Assessment of Mandibular Function Impairment Associated With Temporomandibular Joint Osteoarthrosis and Internal Derangement

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Clinical assessment of function impairment associated with temporomandibular disorders should not only comprise diagnostic assessment of symptoms and signs but also function impairment assessment in the patient's value system. Regarding clinical assessment methods, the range of opening movement has been demonstrated to be one of the few variables that can be measured reliably. However, this variable allows no distinction to be made between articular and muscular causes of movement restriction. To assess joint mobility, a combination of indirect and direct assessments is proposed, including the range of opening movement after passive stretch, the range of horizontal excursion toward the opposite side, and the condylar translatory capacity by palpation. In clinical practice, signs and symptoms needed for diagnosis are frequently used as the only basis for mandibular function assessment. Function assessment in the patient's value system, however, is a neglected area in outcome assessment. The main objective of this study was to design and clinimetrically evaluate a mandibular function impairment questionnaire. The relationship between jaw function impairment and measures of pain, movement restriction, and psychological distress was assessed. The questionnaire appears to be a reliable and valuable complementary tool for assessing mandibular function impairment.

J OROFACIAL PAIN 1993;7:183–195.

Many patients with temporomandibular disorders (TMD) seek treatment primarily to regain normal pain-free function. Consequently, pain relief and improvement of jaw function should form important aspects in assessing treatment outcome. Jaw functions that may be impaired by TMD include taking a large bite, mastication, speech, yawning, and laughing. Hence, impairment of jaw functioning may interfere with nutrition and the ability to communicate with ease and confidence.

Tissue damage associated with TMD may cause clinical signs and symptoms, such as pain and dysfunction. In most studies of TMD, dysfunction is expressed as interferences during movement (eg, clicking) and movement restriction.[1] Without doubt, a detailed registration of movement characteristics is of diagnostic importance. However, clinical observation suggests that the real impact of symptoms and signs on mandibular functioning can be quite varied. Some patients function well, while others are disturbed by the same degree of dysfunction. Slight or even moderate movement restriction may be present without causing a feeling of impaired functioning. On the other hand, a symptom that is frequently regarded as being nonserious, such as painless clicking, may interfere with normal functioning. The patient with a clicking jaw may

be embarrassed to eat in the presence of others, which may limit considerably that person's social life. Thus, abnormality in this regard is an individual matter.

From the patient's point of view, characteristics of dysfunction become truly symptomatic when they interfere in some way with daily activities. Therefore, comprehensive assessment of the functional status of the masticatory system should comprise two elements: (1) the extent of tissue damage and (2) its consequences for the patient's ability to function properly. The first element involves assessment of anatomic and physiologic variables of primary importance for diagnosis. In this respect, there is a growing tendency to rely on instrumental assessment methods, such as electromyography,[2,3] jaw-tracking devices,[4,5] sonography,[6] and Doppler auscultation,[7] to register jaw function and dysfunction objectively. However, closer examination of the reliability and validity of these devices revealed that their clinical significance is limited and insufficiently supported by scientific evidence.[8–11] Therefore, diagnosis and evaluative assessment of jaw function primarily must be carried out using conventional clinical assessment methods. Several reports addressing the reliability of assessment of clinical signs have recently been published.[12–14] These reports emphasize the need for explicit operational definition of the methods used for assessment. Also, a very useful published paper reviews accepted standards for the clinical evaluation of mandibular movement characteristics.[15]

Improper jaw function is thought to be related to pain during movement and to movement restriction. A restricted range of opening may be due to articular restriction, extra-articular restriction (usually muscular), or both. Although the maximal range of opening movement has been demonstrated to be one of the few variables that can be measured reliably,[13] this variable is not specific enough to distinguish between articular and muscular movement restriction.

The second aspect of function assessment relates to the patient's perception of function impairment. In spite of its importance, this way of assessing jaw function is a neglected area in outcome assessment. Therefore, a new method for the assessment of jaw function impairment that focuses on the patient's value system has been designed.

The purpose of this study was two-fold: to design and evaluate specific methods for jaw function assessment, and to examine the relationship between subjective jaw function impairment and possible related factors such as restricted movement, pain, and psychological distress. This article reports the results of a study addressing (1) the interobserver reliability of an assessment method addressing TMJ mobility; (2) the construction and clinimetric evaluation of a questionnaire specifically designed to assess the patient's appreciation of mandibular function impairment; and (3) the relationship of jaw function impairment to pain, restricted movement, and psychological distress.

Materials and Methods

Development, Construction, and Operational Definition of Methods for Jaw Function Assessment

Assessment of Jaw Movement Restriction. In the clinical setting, joint movement ability can be assessed indirectly by measuring the range of mandibular opening after passive stretch[16] and the range of horizontal mandibular excursions. Palpation of the lateral aspect of the joint during movement may provide additional information about the translatory capacity of the joint. With sufficient translatory capacity, anterior condylar movement can be clearly palpated during maximal protrusive movement, and additional translation will occur during opening from the maximally protruded position.

To evaluate the interobserver variability of these assessments, two observers independently assessed maximal opening movement after passive stretch applied following active opening, the maximal range of lateral excursion to the opposite side, and joint mobility by palpation in a sample of 46 consecutive patients with TMJ internal derangements (42 women, 4 men; mean age 28 years, Sd 9.4). Ranges of movement were measured with a millimeter ruler read to the nearest millimeter. Temporomandibular joint mobility was assessed by digital palpation of the lateral aspect of the joint during maximal protrusive movement, followed by maximal opening from the maximum protruded position. Joint mobility was graded on a five-point scale according to the following criteria:

−2 = No or minor translation palpable on protrusive movement or during opening after maximal protrusive movement.
−1 = Translation palpable on protrusive movement; no or only minor additional translation during opening after maximal protrusive movement.
0 = Translation clearly palpable on protrusive movement; additional translation clearly present during opening after maximal protrusive movement.

