A Comparative Study Between Clinical and Instrumental Methods for the Recognition of Internal Derangements with a Clicking Sound on Condylar Movement

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Aims: *To compare the results of 3 methods of recognizing internal derangements with a clicking sound on condylar movement: 2 function-based methods (clinical examination and condylar movement recording) and 1 anatomy-based method (magnetic resonance imaging [MRI]).* ***Methods:*** *For the recognition of an anterior or posterior disc displacement with reduction and of hypermobility within the temporomandibular joint (TMJ), 42 participants underwent a clinical examination, an opto-electronic movement recording, and an MRI scan. The examinations were executed in a single-blind design, with different experienced examiners for each technique. In addition, for 10 randomly chosen participants, the condylar movement recordings and the MRI scans were carried out twice. Without the examiners' knowledge, these second recordings were added to the other data.* ***Results:*** *Intraobserver reliability for the recognition of internal derangements was excellent for condylar movement recording ($\kappa = 0.86$) and fair to good for MRI ($\kappa = 0.73$). Intermethod agreement was fair to good ($\kappa = 0.59$) between the 2 function-based techniques. However, intermethod agreement between the anatomy-based MRI technique and either of the 2 function-based techniques was poor (for condylar movement recording, $\kappa = 0.15$; and for clinical examination, $\kappa = 0.12$).* ***Conclusion:*** *There is a great discrepancy between the diagnoses for internal derangements based upon anatomical TMJ characteristics and those based on functional TMJ characteristics. For a function-based diagnosis, there is probably no need for the sophisticated technique of condylar movement recording, since that method shows fair to good agreement with a carefully performed clinical examination.* J OROFAC PAIN 2004;18:138–147

Key words: clinical criteria, condylar movement recordings, internal derangements, magnetic resonance imaging, temporomandibular joint

An internal derangement of the temporomandibular joint (TMJ) is described as a deviation in the anatomical position or form of the tissues within the capsule of the joint.[1] Interference with smooth TMJ movement is a functional manifestation of internal derangement.[2] Disc displacements with or without reduction within the TMJ are examples of frequently occurring internal derangements. Anterior disc displacement (ADD), ie, disc displacement in an anterior direction, is the most common type of disc displacement, but posterior disc displacement (PDD) has also been described.[3–5] In most cases the disturbed structural relationship between the disc and the condyle is restored during mandibular movement. Clicking sounds during movement are the main clinical manifestation of this restoration. However, in rare cases, nonreduction occurs (ie, the disc is permanently displaced), and the patient

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develops either closed lock (difficulty opening the mouth fully) or open lock (difficulty closing the mouth fully). Hypermobility can also be regarded as a sign of an internal derangement when it is accompanied by interferences with smooth joint movements. Although a joint is generally called hypermobile when it shows an excessive range of motion, it is difficult to establish quantitatively the range of motion of the TMJ that should be regarded as excessive. Functionally, interference with smooth joint movement is manifested as clicking sounds at the end of opening and/or at the beginning of closing, and jerky lateral movements, which probably indicate that the condyle has difficulty passing the apex of the eminence. The prevalence rates of ADD, PDD, and hypermobility are still largely unknown. So far, studies have mainly been focused on the prevalence rate of the TMJ clicking phenomenon as such rather than on the underlying causes.

Although most forms of internal derangements are considered harmless and cause little or no discomfort to patients, disc displacements with reduction may occasionally develop into a more serious clinical condition, viz, nonreducing disc displacement. Unfortunately, it is not known which disc displacements may develop nonreduction and under what conditions this transition may occur. For better insight into the possible long-term clinical implications of internal derangements, research should focus on their prevalence rates and risk factors. However, this is not possible unless one is able to recognize the various forms of internal derangements. For this reason, this study focuses on recognition of the most frequently occurring forms of internal derangements, those associated with a clicking sound on movement.

The recognition of internal derangements can be based upon the anatomical relationships within the joint, or it can be based upon their interference with smooth joint movement. In the latter case, well-defined clinical criteria are needed to recognize interference. For ADD, widely accepted clinical criteria are included in the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD).[6] However, for the recognition of PDD and hypermobility, no clinical criteria are available yet. In this study, clinical criteria are suggested and the results of clinical examinations using these criteria are compared with detection of these conditions by condylar movement recording and magnetic resonance imaging (MRI) of the joint. The aim of this study was to compare the results of these 3 methods of recognizing internal derangements.

