevitable clinical diagnostics in management of musculoskeletal disorders, magnetic resonance imaging (MRI), significantly enhanced TMD diagnostics. MRI has become the gold standard in TMJ disorders diagnostics because it shows images of soft intraarticular tissues *(14–16)*. However, asymptomatic internal derangement of TMJ does not favor MRI over clinical diagnostic procedures, which has been confirmed in other musculoskeletal disorders (for example, back pain) *(1, 17)*.

The aim of the paper was to assess the validity of TMD clinical diagnostics by comparing the findings of MFA and results of MRI of TMJ. Different diagnoses of anterior disc displacement (DD) as well as diagnostic significance of limited mouth opening and pain upon passive mouth opening were taken into account.

## MATERIAL AND METHODS

A prospective study of patients with clinical signs and symptoms of TMDs included a total of 59 patients with mean age of 37.2 ± 17.9 years (76.7% female). All patients were examined consecutively in the period between 2001 and 2004 at the Department of Prosthodontics and these basic clinical parameters were taken into account: pain related to TMJ and/or masticatory muscles, pathological noise or their mention in medical history and limited mouth opening. The inclusion clinical criterion was to determine TMD by using MFA according to Baumann and Groot Landeweer *(13, 14)*. The second part of the study consisted of MR imaging of TMJ, which is the gold standard in TMJ diagnostics, in order to confirm or exclude the arthrogenic form of TMD. Among the 59 patients, there were those with the myogenic form of TMD only with the purpose of calibrating the clinical examiners and radiologists. Also, MRI diagnostics of TMJs was carried out to assess their condition. Conclusive diagnoses of TMD were made after comparison of clinical findings with MRIs *(14)*.

Three patients out of the 59 sought help due to dysfunctional symptoms in their stomatognathic system, yet, they were not clinically diagnosed with TMD. MRI was used in order to verify their clinical and radiologic findings. Subluxation with clicking, and pronounced bruxism were found in those patients.

### Clinical diagnostics

Clinical diagnostics was made by the use of MFA method *(13, 14)*. A nonspecific examination included measuring of active and passive mouth opening as well as isometric testing of groups of masticatory muscles. A sliding caliper was used to measure mandibular movements by means of a marked projection of the incisal edge of the upper central incisor on the labial plane of the lower central incisor. Isometric testing of muscles involved in movements of opening and closing the mouth lasted from 20 to 80 seconds, with manual resistance from the clinician. If the patient experiences pain, the diagnosis of tendomyopathy is to be established by additional positive finding of muscle palpation within the examined group of muscles.

A specific examination included the examination of the TMJ, that is, confirming the painful condition within the intraarticular structures of the TMJ as well as pathologic noise such as clicking and crepitations. Articular surfaces were examined by cranial compression and translations – the patient actively opening the mouth while the clinician continually performs manual manipulation of cranial compression against the TMJs, that is, pushes the mandible performing dynamic translations (simultanously one TMJ laterally and a contralateral joint medially). Joint play is a technique of performing passive compressions cranially, dorso-cranially, medially and laterally which can provoke pain in the bilaminar zone due to anterior DD.

If the medical history mentions noise such as crepitations during active mandibular movements, and dynamic procedures help determine arthrogenic pain accompanied by crepitation, then osteoarthritis can be diagnosed. This diagnosis was made in 8 patients (mean age 47, ranging from 23 to 82 years).

40 patients (mean age 35.5, ranging from 15 to 71) were diagnosed with anterior DD. The following prevalence was determined: total DD with reduction comprising 34.9%, partial DD with reduction comprising 21%, and total DD without reduction in 44.1% of the patients' joints. The anterior DD with reduction causes clicking which occurs at the beginning or in the middle of the active opening movement, while reciprocal clicking occurs during mouth closing. Clicking is examined by dynamic translations if it occurs during lateral and medial translations. Then it is a case of complete anterior DD. In case of partial DD, the clicking is missing during lateral translations (partial lateral anterior DD) or in medial translation (partial medial anterior DD). During the dynamic procedures, intensifying of arthrogenic pain may occur as well as limited opening without any pathologic noise found during a nonspecific and a specific examination. Based on previous clicking symptoms, intensification of arthrogenic pain and limited opening without any noise as well as by provocation of symptoms in the bilaminar zone, a diagnosis of anterior DD without reduction is made by dynamic compression.