1 = Translation clearly palpable on protrusive movement; excessive additional translation palpable during opening after maximal protrusive movement.
2 = Translation clearly palpable on protrusive movement; excessive additional translation during opening movement with "jumping" movement (due to sudden acceleration near maximal opening).

A joint with a negative mobility score was considered restricted, a score of 0 or 1 was considered normal, and a mobility score of 2 was considered symptomatically hypermobile.

Pearson's product-moment correlation coefficient r was calculated as a measure of reliability for range of movement measurements. Cohen's κ $(P_O - P_E) / (1 - P_E)$, where P_O is the proportion of joints on which the observers agree regarding the mobility score and P_E is the proportion for which agreement is expected by chance, was calculated as a measure of interobserver reliability for the mobility assessments.

Assessment of the Patient's Appreciation of Function Impairment: Construction of the Mandibular Function Impairment Questionnaire. A preliminary questionnaire was used in the clinical setting to obtain subjective feedback from patients regarding a range of questions that were designed to assess functional abilities. In this way, areas of imprecision and ambiguity were revealed and the questionnaire was modified accordingly.

The items remaining after the test versions formed the mandibular function impairment questionnaire (MFIQ), which consisted of 17 items (Table 1). Each item was presented with a five-point Likert scale on which the patient could indicate how much difficulty was experienced performing a particular mandibular task (0 = no difficulty; 1 = a little difficulty; 2 = quite a bit of difficulty; 3 = much difficulty; 4 = very difficult or impossible without help).

Scale construction was performed in a sample of 95 patients (86 women, 9 men; mean age 26.0 years, Sd 8.1) with various TMD, including TMJ osteoarthrosis and internal derangement, synovitis, subluxation, myofascial pain, and symptomatic bruxism. The items of the questionnaire were subjected to principal component factor analysis. Factors with eigenvalue > 1 were retained. Factor interpretation was enhanced by means of oblique rotation (oblimin). To achieve sufficient convergent item validity, a correlation with the hypothesized factor of ≥ 0.50 (structure matrix after oblique rotation) was required. To ensure sufficient discrimination, a magnitude ≥ 0.20 between the highest and second highest factor loading (pattern matrix after oblique rotation) was required. The reliability (internal consistency) of the factors (scales) was assessed using Cronbach's coefficient α.

The raw score of a scale ranges from 0 to 1 and is obtained by dividing the sum of the items by four times the number of items (Table 1). The same rule applied to all 17 items yields a total

Table 1 Mandibular Function Impairment Questionnaire (MFIQ) and Scoring Key

Questionnaire	Possible answers	i*
Due to the complaints about your jaw, how much difficulty do you have with:	No difficulty A little difficulty Quite a bit of difficulty Much difficulty Very difficult or impossible without help	0 1 2 3 4
1. Social activities		
2. Speaking		
3. Taking a large bite		
4. Chewing hard food		
5. Chewing soft food		
6. Work and/or daily activities		
7. Drinking		
8. Laughing		
9. Chewing resistant food		
10. Yawning		
11. Kissing		
Eating food includes taking a bite, chewing, and swallowing. How much difficulty do you have with eating:		
12. A hard cookie		
13. Meat		
14. A raw carrot		
15. French bread		
16. Peanuts/almonds		
17. An apple		

Calculation of raw component score		
Item score	i	range 0–4
Numbers of items	N	
Sum item scores	$S = i_1 + \ldots + i_N$	range 0–4 N
Raw Component Score	$C = S/4N$	range 0–1

Calculation of level of function impairment			
Rule for i:		Rule for C:	FIRS†
all $i < 2$		$C \leq 0.3$	0
at least one $i \geq 2$		$C \leq 0.3$	1
all $i < 3$		$0.3 < C \leq 0.6$	2
at least one $i \geq 3$		$0.3 < C \leq 0.6$	3
all $i \neq 4$		$C > 0.6$	4
at least one $i = 4$		$C > 0.6$	5
Qualitative level of function impairment	I	low	0 or 1
	II	moderate	2 or 3
	III	severe	4 or 5

*Item score (0–4).
†Function impairment rating scale.

function impairment index. To enhance interpretation, the raw score can be converted to a six-point rating scale (range 0 to 5) or to a more qualitative indication of the level of function impairment (no or low/moderate/high) by applying the rules summarized in Table 1.

The questionnaire was presented to a subset of 20 consecutive patients (17 women, 3 men; mean age 24.4 years, Sd 6.3, range 15 to 39 years) using two methods: self-administered and assessor-administered during the intake interview. The same assessor performed the interview for all patients. The time between the interview and self-administration of the questionnaire was 2 hours. In half of the group the interview was performed first; in the other half the questionnaire was administered first. The assessor was unaware of the results of the questionnaire. This pilot study addresses questions of repeatability. The inter-method correlation between questionnaire and interview on the subscales (Pearson's product-moment correlation coefficient) was calculated.

Relationship Between Jaw Function Impairment and Other Variables

Subjects. The sample consisted of 80 patients referred because of masticatory pain and dysfunction to the Department of Oral and Maxillofacial Surgery of the University Hospital in Groningen. They were diagnosed clinically as well as radiographically as having TMJ internal derangement or TMJ synovitis without internal derangements. The main (additional) inclusion criterion was provocation or aggravation of pain in response to mechanical stimuli (eg, chewing, clenching). Subjects were considered ineligible if their diagnosis was unclear or if they had any major comorbidity (eg, diseases or intake of medication that could have an impact on their health status). Additional exclusion criteria were a history of condylar fracture, the presence of condylar growth disturbances, and generalized joint disorders. All patients were required to have a complete dentition without obvious occlusal disturbances.