Materials and Methods

Participants

Forty-two people, 22 women and 20 men (mean age ± SD 30.0 years ± 9.9), participated in the study. They were recruited from among patients referred to the Temporomandibular Disorders clinic of our department and from among students at the Academic Centre for Dentistry Amsterdam. All gave informed consent to the study procedures, which were approved by the review board of the Netherlands Institute for Dental Sciences and the Committee for Scientific Research on Humans of Utrecht University.

To ensure that the various forms of internal derangements were present in the group of participants, each participant was clinically screened by an independent examiner (JHS) prior to participation. During this screening, 10 participants showed no signs of an internal derangement and served as the control group. The remaining 32 participants showed clinical signs of an internal derangement in 1 of their TMJs. ADD without reduction (closed lock) as well as painful TMD conditions were clinically excluded during the screening.

Protocol

Each participant underwent a clinical examination, an opto-electronic movement recording, and an MRI scan within 1 month. The examinations were carried out in a single-blind design, using different experienced examiners for each technique. The examiners were blind to the results of the preceding clinical screening and to the results of the other examiners.

Clinical Examination

One examiner (FL) examined patients for the presence of an internal derangement through the use of palpation and auscultation with a stethoscope. The participants performed, in a fixed order, at least 3 maximal opening and closing mandibular movements, 3 opening and loaded closing movements within the patient's normal range, 3 submaximal opening and closing movements (ie, to about half the maximum jaw opening), and 3 protrusive opening and closing movements (ie, movements that started from and ended in a protruded edge-to-edge incisal position). The loaded closing movements were performed while the mandible was loaded with a manually applied, downward force of about 30 N on the chin,[7] which was calibrated beforehand with a weight scale.

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For the auscultation technique, the bell of an infant stethoscope (3M Littmann) was placed over the lateral pole of the TMJ. For the palpation technique, the index and middle fingers were placed over the lateral poles of the patient's TMJ at a pressure of about 5 N, which was calibrated with a weight scale.[6] Both joints were palpated simultaneously.

The following clinical criteria were used for the recognition of the internal derangements.

ADD with Reduction. The criteria for the recognition of an ADD were modified from the criteria suggested by the RDC/TMD.[6] One criterion is that the interincisal distance at the time of the opening click be at least 5 mm greater than the distance at the time of the closing click. However, a recent study[8] indicated that this 5-mm criterion is not characteristic of all ADDs and for that reason, this criterion was not included in our set of clinical ADD criteria. Moreover, it is our clinical experience that the closing click is much softer than the opening click and is often hardly audible. This was compensated for by loading the mandible during closing movements. Loading reduces the intra-articular distance within the TMJ,[7] which strongly enhances the closing click. Furthermore, the closing click, a sign of dislocation of the disc from the condyle, usually occurs just before the condyle re-enters the fossa.[8] Protrusive opening and closing prevents the return of the condyle into the fossa and thus will eliminate the ADD clicking sounds.

Therefore, the clinical ADD criteria used in this study were reproducible TMJ clicking on opening and on (loaded) closing on at least 2 of 3 trials and elimination of the TMJ clicking on protrusive opening and closing.

PDD with Reduction. Some studies suggest that in PDD, the disc is posteriorly displaced during maximal jaw opening but restores its structural relationship with the condyle during jaw closing.[9,10] Therefore, the disc dislocation is eliminated not on protrusive opening but on submaximal jaw opening. Therefore, the clinical criteria for the recognition of PDD were:

- Reproducible TMJ clicking on opening and/or on (loaded) closing in at least 2 of 3 trials
- Elimination of TMJ clicking on submaximal jaw opening
- No elimination on protrusive opening and closing

Hypermobility. Clinically, hypermobility in the TMJ can be noted only when it interferes with smooth mandibular movement. These interferences manifest themselves as jerky mandibular movements and clicking sounds; they signify that the condyle is snapping over the apex of the eminence during opening and closing. Such interferences are not eliminated during protrusive opening and closing, because condylar subluxation is not prevented then.