### MRI diagnostics

The MRI diagnostics of both TMJs of all the subjects who participated in the study was performed by a magnet on a »Harmony« supraconductive machine manufac-

tured by Siemens (Erlangen, Germany) with the magnetic field power of 1T. Each image had a 3-mm section, with seven slices in sagittal oblique plane. Scanning sequences included $T_1$-weighted images (parameters: 450 ms TR, 12 ms TE, a field of view of 160 × 160, a matrix of 256 × 192) of all subjects were scanned in the closed mouth and the open mouth position. The physiological position of the disc was determined according to the intermedial zone position within the shortest span of the osseous contours of the ventocranial part of the condyle and the articular eminence (*16*).

## Statistical analysis

Statistical analysis was performed by using SAS software. Data were analyzed in the following two ways: once the object of observation was the person and the other time it was the temporomandibular joint. In a data analysis regarding joints, the left and the right TMJ of one person were presented as two entities. Three joints were excluded from the analysis of joints as separate entities: two with asymptomatic DD and one with osteoarthritis. The remaining joints were diagnosed with DD, osteoarthritis and physiological disc position.

Validity was examined by MFA – a diagnostic test is used to describe the examined pathologic condition – as well as reliability – the same or different examiners at repeated use of the same diagnostic test reach the same diagnosis. Validity of a diagnostic procedure is described by means of its sensitivity and specificity. MRI results were used as the diagnostic standard *(14)*.

All patients (n=59) who were diagnosed by MRI were included in diagnostics of arthrogenic TMD to confirm validity of MFA. The validity analysis of clinical diagnostics of DD included joints (n=43) within the group of 40 patients with individual diagnoses of DD. Only the patients with DD (n=38) who had unilateral DD or the same diagnosis of DD bilaterally were taken into account in validity analysis of limited mouth opening findings. Two patients who had different diagnoses of bilaterally DD simultaneously were excluded. Validity analysis of tendomyopathy also included 38 patients regardless of whether they had unilateral or bilateral positive findings. Joints of the patients with DD and physiological position of the articular disc ($n_{joints}$=77) were included in validity analysis of clinical findings of pain in the TMJ on passive mouth opening.

Sensitivity is defined as the proportion of diseased subjects who are test positive. Specificity is defined as the proportion of healthy subjects who are test negative. An important feature of an applied diagnostic test is its diagnostic probability, that is, the positive and negative predictive value. Positive predictive value is defined as the proportion of the test positive subjects who are diseased, and negative predictive value as the proportion of the test negative subjects who are healthy (Table 1).

The reliability of MRI assessment was evaluated for each diagnosis of DD on the basis of two researchers' (a radiologist's and a dentist's) inspection by means of

**TABLE 1**

Relations between values and formulas for calculating statistical validity of a diagnostic test.

| | Actual condition – diagnosis | | | |
|---|---|---|---|---|
| Applied test | + | – | Total | Sensitivity: a/(a+c)<br>Specificity: d/(b+d) |
| + | a | b | a+b | Positive predictive value: a/(a+b) |
| – | c | d | c+d | Negative predictive value: d/(c+d) |
| Total | a+c | b+d | | a – True positive<br>b – False positive |

Kappa statistics *(18),* which was conducted on MRI images independently of the clinical signs of 12 patients, twice on the same MRIs of both TMJs. Using Cohen's kappa statistics, the interexaminer agreement was measured between 0.8 and 1.0 for MRIs.