The sample comprised 71 women (89%) and 9 men (11%) with a mean age of 25.2 years (Sd 7.3). Thirty-four patients had a reducing disc displacement and 29 patients had a permanent disc displacement. The remaining 17 patients had synovitis without internal derangements. (Synovitis was judged to be present when two of the following criteria were present: pain aggravated by joint movement or by functional loading; joint tenderness on palpation, on maximal voluntary clenching, or on manual joint compression or distraction.) Table 2 presents several characteristics of the subgroups.

Variables. Mandibular movement was assessed by measuring the range of opening after passive stretch and the range of lateral excursion to the opposite side, and by assessing TMJ mobility. The operational definitions of these variables have been described in the previous section.

All subjects completed the MFIQ. The level of function impairment was calculated according to the scoring key defined in Table 1.

Pain was assessed using a visual analog scale (VAS), the West Haven–Yale multidimensional pain inventory (MPI),[17] and a global pain impact (GPI) scale (Table 3). The VAS consists of a 100-mm line labeled *no pain* at one end and *worst possible pain* at the other. The line is marked to indicate pain intensity, which is measured as the distance from the *no pain* end to the mark (mm VAS). The MPI has been demonstrated to have good reliability and validity with several types of pain patients, including patients with TMD.[18] The MPI is divided into three sections, each of which comprise three to five separate scales:

1. The experience of pain and suffering, as evaluated on five scales (interference, support, pain severity, self-control, negative mood)
2. The patient's perception of the response of significant others to their pain, as evaluated on three scales (punishing, solicitous, and distracting responses)
3. General daily activities, as evaluated on four scales (household, outdoor work, activities away from home, social activities)

Application of a principal component analysis on this sample yielded a factor structure similar to that of the original questionnaire only for the first section. Therefore, analyses were limited to the scales from this section.

The overall subjective pain intensity was assessed by calculating the mean of the subjective pain ratings of *usual pain* and *worst possible pain* provoked by mechanical stimulus. These pain ratings were made on a VAS (range 0 to 100). As an additional measure of pain intensity, the pain severity scale of the MPI was used.

Joint pain during the clinical examination was assessed by recording the presence or absence of pain with the joint at rest, and of joint tenderness in response to palpation (lateral, posterior), voluntary movement (opening, protrusive, lateral), and manipulation (passive stretch, static and dynamic compression, and distraction). From these data a clinical joint pain index (range 0 to 1) was derived.

Table 2 Characteristics of Diagnostic Subgroups and the Total Sample

	Reducing disc displacement	Permanent disc displacement	Synovitis	Total
Demographics				
Number	34	29	17	80
Age				
Mean	25.8	24.8	24.8	25.2
SD	7.7	7.3	6.9	7.3
Range	15-48	16-45	17-42	15-48
Sex				
Female	31 (91%)	25 (86%)	15 (88%)	71 (89%)
Male	3 (9%)	4 (14%)	2 (12%)	9 (11%)
Pain symptoms				
Joint pain at rest	6 (18%)	8 (28%)	7 (41%)	21 (26%)
Clinical pain (range 0-1)*	0.34	0.65	0.45	0.48
Muscular pain	13 (38%)	9 (31%)	11 (65%)	33 (41%)
Overall pain (mm VAS)	37	48	45	43
Movement characteristics				
Range of opening (mm)				
Active				
Mean (SD)	49.0 (8.7)	32.8 (6.6)	45.3 (9.6)	42.4 (10.9)
Range	27-60	10-42	25-60	10-60
After passive stretch				
Mean (SD)	52.2 (6.5)	36.0 (7.1)	49.5 (6.7)	45.8 (10.0)
Range	35-62	11-49	34-61	11-62
Horizontal excursion (mm)				
Protrusive				
Mean (SD)	9.8 (1.7)	8.1 (2.8)	9.5 (2.4)	9.1 (2.4)
Lateral to opposite side				
Mean (SD)	9.9 (2.6)	7.2 (2.6)	11.1 (2.5)	9.2 (3.0)
Restricted joint mobility†				
Mean (normal = 0)	0.4	-0.7	0.4	0.3
No. (%) of patients	1 (3%)	24 (83%)	1 (6%)	26 (33%)

*Index (range 0-1) composed of joint pain at rest, and joint tenderness in response to palpation (lateral, posterior), in response to voluntary movement (opening, protrusive, lateral), and in response to manipulation (passive stretch, static and dynamic compression, and distraction).

†Assessment of joint mobility scored according to the criteria defined in the text (five-point scale, ranging from –2 to +2). Mobility was considered restricted when the score was <0.

Table 3 Global Pain Impact Scale (GPI): Operational Definition

Rating	Pain	Ability to perform usual jaw activities		Description
0	–	++	No impairment	No pain at all
1	+	++	No impairment	Pain is present, but is not disturbing
2	+	++	No impairment	Disturbing pain is present; despite the pain I can perform any usual activity or task I like without difficulty
3	+	+	Impairment*	Disturbing pain is present; although difficult because of the pain, it is possible to perform any usual activity or task I like
4	+	±	Disability*	Disturbing pain is present; because of the pain, I cannot perform some usual activities or tasks
5	+	–	Handicap*	Disturbing pain is present; because of the pain, cannot perform any usual activity or task without help

* In accordance with World Health Organization definitions: impairment = functional limitation; disability = task-specific limitation of performance; handicap = disability with dependency.

The impact of pain was assessed using a GPI scale (Table 3) and the pain interference scale of the MPI.