Therefore, the clinical criteria for the recognition of hypermobility were TMJ clicking occurring in the last part of the opening and the first part of the closing movement, often in combination with characteristic jerky lateral movements of the mandible, on at least 2 of 3 trials and no elimination of TMJ clicking and jerky movements on protrusive opening and closing.

"Other" Internal Derangements

When the interference with smooth mandibular movement did not meet 1 of these sets of criteria, the internal derangement underlying the interference was classified as "other."

Interrater Reliability

The interrater reliability of the clinical protocol has previously been tested.[11] In that study, interrater reliability for clinical assessment of the presence of an internal derangement was "fair to good" ($\kappa = 0.58$); for classification of the internal derangements, interrater reliability was "excellent" ($\kappa = 0.90$).

Opto-electronic Movement Recording

The participants were asked to perform, during 20-second recordings, free jaw opening and closing, free opening and loaded closing, submaximal opening and closing to about half the maximum jaw opening, and protrusive opening and closing. To load the joint during closing, a small manual, counteracting force of about 30 N was applied to the participant's chin. Movements were recorded by means of the OKAS-3D system, an opto-electronic device developed by the authors capable of accurately recording mandibular motion with 6 degrees of freedom at a sampling frequency of 300 Hz per coordinate.[12] Small condenser-type microphones were placed over the lateral pole of the TMJs to simultaneously record joint sounds. All recordings were interpreted off-line by a single investigator (MN). Specialized software graphically visualized the movement traces of the incisal point and those of the kinematic centers of the condyles[13,14] in sagittal, horizontal, and frontal planes. The occurrence of a joint sound was depicted by an asterisk on these traces.

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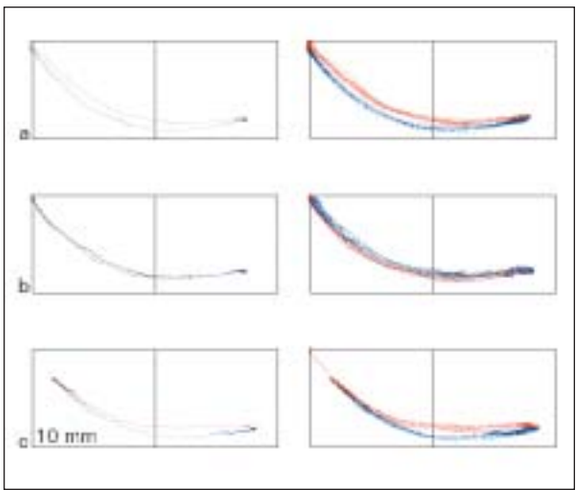

Fig 1 Typical example of the kinematic center condylar movement traces of an asymptomatic TMJ. Single sagittal condylar traces (*left*) and superimposed sagittal condylar traces (*right*) are shown for opening and closing jaw movements *(a)*, opening and loaded closing movements *(b)*, and protrusive opening and closing movements *(c)*. The condyle performed smooth and reproducible movements (see the superposition of the multiple movement traces), and no clicking sounds were recorded. The upper left corner of each represents the condylar position with the mandible in the intercuspal position. Opening traces are in red; closing traces are in blue.