## RESULTS

Validity analysis of clinical diagnostics compared with MRI results as a diagnostic standard used to determine arthrogenic TMD is shown in Table 2. The sample included all patients (n=59) examined on the basis of their clinical symptoms and clinically diagnosed arthrogenic or myogenic form of TMD. Despite the established clinical diagnosis, the arthrogenic cause of symptoms and clinical signs of TMDs (DD, osteoarthritis of the TMJ) was excluded in three patients after MRIs of TMJs.

The reliability of manual functional analysis in diagnostics of certain diagnoses of DD in patients ($n_{patients}$=40) included in statistical analysis with MRI findings was assessed. Clinical diagnosis of DD was confirmed in 29 patients (73%), while a clinically different diagnosis of DD was established in 11 patients (27%) by MRI. Accuracy of certain clinical diagnoses for certain joints with DD ($n_{joints}$=43) compared with MRI was shown in Table 3. Tables 4–6 show values of components of validity of clinical diagnostics used in making certain diagnoses within the joints with DD.

Values of validity of clinical findings in limited mouth opening less than 40 mm (Tables 7–9) were determined for certain diagnoses. The same criterion was established

**TABLE 2**

Validity of clinical diagnostics in determining arthrogenic TMD for all examined patients who were scanned by MRI (n=59).

| Clinical diagnosis | MRI | | |
|---|---|---|---|
| | + | – | Sensitivity 100%<br>Specificity 57% |
| + | 52 | 3 | Positive predictive value 95%<br>Negative predictive value 100% |
| – | 0 | 4 | Matching of diagnoses 95% |

**TABLE 3**

Distribution of correspondence of diagnoses of DD determined by a clinical examination and MRI.

| DD diagnosis | | Diagnosis confirmed by MRI | | | |
|---|---|---|---|---|---|
| **Clinical diagnosis** | | **Partial DD with reduction** | **Complete DD with reduction** | **Complete DD without reduction** | **Total** |
| Partial DD with reduction | n | 7 | 2 | 1 | 10 |
| | hp | 70.0% | 20.0% | 10.0% | 100% |
| | pu | 16.3% | 4.7% | 2.3% | 23.3% |
| Complete DD with reduction | n | 1 | 10 | 4 | 15 |
| | hp | 6.2% | 66.7% | 26.6% | 100% |
| | pu | 2.3% | 23.2% | 9.3% | 34.8 |
| Complete DD without reduction | n | 1 | 3 | 14 | 18 |
| | hp | 5.9% | 16.7% | 77.8% | 100% |
| | pu | 2.3% | 7% | 32.6% | 41.9 |
| Total | | 9 | 15 | 19 | 43 |
| | | 20.9% | 34.9% | 44.2% | 100% |

n – number of joints; hp – percentage with respect to the horizontal sum; pu – percentage with respect to the total sum

to assess validity in case of tendomyopathy (Table 10). Only the patients who did not have different diagnoses of DD ($n_{patients}$=38) were taken into consideration. Pain in the TMJ caused by passive mouth opening was compared with findings of DD, and the analysis also included joints with physiological disc position (ukupno $n_{joints}$=77; Table 11).

**TABLE 4**

Validity of clinical diagnostics for partial DD with reduction.

| Clinical diagnosis | MRI + | MRI – |
|---|---|---|
| + | 7 | 3 |
| – | 2 | 31 |

Sensitivity 78%
Specificity 91%
Positive predictive value 70%
Negative predictive value 94%

**TABLE 5**

Validity of clinical diagnostics for complete DD with reduction.

| Clinical diagnosis | MRI + | MRI – |
|---|---|---|
| + | 10 | 5 |
| – | 5 | 23 |

Sensitivity 67%
Specificity 82%
Positive predictive value 67%
Negative predictive value 82%

**TABLE 6**

Validity of clinical diagnostics for complete DD without reduction.

