Two-year Natural Course of Anterior Disc Displacement with Reduction

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Aims: *To test if the disappearance of clicking associated with anterior disc displacement with reduction (ADDR) is related to a gradual loss of reducing capacity of the disc in the temporomandibular joint.* ***Materials:*** *Twenty-five ADDR subjects without and 30 ADDR subjects with intermittent locking participated in this 2-year follow-up study. Clinical examinations and mandibular movement recordings were performed at baseline and after 1 and 2 years. If mandibular movement recordings no longer showed signs of an ADDR, magnetic resonance imaging (MRI) of the disc was carried out.* ***Results:*** *Mandibular movement recordings showed the moment of disc reduction (MDR) to be stable over the observation period in the subjects without intermittent locking (P = .95). In the subjects with intermittent locking, MDR had shifted to a later mouth opening (P = .000). In seven of these subjects, clicking had totally disappeared, usually without symptoms of permanent locking. On the MRI scans of these subjects, the disc displacement was still present, but with no, or only a partial, reduction.* ***Conclusion:*** *Intermittent locking may be indicative of the development of a disc displacement without reduction. This loss is only rarely accompanied by symptoms of permanent locking.*
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The most common internal derangement within the human temporomandibular joint (TMJ) is anterior disc displacement with reduction (ADDR).[1] In the closed mouth position, the articular disc is then located anteriorly to the condyle. During mouth opening, the disc reduces by slipping back on top of the condyle. At the end of closing, the disc is again anteriorly dislocated. Clinically, an ADDR is characterized merely by reciprocal joint clicking at the moments of disc reduction and dislocation and is usually a nonproblematic joint condition.[2]

Studies have suggested that in patients with a history of temporary and recurrent symptoms of painful limited mouth openings (intermittent locking), the reciprocal clicking may disappear over time.[3–5] In some patients, reciprocal clicking had been replaced by a long-lasting painful limitation of mouth opening (locking), which was taken as a characteristic sign of an anterior disc displacement without reduction (ADDWoR). However, in other patients, reciprocal clicking had disappeared, with the preservation of normal joint function. Because no arthrography or magnetic resonance imaging (MRI) was performed at the disappearance of clicking, it was unknown which

functional and/or morphological alterations within the TMJ were responsible for this disappearance. Had the ADDR been converted to an ADDWoR without symptoms of locking or, conversely, had the disc position within the TMJ become normalized?

The aim of this 2-year follow-up study was to test if the disappearance of ADDR clicking is related to a gradual loss of reducing capacity of the disc. Recognition of the ADDR and of changes in the moment of disc reduction (MDR) over time was objectively determined with the use of mandibular movement recordings. When ADDR clicking disappeared, MRI was carried out to assess the condyle-disc relations within the TMJ.

Materials and Methods

This study was reviewed and approved by the Medical Ethics Committee of the VU University, Amsterdam, The Netherlands.

Participants and Protocol

After giving a written informed consent, subjects who received the clinical diagnosis of ADDR, which was subsequently confirmed by the results of a mandibular movement recording (see below), were included. ADDR subjects with reports of intermittent locking (n = 35) were recruited from among patients visiting the clinic for Oral Kinesiology at the Academic Centre for Dentistry Amsterdam (ACTA). The reason of consultation was the intermittent locking, and the patients had pain from their TMJ only during the periods of locking. ADDR subjects without reports of intermittent locking (n = 26) were recruited from dental students, coworkers of ACTA, and dental patients without temporomandibular complaints. Prior to the start of the study, and as part of a yearly routine, the clinical investigator was engaged in a training session for standardization of the clinical examination of the TMJ. All subjects received an explanation about the cause of clicking and locking of their TMJ and were reassured about the benign character of the ADDR.

Clinical examinations and mandibular movement recordings were performed at baseline and after 1 and 2 years. Subjects also were instructed to return to ACTA between follow-ups when they perceived that their joint clicking had disappeared and/or that their mouth opening had become permanently limited. If then, or if at a scheduled follow-up, mandibular movement recordings no longer showed signs of an ADDR, MRI was carried out.