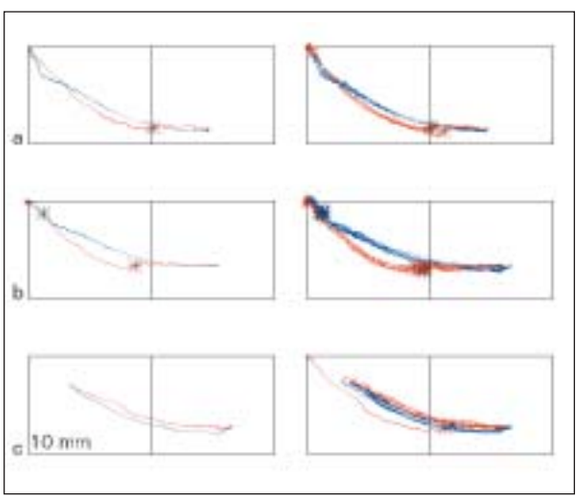

Fig 2 Typical example of single (*left*) and superimposed (*right*) sagittal kinematic center condylar movement traces of a TMJ with an ADD with reduction. Clicks are indicated with an asterisk (*). During opening and closing movements *(a)*, only opening sounds were detected. The simultaneously occurring upward deflections in the opening traces reflect the reduction of the disk on the condyle. The sounds detected during loaded closing *(b)* also coincided with deflections in the closing movement traces. They indicate the dislocation of the disk off the condyle. During protrusive opening and closing *(c)*, an opening sound was detected only on the first opening movement, which started at the intercuspal position. No clicking sounds were recorded for the subsequent movements, and none were recorded when the condyle passed the position where the opening clicks occurred during normal opening and closing. The superimposed condylar movement traces demonstrate the reproducibility of the trace deflections and the clicking sounds between subsequent condylar movements. The upper-left corner of each figure represents the condylar position with the mandible in the intercuspal position. Opening traces are in red; closing traces are in blue.

The presence of internal derangement in a joint was recognized when the condylar movement traces showed characteristic and reproducible deflections with respect to the smooth TMJ condylar movement traces of a symptom-free joint and when clicking sounds were detected. Figure 1 shows a typical example of the smooth, reproducible condylar movement traces of a symptom-free joint. No clicking sounds were recorded.

The presence of an ADD was recognized when

- The movement traces of the kinematic center of the condyle showed characteristic and reproducible deflections from smooth movement traces during opening and (loaded) closing, as shown in Fig 2
- The deflections coincided with the occurrence of the clicks
- The deflections and the clicks were eliminated during protrusive opening and closing

The presence of a PDD was recognized when

- The sagittal kinematic condylar movement traces showed the characteristic and reproducible interferences in the opening and (loaded) closing movement traces, as shown in Fig 3
- The interferences coincided with the occurrence of the clicks
- The interferences and the clicks were eliminated during submaximal opening and closing

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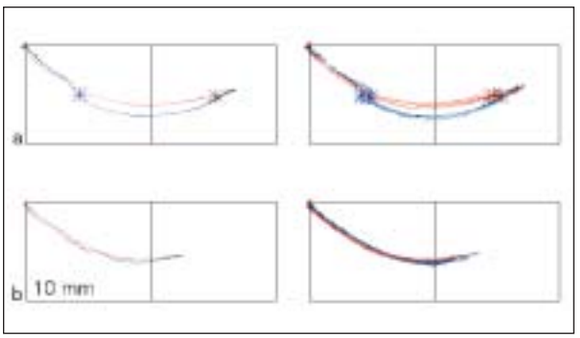

Fig 3 Typical example of single (*left*) and superimposed (*right*) sagittal kinematic center condylar movement traces of a TMJ with a PDD with reduction. Clicks are indicated with an asterisk (*). During normal-range opening and closing *(a)*, the opening clicks occurred at the end of the opening, indicating the posterior dislocation of the disk. During closing, an upward condylar deflection at the time of clicking was noted, indicating the reduction of the disc onto the condyle. *(b)* No clicks were recorded during submaximal opening and loaded closing, and none were recorded when the condyle passed the position where the closing clicks occurred during full opening and closing. The superimposed condylar movement traces demonstrate the reproducibility of the trace deflections and the clicking sounds between subsequent condylar movements. The upper-left corner of each plot represents the condylar position with the mandible in the intercuspal position. Opening traces are in red; closing traces are in blue.