The 28-item scaled version of the General Health Questionnaire (GHQ-28) is a reliable and valid screening questionnaire that detects the presence of distressing phenomena and assesses the ability to carry out "healthy" functions.[19] The following scales were used for this study: tendency to develop somatic symptoms, social dysfunction, anxiety and insomnia, and the total score of general psychological distress.

Temporomandibular joint osteoarthrosis and internal derangement may impair masticatory function. Irritation of the retrodiscal tissues in the case of articular disc displacement may impair static and dynamic loading, ie, occlusion and mastication. Interincisal occlusal force (50 N) endurance time has previously been demonstrated to be significantly reduced in patients with TMJ osteoarthrosis and internal derangement.[20] In a randomly selected subgroup of the present sample (n = 50), occlusal force endurance time was assessed.

The time needed to chew a certain amount of tough food and to prepare it for swallowing may increase when this action causes pain. This assumption prompted the assessment of the length of time needed to chew and swallow a standardized amount of tough test food. The mastication time, defined as the time between the first masticatory stroke and the last swallow, was recorded with a digital stopwatch in a randomly selected subgroup of the sample (n = 43). The test food consisted of 15 small pieces of sweets (NL-Pharma, Nieuwegein). A major advantage of this test food is its familiarity to the patients compared to artificial food generally used in more formal assessments of masticatory efficiency. The test food is resistant and requires considerable masticatory force; it comprises small pieces so that no major food reduction is necessary.

Procedure. The pain and function impairment inventories were completed at the TMJ and Orofacial Pain Clinic of the Department of Oral and Maxillofacial Surgery, University Hospital of Groningen, as part of the routine examination of the patients. Additional assessments, such as the occlusal force and mastication tests, were performed following the clinical examination after the patient had given informed consent.

Analytic Methods. The extent to which the function impairment variables obtained from the MFIQ are explained by demographic and status measures was determined using multivariate regression analyses. A hierarchical stepwise model of regression analysis was used in which the independent variables were entered in two steps: (1) demographic variables (age, sex), and (2) status variables (measures of pain, mandibular mobility, and psychological distress). A separate regression analysis was performed to determine the extent to which occlusal force endurance and masticatory test results were predicted by the above-mentioned variables and by the level of function impairment. The variables were entered in three steps: (1) demographic variables, (2) status variables, and (3) function impairment variables. All analyses were carried out with the Statistical Package SPSS (SPSS Europe BV, Groningen, The Netherlands).

Results

Development, Construction, and Operational Definition of Methods for Jaw Function Assessment

Both observers measured a mean range of opening after passive stretch of 44.5 mm (observer 1: SD 11.0, range 12 to 67 mm; observer 2: SD 10.5, range 14 to 63 mm). The mean range of horizontal excursion measured by the observers was 9.3 mm (SD 2.4, range 4 to 14 mm) and 9.1 mm (SD 2.4, range 5 to 14 mm), respectively. The agreement between the observers was highly significant (r = .97 for opening after passive stretch, r = .82 for horizontal excursion).

The observers agreed on the TMJ mobility score in 89% of the cases for the left joint and in 87% for the right joint. The κ indices were 0.81 and 0.78, respectively. When joint mobility was judged as being restricted, normal, or symptomatically hypermobile, the two observers achieved complete agreement.

Three factors were extracted by principal component analyses, accounting for 68.6% of the total variance. Both varimax and oblimin rotation permitted a straightforward interpretation of the extracted factors. Because it is unlikely that the factors are not correlated, the oblique rotation was used for interpretation.

The first principal component consisted of a weighted sum of all 17 items with positive weights ranging from 0.54 to 0.86 (Table 4, unrotated factors). This factor accounted for 50.7% of the common variance. Items loading $\geq$ 0.50 on this factor (Table 4, factor structure after rotation) formed the MASTIC scale, as their content was associated with perception of masticatory ability. The second factor explained another 11.1% of the variance.

Table 4 Mandibular Function Impairment Questionnaire: Items, Unrotated Factors, and Factor Structure and Pattern After Oblique Rotation

	Unrotated factors			Factor structure‡			Factor pattern§		
Item*	I	II	III	I	II	III	I	II	III
3. Taking a bite	0.77	-0.23	0.24	**0.77**	0.31	**0.55**	**0.71**	-0.11	0.34
4. Chewing hard food	0.85	-0.29	0.02	**0.88**	0.37	0.39	**0.88**	-0.08	0.12
5. Chewing soft food	0.54	-0.17	-0.26	**0.59**	0.29	0.01	**0.64**	0.05	-0.21
9. Chewing resistant food	0.82	-0.22	0.07	**0.84**	0.38	0.43	**0.79**	-0.03	0.17
12. Eating† a hard cookie	0.83	-0.25	-0.16	**0.88**	0.42	0.23	**0.89**	0.02	-0.06
13. Eating meat	0.84	-0.24	-0.15	**0.88**	0.43	0.24	**0.89**	0.03	-0.06
14. Eating a raw carrot	0.86	-0.16	-0.15	**0.88**	0.49	0.27	**0.84**	0.11	-0.03
15. Eating french bread	0.84	-0.26	0.00	**0.87**	0.38	0.37	**0.86**	-0.05	0.10
16. Eating peanuts/almonds	0.84	-0.05	-0.20	**0.84**	**0.57**	0.23	**0.76**	0.24	-0.08
17. Eating an apple	0.81	-0.13	0.58	**0.80**	0.44	0.42	**0.71**	0.06	0.17
1. Social activities	0.54	0.66	-0.08	0.34	**0.85**	0.29	-0.10	**0.87**	0.10
2. Speaking	0.55	0.53	-0.32	0.41	**0.81**	0.06	0.08	**0.82**	-0.17
6. Work and daily activities	0.55	0.53	-0.15	0.39	**0.78**	0.22	0.04	**0.76**	0.01
7. Drinking	0.59	0.41	-0.11	0.46	**0.71**	0.25	0.15	**0.63**	0.04
8. Laughing	0.57	0.47	0.19	0.39	**0.68**	**0.51**	0.00	**0.59**	0.36
10. Yawning	0.54	0.11	0.64	0.41	0.31	**0.83**	0.13	0.06	**0.77**
11. Kissing	0.54	0.19	0.57	0.39	0.38	**0.78**	0.08	0.16	**0.72**

*Listed according to factor scales.
†Eating includes taking bites, chewing, and swallowing.
‡Loadings ≥ 0.50 are printed boldface.
§Loadings ≥ 0.20 between two highest factors are printed boldface.