| Clinical diagnosis | MRI + | MRI – |
|---|---|---|
| + | 14 | 3 |
| – | 5 | 21 |

Sensitivity 74%
Specificity 88%
Positive predictive value 82%
Negative predictive value 81%

**TABLE 7**

Validity of limited mouth opening findings (<40 mm) for partial DD with reduction.

| Active mouth opening | partial DD with reduction + | partial DD with reduction – |
|---|---|---|
| <40 mm | 2 | 10 |
| ≥40 mm | 6 | 20 |

Sensitivity 25%
Specificity 67%
Positive predictive value 17%
Negative predictive value 77%

**TABLE 8**

Table 8 Validity of limited mouth opening findings (<40 mm) for complete DD with reduction.

| Active mouth opening | complete DD with reduction + | complete DD with reduction – |
|---|---|---|
| <40 mm | 4 | 8 |
| ≥40 mm | 9 | 17 |

Sensitivity 31%
Specificity 68%
Positive predictive value 33%
Negative predictive value 65%

**TABLE 9**

Validity of limited mouth opening findings (<40 mm) for complete DD without reduction.

| Active mouth opening | complete DD without reduction + | complete DD without reduction – |
|---|---|---|
| <40 mm | 6 | 6 |
| ≥40 mm | 11 | 15 |

Sensitivity 35%
Specificity 71%
Positive predictive value 50%
Negative predictive value 58%

**TABLE 10**

Validity of limited mouth opening findings (<40 mm) for tendomyopathy.

| Active mouth opening | Tendomyopathy | | Sensitivity 15%<br>Specificity 58%<br>Positive predictive value 17%<br>Negative predictive value 58% |
|---|---|---|---|
| | + | – | |
| <40 mm | 2 | 10 | |
| ≥40 mm | 11 | 15 | |

**TABLE 11**

Validity of findings of pain in the TMJ by applying the passive mouth opening test for joints of patients with DD.

| Pain on passive mouth opening | DD diagnosis | | Sensitivity 86%<br>Specificity 88%<br>Positive predictive value 90%<br>Negative predictive value 83% |
|---|---|---|---|
| | + | – | |
| + | 37 | 4 | |
| – | 6 | 30 | |

## DISCUSSION

Validity of RDC/TMD Axis I is not satisfactory and does not reach the necessary levels of sensitivity (≥0.70) and specificity (≥0.95) *(19)*. Present opinion is that RDC/TMD should be supplemented by specific methods of TMJ examination, such as the joint play test. Advantages of RDC/TMD use are pointed out, although, for example, MFA actually uses orthopedic tests such as compression tests and joint play test *(20)*.

RDC/TMD system classifies TMDs into three subclasses: muscle disorders, DDs, and arthralgia/arthritis/arthropathy *(5)*. There are certain doubts about the making of some diagnoses, such as arthralgia which is actually a symptom rather than a diagnosis *(4)*. Development of clinical diagnostics within diagnostic methods used in other musculoskeletal disorders of the human body should be based on evaluation and assessment of clinical signs, symptoms and data from patient's history (*2–4*). MFA enhances clinical diagnostics and shows high values of sensitivity (up to 78%) for certain diagnoses of DD. Certain signs, such as limited mouth opening do not have this diagnostic strength (the highest sensitivity of 35%) if they are considered separately from key manual methods – compression and joint play.

Arthrogenic form of TMD can be diagnosed in the same patient independently of the confirming or excluding the tendomyopathy diagnosis. Researchers were mostly focused on determining the highest prevalence of muscle disorder, which is considered overrated by Manfredini *et al. (6)*. For example, in a previous study, Manfredini *et al. (7)* found muscle disorder in 38.2% of patients and an equal prevalence of DD diagnoses and groups of arthralgia/arthritis at 52.3% and 52.6% respectively. However, by use of RDC/TMD, Yap *et al. (8)* found twice as high prevalence of muscle disorder compared to 12.6–15.7% of TMJ disorder diagnoses. From the total sample of patients (n=59) who participated in our study, clinical diagnosis of tendomyopathy, which was confirmed by excluding TMJ pathologies using MRI, was made in only 6 patients. However, the results of analysis of clinical diagnoses made by MFA showed prevalence of tendomyopathy in 8 to 17 out of the total 40 patients with different diagnoses of DD *(14)*.