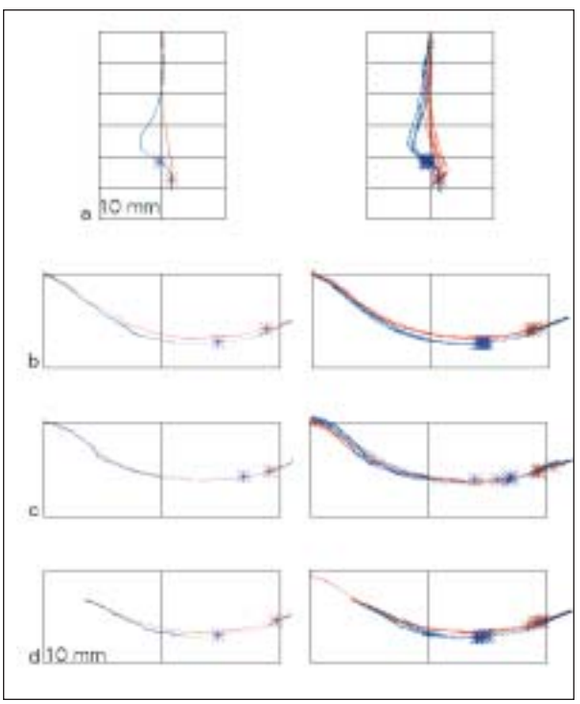

Fig 4 Typical example of single (*left*) and superimposed (*right*) movement traces of a mandible with a hypermobile TMJ. Clicks are indicated with an asterisk (*). The frontal recordings of the incisal point during opening and closing show jerky mandibular movements, a sign that the condyle snapped over the apex of the articular eminence *(a)*. The rapid changes in spacing between subsequent condylar positions in the sagittal kinematic condylar movement traces show the sudden accelerations and decelerations experienced by the condyle at the time of clicking, both during opening and closing *(b)* and during opening and loaded closing *(c)*. During protrusive opening and closing *(d)*, the clicks and the sudden condylar accelerations and decelerations were not eliminated. The superimposed movement traces give an impression of the reproducibility of the trace deflections and the clicking sounds between subsequent mandibular movements. The top midpoint of the plots with the incisal point movement traces, and the top-left point of the plots with the condylar movement traces, indicate the position with the mandible in the intercuspal position. Opening traces are in red; closing traces are in blue.

The presence of hypermobility was recognized when

- The sagittal kinematic condylar movement traces showed the characteristic and reproducible decelerations/accelerations in the last part of the opening movement and/or the first part of the (loaded) closing movement, as shown in Fig 4
- The decelerations/accelerations coincided with the occurrence of the clicks
- The incisal point showed reproducible and characteristic (jerky) lateral movements coinciding with the occurrence of the clicks, as shown in Fig 4
- No elimination of the decelerations/accelerations or clicks was noted during protrusive opening and closing

When the movement interferences and the observed clicks did not meet 1 of these sets of criteria, the internal derangement was classified as "other" (Fig 5).

MRI

T_1-weighted images were made with a 1.5 T MRI system (Gyroscan NT Intera, Philips Medical

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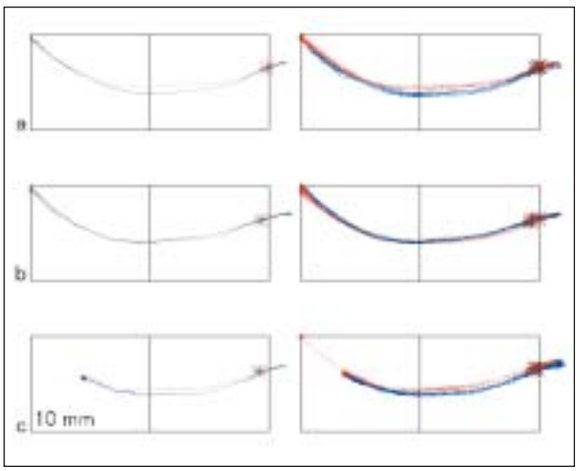

Fig 5 Typical example of single (*left*) and superimposed (*right*) sagittal kinematic center condylar movement traces of a TMJ with an internal derangement classified as "other." Clicks are indicated with an asterisk (*). During free opening and closing *(a)*, opening sounds were detected, but no corresponding deflections in the condylar traces. Opening and loaded closing movements did not provoke a closing click *(b)* and the protrusive opening and closing movements did not eliminate the opening joint sounds *(c)*. The superimposed condylar movement traces give an impression of the reproducibility of the trace deflections and the clicking sounds between subsequent condylar movements. The top-left point of each plot is the condylar position with the mandible in the intercuspal position. Opening traces are in red; closing traces are in blue.