Table 5 Summary Statistics of the MFIQ Scales

					Scale intercorrelation		
Scale	κ*	Mean	SD	Reliability†	I	II	III
I‡	10	0.47	0.26	0.95	1.00		
II§	5	0.15	0.16	0.82	0.54	1.00	
III	2	0.48	0.26	0.63	0.52	0.47	1.00
II+III§	7	0.24	0.16	0.80	0.61		

*Number of component items.
†Internal consistency estimated using Cronbach's α (N=95).
‡Scale representing masticatory impairment (MASTIC).
§Scale representing nonmasticatory function impairment (NONMASTIC).

The five items represented mandibular functions of daily living not associated with mastication but mainly related to interpersonal contacts. The third factor consisted of two items, accounting for 6.8% of the variance.

Table 5 summarizes the scale statistics for the MFIQ. Cronbach's α (internal consistency) ranged from 0.63 to 0.95. This measure depends on the number of items (κ in Table 5) and the correlation of the items in the test. Cronbach's α of 0.63 for factor III (two items) is equivalent with a coefficient α of 0.81 for five items with the same covariance/variance ratio. Because of the limited number of items of factor III, we also assessed the reliability of the items suggested by the second and third factors taken together: Cronbach's $\alpha = 0.80$. The combination of these factors represents daily, nonmasticatory mandibular functioning (NONMASTIC).

Table 6 shows the mean scores and standard deviations for the self-administered questionnaire and interview formats on the two components, and of the total function impairment index. The intermethod correlations (Pearson's r) between questionnaire and interview on the components varied from 0.91 to 0.96, indicating that the outcome is independent of the method used.

Table 6 Intermethod Reliability of the MFIQ (N = 20)

Scale	Mean SD Test*	Mean SD Retest	Correlation (r)
MASTIC	0.45 (0.25)	0.50 (0.22)	0.94
Factor II	0.12 (0.15)	0.13 (0.14)	0.91
Factor III	0.38 (0.23)	0.45 (0.23)	0.96
NONMASTIC	0.19 (0.17)	0.22 (0.16)	0.96
Total FI†	0.34 (0.18)	0.38 (0.17)	0.95

*Test that was completed first.
†FI = Function impairment index.

Perceived Jaw Function Impairment Related to Other Variables

Table 7 shows the mean scores on the MFIQ scales and their standard deviations. The means and standard deviations for variables related to pain, movement, and psychological distress as well as for task-performance assessment (occlusal force endurance and mastication) are also presented in Table 7.

Table 8 presents the results of the multiple regression analyses. As predictors of function impairment, the demographic (control) variables age and sex were entered prior to entering the variables related to pain, mandibular mobility, and psychological distress. A significant contribution of the control variables was not found for any of the function impairment scales, and, consequently, these variables were dropped from the model. The presence of joint pain assessed during clinical examination (summarized in the clinical joint pain index) and the GPI score were found to be predictive for both functional impairment subscales (MASTIC and NONMASTIC) and for the total function impairment index. Restricted range of opening contributed significantly to masticatory function impairment. The three variables accounted for more than half of the variance in function impairment ($F = 24.02$, $P < .001$), clinical joint pain accounting for 40%. None of the MPI measures or variables related to psychological distress was found to be associated with function impairment.

Multiple regression analyses were also conducted with masticatory and nonmasticatory function impairment measures as independent variables. The masticatory function impairment score on the MFIQ accounted for 38% of the variance in the clinical joint pain index ($F = 40.23$, $P < .001$), and for 18% of the variance in the range of opening movement ($F = 15.14$, $P < .001$). The nonmasticatory function impairment score accounted for 27% of the variance in the subjective pain intensity ($F = 24.32$, $P < .001$). The combination of masticatory and nonmasticatory function impairment score accounted for 32% of the variance in GPI ($F = 15.18$, $P < .001$). None of the function impairment indices could explain the variance in measures of psychological distress.

Only the subjective pain intensity accounted for a small (11%) but significant percentage of the variance in occlusal force endurance time ($F =$

Table 7 Descriptive Statistics of the Sample

Variables	N*	Mean (SD)
Function impairment	80 (0)	
Masticatory function impairment		0.46 (0.25)
Nonmasticatory function impairment		0.24 (0.16)
Total function impairment		0.37 (0.20)
Qualitative Level	L M S	
Masticatory function impairment	29 26 25	
Nonmasticatory function impairment	61 16 3	
Total function impairment	33 35 12	
Pain measures†		
MPI — severity (PS)	68 (12)	0.32 (0.24)
MPI — interference (PI)		0.15 (0.21)
Clinical joint pain index	80 (0)	0.47 (0.29)
Pain intensity (mm VAS)	69 (11)	42.6 (24.7)
Global pain impact (GPI)	Level	2.41 (0.99)
0	2	
1	8	
2	29	
3	21	
4	8	
5	1	
Mandibular movement	80 (0)	
Range of maximal opening		39.4 mm (10.7 mm)
Range of horizontal movement		9.2 mm (3.0 mm)
Restricted translatory capacity	26	
Psychological distress†		
MPI — negative mood	68 (12)	0.30 (0.23)
GHQ — somatic	69 (11)	0.31 (0.20)
GHQ — anxiety/insomnia		0.28 (0.18)
GHQ — social dysfunction		0.34 (0.12)
GHQ — psychological distress		0.18 (0.09)
Physical tests		
Occlusal force endurance time	42 (38)	66s (52s)
Mastication time	40 (40)	67s (28s)

*Number of patients. The number of patients with missing values is given parenthetically.
†Scores standardized to values between 0 and 1. L = low; M = moderate; S = severe function impairment.