Since the research on prevalence of TMD diagnoses according to RDC/TMD is exclusively clinical, the issue of arthralgia remains unresolved because it is the main symptom in almost all the patients who seek help. Limchaichana *et al. (9)* found a high prevalence of clinically unrecognized forms of DD which were, in combination with muscle disorders, classified as arthralgia/arthritis according to RDC/TMD.

Numerous authors implemented orthopedic and manual specific tests in order to improve clinical diagnostics. Certain orthopedic techniques such as compression, passive opening, and the joint play test which were used in this study showed diagnostic value. Lobbezoo-Scholte *et al. (10)* stress the need to use orthopedic tests in order to distinguish between myogenic and arthrogenic disorders. The most important diagnostic parameter is locating the pain, which cannot be specified only by use of traditional methods of dental examination. Hesse *et al. (11)* consider dynamic and static orthopedic tests (compression on intraarticular structures of TMJ) to be the gold standard of pain location and at the same time of distinguishing between muscular and articular disorder. They concluded that in certain patients the diagnosis cannot be made with certainty, which can be seen from the results of our specificity evaluation (82 to 91%). However, MFA is a clinical system of tissue-specific diagnosing of forms of TMD, as well as of even more specific differentiating of certain DD diagnoses. RDC/TMD cannot distinguish between partial and complete DD, hence it does not provide the methodology and criteria for clinical diagnostics.

Bumann in collaboration with Groot Landeweer (*13*) provided an overall system to diagnose TMDs, and, together with Lotzmann, confirmed it by thorough MRI diagnostics of TMJ. Bumann *et al. (14)* confirmed clinical diagnosis of DD by MRI in as many as 90% of cases. In this study, the accuracy of all TMD diagnoses was the same as positive predictive value of MRI at 95%, while the procedure of differentiating between certain DD diagnoses ranged between 66.7 and 78%. In their recent study, DuPont and Brown *(22)* pointed out that provocation by specific clinical procedures is an important part of diagnostics; this is particularly stressed in other recent studies which used MFA *(14, 22–25)*. MFA is used as a screening test for symptoms and signs of TMD before orthodontic treatment *(26, 27)* or as clinical standard for less sensitive diagnostic methods of TMD such as electronic axiography *(28)*.

Low validity and sensitivity for borderline value of limited mouth opening in our study can be explained by

the fact that the lower the borderline value, the higher the validity of measurement. That is why Miller *et al.* (*29*) calculate the mouth opening index according to the formula which includes the range of passive mouth opening. In our study, the sensitivity of in TMJ on passive mouth opening was high, that is 86%.

Asymptomatic DD has a prevalence of at least 20 to 33% in nonpatient population (*17*). Due to this fact, our study confirms the validity of MFA in diagnostics and differentiation of various diagnoses of TMD. However, the analysis of the total number of patients showed maximal sensitivity of 100% and low specificity of 57%. The reason for this is the fact that MRI is a diagnostic standard and that each MRI finding without a clinical confirmation would be considered an asymptomatic finding rather than an unrecognized illness (*9, 16, 17*). Indeed, MRI is not an appropriate screening method but a strictly applied diagnostic and differential-diagnostic method.

In conclusion, our study showed diagnostic value of MFA in diagnosing myogenic and arthrogenic TMD as well as certain diagnoses of DD. Matching of diagnoses made by MFA and MRI was 95%. Sensitivity of MFA for certain diagnoses of DD was between 67 and 78%. Lower values were determined for active mouth opening (<40 mm) in certain diagnoses of DD (from 25 to 35%).

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