Systems), with a surface coil used as a receiver. The patient's head was placed in a headrest in the imager. The repetition time was 530 ms; the echo time, 18 ms. Imaging was performed in a closed-mouth position. Nine interleaved 3-mm sagittal planes (perpendicular to the mediolateral pole of the condyle) were obtained from lateral to medial, followed by 9 interleaved 3-mm coronal planes. Thereafter, imaging was performed with the mouth in the maximally opened position, controlled with a resin bite block. Nine interleaved 3-mm sagittal planes were obtained from lateral to medial. For all images made, the data matrix was 205 × 256 pixels, and the imaging time was 4 minutes and 21 seconds.

MRI scans were interpreted by a single investigator (Y-JC). The criteria described by Katzberg and Westesson[15] were used to interpret the disc position. ADD with reduction was diagnosed when

- The inferior surface of the intermediate zone was anterior to the anterior prominence of the condyle
- The inferior surface of the intermediate zone was not in contact with the condyle when the mouth was closed
- The condyle was underneath the intermediate zone of the disc when the mouth was opened

Although ADD without reduction (closed lock) was excluded during the clinical screening, the MRI scans could still suggest the presence of a closed lock. ADD without reduction was diagnosed when the inferior surface of the intermediate zone stayed in front of the condyle when the mouth was opened.

For PDD with reduction, no criteria for the diagnosis of PDD by MRI are described in the literature. The criteria used to diagnose PDD with reduction were

- The condyle was underneath the intermediate zone of the disc when the mouth was closed
- The inferior surface of the intermediate zone was posterior to the condyle
- The inferior surface of the intermediate zone was not in contact with the condyle when the mouth was maximally opened

Criteria for the diagnosis of hypermobility by MRI are not described in the literature either. In order to diagnose hypermobility, criteria based on the anterior-posterior relationship between condyle and eminence were used. Hypermobility was diagnosed when the posterior condylar surface was in front of the lowest part of the articular eminence at maximal jaw opening.

Intraobserver Reliability for Condylar Movement Recording and MRI Scans

To test the intraobserver reliability of the instrumental techniques (opto-electronic movement recording and MRI), 10 randomly chosen participants were recorded twice. The data for these "double" participants were added to the other data without the knowledge of the examiners. Second MRI recordings were made within 1 hour of the first recording, and second opto-electronic movement recordings were made within 10 weeks of the first recording.

Statistical Analysis

Cohen's kappa was calculated from the data of the 10 double participants and used as an estimation of the intraobserver reliability. To analyze intermethod

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Table 1 No. of TMJs with an Internal Derangement Recognized by Clinical Examination and Condylar Movement Recordings (OKAS)

Clinical examination	OKAS								
	NID	ADD	Hyp	PDD	Other	CL	A + H	NI	Total
NID	37		1		1	1			40
ADD	6	13			6				25
Hyp	5		8						13
PDD				1	1				2
Other					2				2
CL									0
A + H			1		1				2
NI									0
Total	48	13	10	1	11	1	0	0	84

NID = no internal derangement; ADD = anterior disc displacement; Hyp = hypermobility; PDD = posterior disc displacement; Other = other internal derangements; CL = closed lock; A + H = combined score of anterior disc displacement and hypermobility; NI = not interpretable.

Table 2 No. of TMJs with an Internal Derangement Recognized by Clinical Examination and MRI

Clinical examination	MRI								
	NID	ADD	Hyp	PDD	Other	CL	A + H	NI	Total
NID	12	11	7			4	5	1	40
ADD	5	8	1			4	6	1	25
Hyp	4		6				3		13
PDD							1	1	2
Other	2								2
CL									0
A + H						1	1		2
NI									0
Total	23	19	14	0	0	9	16	3	84

NID = no internal derangement; ADD = anterior disc displacement; Hyp = hypermobility; PDD = posterior disc displacement; Other = other internal derangements; CL = closed lock; A + H = combined score of anterior disc displacement and hypermobility; NI = not interpretable.

agreement, Cohen's kappa was calculated for each combination of 2 techniques (eg, clinical examination versus movement recordings, clinical examination versus MRI) as well. The κ values were interpreted according to Fleiss and Chilton.[16] Values below 0.40 indicate poor agreement beyond chance, values between 0.40 and 0.75 indicate a fair to good agreement beyond chance, and values greater than 0.75 indicate an excellent agreement beyond chance.