Table 8 Summary of Regression Analysis for MFIQ Measures

Measures	Total R^2	*df*	F-ratio	R^2 change	F for R^2 change
Masticatory function impairment	0.49	3,62	19.81***		
Clinical joint pain index				0.37	37.55***
Global pain impact				0.08	9.39**
Range of opening movement				0.04	4.60*
Non-masticatory function impairment	0.37	2,63	18.61***		
Clinical joint pain index				0.28	25.04***
Global pain impact				0.09	9.04**
Function impairment index	0.54	3,62	24.02***		
Clinical joint pain index				0.40	43.14***
Global pain impact				0.10	12.54**
Range of opening movement				0.04	4.79*
Occlusal force endurance	0.11	1,35	4.43*		
Subjective pain intensity				0.11	4.43*
Mastication time	0.50	4,32	8.01***		
Age				0.15	6.11*
Clinical pain index				0.18	9.20**
Range of horizontal movement				0.10	5.56*
Masticatory function impairment				0.07	4.72*

*P<.05.
**P<.01.
***P<.001.

4.43, $P < .05$). Age, clinical pain, range of horizontal movement, and masticatory function impairment together accounted for 50% of the variance in mastication time. Each of the variables contributed to a comparable extent.

Discussion

Two methods of jaw function assessment are proposed in the present study. The first addresses the clinical assessment of jaw movement restriction. On theoretical grounds, the combination of measurement of horizontal excursion, opening movement with passive stretch, and assessment of condylar translatory capacity by palpation provides sufficient diagnostic information about the mobility of the joint. The results of this study suggest that these variables can be reliably assessed provided precise criteria are defined. The other method, the mandibular function impairment questionnaire, was specifically designed to assess the patient's appreciation of mandibular function impairment. This instrument appears to be a valuable addition to the assessment of mandibular movement parameters. Perceived function impairment appears to be primarily associated with the subjective and clinical presence of pain and its impact on mandibular functioning.

Assessment of Mandibular Movement Restriction

Maximal mouth opening is one of the most frequently used variables in diagnostic and treatment-outcome studies. This measure is of limited value for differential diagnosis because the active range of opening may be restricted by several factors. Occasionally, restricted mandibular movement is caused by a factor independent of the joint or muscles (eg, hypertrophy of the coronoid process, orofacial inflammatory conditions). In general, however, movement restriction is due to restriction in the TMJ, the masticatory muscles, or both. Therefore, to be useful for differential diagnosis, assessment of jaw movement restriction should be directed to identifying the cause(s) of restriction. Articular restriction may be due to obstruction of condylar translation by a displaced articular disc, to a reduced extensibility of the capsular ligament, or to intra-articular adhesion formation. Muscular restriction is related to elevator muscle shortening, which may be the result of active contraction (eg, associated with protective muscle splinting in response to articular pain or other muscular pain), inflammation, or contracture.[1]

A common cause of restricted joint mobility is obstruction of condylar translation by a displaced articular disc (permanent disc displacement). Restricted translatory capacity of the joint is reflected in any jaw movement requiring anterior

condylar movement, ie, opening and protrusive movement and contralateral movement. Restriction of horizontal excursion appeared to be one of the predicting variables for the outcome of the mastication test. This might indicate that restriction of lateral excursion contributes to impaired bilateral masticatory ability.

Other possible causes of a restricted translatory capacity of the joint include adhesion formation between the articular surfaces of the disc and the articular eminence[21] and reduced extensibility of the joint capsule, imposing premature limitation of translatory movement. These conditions, therefore, also will reduce the ranges of vertical and horizontal excursions. Horizontal excursions, by contrast, are not appreciably affected by a shortened elevator muscle.[1] Therefore, assessment of the range of lateral movement toward the contralateral side may differentiate muscular from articular movement restriction.

To assess the type of movement restriction, the range of opening movement followed by passive stretch may provide useful information.[22] A gradual but considerable increase of the range of opening in response to gentle passive stretch suggests muscular inhibition due to muscle splinting. Muscular inhibition also causes a soft end-feel. By contrast, a strong resistance to passive stretch is felt when there is muscular contracture or an articular restraint.

Several recent studies have confirmed the reliability of measuring the range of mandibular opening movement.[12–14] Forcing the opening movement to its mechanical constraints by applying gentle passive stretch likely increases the reliability of its assessment, which is supported by the results of the present study. Measurement of the range of lateral movement is somewhat less reliable[14] but still acceptable. This trend is also supported by our results. Measurement of mandibular movement ranges remains an indirect assessment of TMJ mobility. Temporomandibular joint translatory mobility may be assessed more directly by palpation during protrusive movement followed by opening from the protruded position. However, this more subjective assessment is less reliable. There are several methods to increase this reliability, one of which is explicit definition of judgment criteria. Another way of increasing the assessment of TMJ mobility is to combine the results of several supporting assessments. Measurement of horizontal excursion and opening movement with passive stretch, and assessment of condylar translatory capacity by palpation provide sufficient diagnostic information about the mobility of the joint, and these variables can be reliably assessed provided precise criteria are defined.

Assessment of the Patient's Appreciation of Function Impairment

Although detailed assessment of movement restriction is important for diagnostic reasons,[15] the results of the present study suggest that the contribution of movement restriction to the patient's appreciation of function impairment is much less important than that of pain or global pain impact. Therefore, the significance of the range of opening movement as a measure of treatment effectiveness seems to be currently overestimated.

Valid techniques for assessing function impairment for routine clinical use have hardly been developed. Helkimo's clinical dysfunction index,[23] which was originally developed for epidemiologic purposes, is still widely used erroneously in the clinical setting. This may explain why function assessment usually is limited to assessment of clinical symptoms assumed to be associated with function impairment, rather than assessing function impairment from the patient's point of view. Several indices have been proposed as an alternative for Helkimo's index.[24–26] These indices may be useful as a global estimate for symptom severity, although several objections regarding scale construction made for Helkimo's index also apply to its alternatives.[27] Since these indices are mainly composed of clinical symptoms and signs, their utility as an index of function impairment is limited.

Various objective methods have been suggested for measuring masticatory ability.[28,29] Most researchers determine the degree of food breakdown using a sieve system.[28] These approaches involve drying, screening, weighing, and analyzing. Although valuable in the research setting, these procedures are too complicated, time-consuming, and impractical for clinical use. Another drawback of some of these methods is that they use test foods that are unfamiliar to the patient, such as alginate. As an alternative, a less formal mastication-time test was utilized in the present study. In an unpublished pilot study, this test appeared to be capable of differentiating patients with TMJ osteoarthrosis and internal derangement from asymptomatic controls, but no difference in mastication time could be observed between patients with reducing disc displacement and those with permanent displacement. In the present study, however, there was a significant difference in mastication time between the three diagnostic subgroups (analysis of variance: $F = 4.16$, $df = 2.40$, $P = .023$),

and according to the multicomparison test of Scheffé, the reducing and permanent disc displacement groups were responsible for this difference ($P < .05$). Four variables — age, clinical pain index, ability to move the jaw laterally, and masticatory function impairment — accounted for 50% of the variance in mastication time (Table 8). This suggests that this test actually measures several aspects of mastication. The significant relationship between occlusal force endurance time and subjective pain intensity suggests that this latter test should be considered a contributing measure of pain rather than a measure of function impairment. With the simplicity of these tests taken into account, the results indicate that both tests may be valuable complementary tools for assessing jaw function impairment and pain. Further investigations are justified.

Assessment methods utilizing various instruments have also been suggested to measure mandibular function. However, based on an extensive review of the literature, Mohl et al[10,11] concluded that there is insufficient evidence to support the use of jaw tracking devices, surface EMG, sonography, and Doppler ultrasound for the clinical evaluation of TMD. This supports Feinstein's observation that " . . . much of the 'hard' (objective) information in the literature is softer than we like to think and many of the outcomes regarded as being 'soft' are really as solid as, or more reliable than, those long accepted as 'hard.'"[30] This makes studies like those of Mohl et al even more valuable. In contrast to objective assessment methods, the measurement characteristics of "soft" instruments are usually carefully studied. This may in part be attributed to the recognition that general acceptance of "soft" measures would depend upon especially solid documentation.

As a tool for assessing mandibular function impairment, the MFIQ seems to be promising because of its clinimetric qualities. During its development, the MFIQ was adjusted several times based on interitem cross-correlation analyses. Items with very high (> .85) or very low (< .20) correlations were deleted. Very high correlations would suggest the possibility of redundancy between items. Items that correlated very poorly might belong in another index. The present set of 17 items is concise, and interitem correlations are between .35 and .70.

The first principal component consisted of a weighted sum of all 17 items with positive weights ranging from 0.54 to 0.86 (Table 4). This suggests that the total score of the questionnaire adequately represents overall function impairment. This is supported by the rather high interscale correlations (Table 5). On the other hand, these intercorrelations are considerably lower than the values of Cronbach's α for the scales, suggesting adequate distinctiveness between the masticatory and nonmasticatory function impairment scales.

The high intermethod correlation coefficients (Table 6) indicate that the results of the assessment are independent of the method. The use of a self-administered questionnaire has several advantages over the interview as a means of assessing function impairment. It does not depend on the skill of a particular interviewer, and it does not require interobserver validation.

Pain reported during the clinical examination appeared to account for a striking proportion of the variance in function impairment. During the clinical examination, most of the pain is provoked by stretching and loading movement and manipulation. This indicates that function impairment is most strongly associated with similar movements, which is supported by relatively high scores on individual items associated with masticating tough food and yawning.

Another striking result was the low score on the pain interference scale of the MPI in our sample (Table 7). In contrast with the GPI score, the pain interference score did not significantly contribute to mandibular function impairment. This scale measures the extent to which (TMJ) pain affects daily life situations such as the ability to work; the ability to participate in social activities; the amount of satisfaction from work, family, or social activities, and relationships with family or friends. Apparently, TMJ pain does not interfere to a significant extent with these situations compared to specific mandibular activities such as chewing. This is somewhat supported by the relatively large proportion of the sample scoring low on the NONMASTIC scale compared to MASTIC scale (Table 7). Nonmasticatory mandibular functions are likely more associated with daily life situations.

The absence of a significant relationship between perceived function impairment and measures of psychological distress provides additional support for the system-specific nature of mandibular functioning. However, the lack of such a relationship may, in part, be explained by the low scores on the GHQ scales. The mean scores on three of the four scales were around 0.30, while the mean for severe depression was very low, yielding a mean total score for psychological distress of 0.18. A cutoff score of 0.90 has been suggested for the presence of psychiatric illness, and of 0.80 for the presence of psychological distress.