Results

The intraobserver reliability for the recognition of internal derangements was excellent for the movement recordings (κ = 0.86) and fair to good for the MRI technique (κ = 0.73). The intermethod agreement for the recognition of the internal derangements was fair to good (κ = 0.59) between clinical examination and movement recording, but poor between clinical examination and MRI (κ = 0.12) and between the movement recording and MRI (κ = 0.15).

Table 1 shows the assessments of the clinical examinations and the movement recordings of the 84 joints. In 61 cases (73%), diagnoses based on the 2 techniques agreed. Disagreement was found most often with those cases where an internal derangement (ADD in 6 cases and hypermobility in 5 cases) was found by clinical examination but not by movement recording. Of the 11 internal derangements detected by movement recording and placed in the "other" category, 6 were classified as ADDs when detected by clinical examination.

The assessments of the clinical examinations and the MRI scans are given in Table 2. The 2 techniques agreed in only 27 cases (32%). Disagreement was found mostly with the 40 cases in which the clinical examination found no internal derangement (NID). MRI categorized 12 of those cases as NIDs, 11 as ADDs, 7 as hypermobilities, 4 as

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Table 3 No. of TMJs with an Internal Derangement Recognized by Condylar Movement Recordings (OKAS) and MRI

	MRI								
OKAS	NID	ADD	Hyp	PDD	Other	CL	A + H	NI	Total
NID	15	11	7			5	9	1	48
ADD	1	7	1				3	1	13
Hyp	2	1	5				2		10
PDD							1		1
Other	5		1			3	1	1	11
CL						1			1
A + H									0
NI									0
Total	23	19	14	0	0	9	16	3	84

NID = no internal derangement; ADD = anterior disc displacement; Hyp = hypermobility; PDD = posterior disc displacement; Other = other internal derangements; CL = closed lock; A + H = combined score of anterior disc displacement and hypermobility; NI = not interpretable.

closed locks, 5 as ADDs in combination with hypermobility, and 1 as not interpretable. In the 23 cases in which MRI found NID, the clinical examination found 5 ADDs, 4 hypermobilities, and 2 internal derangements classified under "other."

The assessments of the movement recordings and the MRI scans are given in Table 3. The 2 techniques agreed in only 28 cases (33%). Disagreement was found most often with the 48 cases in which the movement recording technique did not find internal derangement. MRI classified 15 of these cases as NIDs, 11 as ADDs, 7 as hypermobilities, 5 as closed locks, and 9 as ADDs in combination with hypermobility. Of the 23 cases in which MRI did not find internal derangement, movement recording found 15 NIDs, 1 ADD, 2 hypermobilities, and 5 internal derangements classified under "other."

Discussion

Clinical criteria for the recognition of the various forms of internal derangement within the TMJ will play an important role in studies of the long-term clinical implications of these internal derangements. In this study, clinical criteria for the recognition of internal derangements with a clicking sound on movement were formulated. These criteria were partly modifications of suggestions from the literature[6] and were partly based upon intellectual inferences from the functional anatomy of the different tissues within the TMJ. In a study of these criteria, it is important that the various forms of internal derangements are more or less equally represented within the study sample. Although strong efforts were made to accomplish this, posteriorly displaced discs were underrepresented. The difficulty encountered in finding PDDs was probably partly due to difficulty recognizing them clinically and partly due to their suspected low prevalence rate.[5,17] As a consequence, the conclusions of this study may not necessarily hold true for PDD.

When TMJ clicking sounds were notable on movement, but the sounds and the associated interferences with smooth TMJ movements did not meet 1 of the described sets of criteria, the internal derangement was classified as "other." Apart from disc displacement and hypermobility, the literature on the subject suggests that condyle snapping along the joint capsule[18] and the condyle passing irregularly formed articular tissues (deviation in form)[2] are among the possible causes of a clicking sound from the joint. However, these suggestions are not widely accepted. The deviation in form is mentioned in the 1993 version of the guidelines of the American Academy of Orofacial Pain[2] but not in the 1996 version.[19] For this reason, no attempts were made to further specify the internal derangements within the "other" group.