Thus, the mean distress score of our sample is far below these cutoff points. Although the results do not suggest a relationship, it would be premature to draw the conclusion that psychological distress does not influence the degree of mandibular function impairment.

Several general criteria must be evaluated before any assessment instrument, whether it measures a particular construct subjectively or objectively, can be considered clinically useful.[31] First, it should meet accepted standards of reliability and validity. The results of the present study are encouraging in this respect and justify further investigations in larger and more varied samples. The scales are represented by separate analytic factors, and items that rationally seem to belong together also coalesce quantitatively (Table 4). In addition, the internal consistency of the MFIQ appears to be good. Another criterion for clinical utility is that data obtained from the instrument should cover the construct that is measured without being expensive or time-consuming. Moreover, an often-neglected criterion is that the instrument should be simple. Containing only 17 items, the MFIQ can be administered quickly and is reported by the patients to be relevant and easy to understand. Since scoring of the MFIQ is simple and straightforward, requirements of practicality are sufficiently met.

Whether the MFIQ can be generalized and applied in other populations and disciplines, eg, in implantology research and prosthodontics, has not yet been tested and is a consideration for its future use. In a separate article,[32] the sensitivity of the MFIQ to change is addressed by repeated application of the questionnaire at critical points throughout the course of treatment.

Detailed assessment of pain and movement disturbances associated with TMD is necessary for proper diagnosis. Further methodologic evaluation of clinical assessment methods remains necessary. Methods proposed in this section focus on assessment of movement restriction and assessment of mandibular function impairment from the patient's viewpoint. A combination of measurement of ranges of lateral movement and opening after passive stretch, together with an operationally defined assessment of TMJ translatory capacity, is proposed as a useful method for assessing TMJ mobility. The MFIQ reliably assesses the degree of impairment of specific jaw functions without measuring symptoms and signs causing the function impairment. It appears to be a promising and simple instrument for complementary mandibular function impairment assessment.

Acknowledgment

The authors wish to express their appreciation to Leo Th. van der Weele for his valuable assistance in the performance and interpretation of the statistical procedures.

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Resumen

La evaluación del deterioro de la función mandibular asociada con la osteoartrosis y el malfuncionamiento interno de la articulación temporomandibular

La evaluación clínica del deterioro de la función asociada con los desórdenes temporomandibulares no debería comprender solamente la evaluación diagnóstica de síntomas y signos, pero también debe incluir la evaluación del deterioro de la función, por parte del paciente. Con respecto a los métodos evaluativos; la extensión del movimiento de apertura ha demostrado ser una de las pocas variables que puede ser medida con seguridad. Sin embargo, esta variable no permite que se haga una distinción entre los orígenes articulares y musculares de la restricción del movimiento. Se propone una combinación de evaluaciones indirectas y directas, incluyendo la extensión del movimiento de apertura después de un estiramiento pasivo, la extensión de la excursión horizontal hacia el lado opuesto, y la capacidad translatoria condilar por medio de la palpación; para así evaluar la movilidad de la articulación. En la práctica clínica, los signos y síntomas necesarios para el diagnóstico son usados frecuentemente como la única base para la evaluación de la función mandibular. La evaluación de dicha función por parte del paciente, sin embargo, es un área descuidada cuando se examinan los resultados de la misma. Por lo tanto, el objetivo principal de este estudio, fue el de diseñar y evaluar clinimétricamente un cuestionario sobre el deterioro de la función mandibular. Se evaluaron la relación entre el deterioro de la función mandibular y las mediciones de dolor, restricción del movimiento, y afliccion psicológica. El cuestionario parece ser un instrumento complementario confiable y valioso, para la evaluación del deterioro de la función mandibular.

Zusammenfassung

Bewertung von Funktionsbeeinträchtigungen des Kausystems bei Kiefergelenksarthrose und Diskusverlagerung

Die klinische Evaluation von Funktionsbeeinträchtigungen, die mit Myoarthropathien des Kausystems einhergehen, sollte nicht nur auf der diagnostischen Erfassung der Symptome sondern auch der Einschätzung der Funktionsbeeinträchtigung durch den Patienten basieren. Das Ausmass der Mundöffnung ist eine der wenigen Variablen, die zuverlässig gemessen werden können. Allerdings erlaubt diese Variable keine Unterscheidung zwischen einer artikulären oder muskulären Ursache einer Mundöffnungseinschränkung. Um die Beweglichkeit im Gelenk zu beurteilen, wird eine Kombination von indirekten und direkten Tests vorgeschlagen, nämlich die Messung der Öffnungsbewegung nach passivem manuellem Dehnen, die Messung der horizontalen Exkursionsbewegung zur Gegenseite und die Erfassung der Translation des Kondylus durch Palpation. In der Praxis wird der Funktionszustand des Kausystems oft nur anhand der subjektiven und objektiven Symptome evaluiert, die zur Diagnoseerstellung verwendet werden. Die Selbsteinschätzung des Funktionszustandes durch den Patienten wird für die Beurteilung des Behandlungsergebnisses kaum berücksichtigt. Das Hauptziel dieser Studie war es, einen Fragebogen zur Evaluation des Funktionszustandes des Kausystems zu erarbeiten und klinisch zu testen. Die Beziehung zwischen Funktonsbeeinträchtigung und Schmerz, Bewegungseinschränkung sowie psychologischem Leidensdruck wurde untersucht. Der Fragebogen scheint ein zuverlässiges und wertvolles zusätzliches Instrument in der Evaluation des Funktionszustandes des Kausystems zu sein.