Movement recordings made with 6 degrees of freedom have shown great potential for the study of mandibular motion.[14] They enable the reconstruction of the movement traces of any point of the mandible relative to the skull. Furthermore, they offer the advantage of detailed off-line analysis of condylar movement interference, which is often associated with an internal derangement, from different viewpoints and at a lower speed than is possible during a clinical examination. When using single-point condylar movement traces to diagnose internal derangements, unusually short or irregular traces. The crossing of opening and closing traces, or a substantial distance between opening and closing traces may indicate an internal derangement.[20–23] To avoid "false-positive" diagnoses, it is crucial that the single-point condylar movement traces of asymptomatic joints show

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none of these characteristics. The movement traces of the condylar kinematic center meet these criteria.[14,24] The characteristics of these traces are determined mainly by the contour of the articular eminence and are insensitive to variations in the rotational component of mandibular movement between opening and closing and also between consecutive movements.

So far, no universally accepted criteria are available for the diagnosis of TMJ internal derangements by means of condylar movement recording or MRI. The criteria for the condylar movement traces used in this study are based partly upon inferences from the functional anatomy of TMJs with an internal derangement, and are also an elaboration of criteria suggested by Ozawa and Tanne[23] and Mauderli et al.[25] The interpretation of the MRI scans was based upon an anatomical evaluation of the position and form of the tissues within the capsule. For the recognition of ADDs, the criteria suggested by Katzberg and Westesson[15] were used. However, for the recognition of a PDD or of hypermobility by MRI, new criteria were formulated because no previously established criteria were available.

The excellent and fair to good intraobserver reliability of the movement recordings and the MRI scans indicated that these techniques can be used reproducibly in the evaluation of internal derangements. The intermethod agreement between clinical examination and movement recording was fair to good. This is not surprising because both methods rely upon the same functional criteria. It does indicate that for a function-based diagnosis for internal derangements, sophisticated, "objective" condylar movement recording techniques may be unnecessary; a carefully performed clinical examination may be sufficient. Disagreement between clinical examination and movement recording was most often found in those cases where clinical examination found an internal derangement and movement recording did not. This may be caused by "cross-talk" from the contralateral joint. The left and the right TMJ condyles are rigidly connected by a bony segment, the mandible. The clinical determination may be obscured by clicking sounds originating not from the joint under examination but from the contralateral joint. Condylar movement recording may be less sensitive to cross-talk, because the deflections seen in the condylar traces are specific to the joint with the internal derangement.

The agreement was poor between the MRI scans on one hand and the clinical examination and the movement recordings on the other hand. Apparently, the method based upon the anatomical evaluation of the position and form of the tissues within the TMJ comes to quite different conclusions than the methods based upon the functional characteristics of the TMJ. In a study comparing 3 methods of internal derangement assessment (clinical examination, condylar movement recording, and MRI) to arthrography, the "gold standard," Romanelli et al[26] concluded that diagnoses made by clinical examination and by movement recording agreed most often with those made by arthrography, but that MRI often failed to detect the presence of an internal derangement. Ozawa and Tanne[23] and Parlett et al,[27] who compared the results of axiographic recordings with those of MRI findings, also reported great discrepancies between the 2 techniques. Diagnosis by MRI of disc displacements in joints with no functional disturbances whatsoever is a known problem.[28–31] This may be related to the uncertainty about how to interpret MRI findings. In this respect, the wide biological variations in TMJ structure between subjects is probably a complicating factor as well. It is worthwhile to see whether use of newer MRI techniques, such as dynamic MRI[32] and the individualized oblique-axial MRI technique,[32,33] will improve the concordance between function-based and anatomy-based diagnoses of internal derangements within the TMJ.

In conclusion, there is a great discrepancy between the diagnoses of internal derangements based upon anatomical TMJ characteristics and those based on functional characteristics. For a function-based diagnosis, there is probably no need for sophisticated condylar movement recording techniques, since the agreement with a carefully performed clinical examination is fair to good.

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