Clinical Examination

During the oral history, subjects were asked whether they experienced occasions of intermittent locking. If so, its frequency (daily, weekly, monthly, or less frequently) and duration (< 1 minute, < 15 minutes, < 30 minutes, < 60 minutes, < 3 hours, ≥ 3 hours) were noted. During the physical examination, subjects performed maximal open-close movements, maximal open-close movements from a protruded jaw position (eg, from an incisal end-to-end position), and maximal free opening and loaded (ie, with a manually applied, downward directed force of about 30 N on the chin) closing movements. Presence of an ADDR was established with the following criteria[6,7]: *(1)* reproducible reciprocal joint clicking during opening and free or loaded closing movements; and *(2)* elimination of clicking when open-close movements were performed from a protruded jaw position.

Mandibular Movement Recordings

Movement recordings were made with the Oral Kinesiology Analysis System (OKAS-3D),[8] which records mandibular movements with six-degrees of freedom at a sampling frequency of 300 Hz per coordinate. Joint sounds were simultaneously recorded with small condenser-type microphones placed over the palpated lateral poles of the TMJs. Specialized software graphically visualized, in three dimensions, the movement traces of the incisal point and those of the kinematic centers of the condyles.[9,10] During the recordings, subjects were sitting upright and performed similar movements as during the clinical examination. Each movement recording lasted 20 seconds and contained, on average, six movements.

The clinical diagnosis of an ADDR was confirmed by the movement recordings when the joint sounds were accompanied by characteristic and reproducible deflections in the sagittal movement traces of the condylar kinematic center and when the joint sounds and deflections were eliminated on protrusive open-close movements (Fig 1). The reliability and validity of this approach have previously been documented[6] and extensively discussed.[7]

Mandibular movement recordings were also used to determine objectively the MDR during mouth opening. MDR was assessed as the distance travelled by the condylar kinematic center until the opening click, expressed as a percentage of the distance travelled until maximum mouth opening (Fig 1a). If disc reduction was no longer possible, an MDR value of 100% was noted. In a pilot study, the reliability of

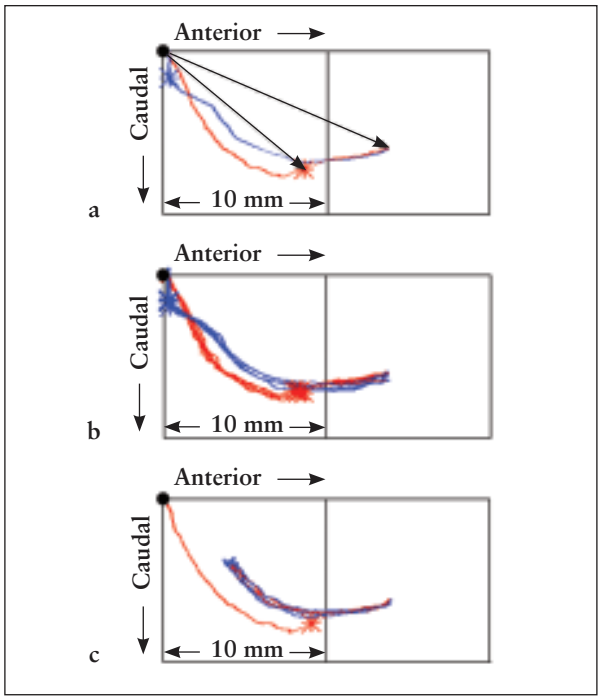

Fig 1 Example of a single *(a)* and of the superimposed *(b,c)* sagittal movement traces of the kinematic center of a TMJ with an ADDR while the subject performed six maximal open-close movements starting from *(a,b)* the intercuspal position or starting (apart from the first movement) from *(c)* a protruded incisal end-to-end position (the elimination test). The MDR is the distance travelled by the kinematic center until the opening click, expressed as a percentage of the distance travelled until maximum mouth opening *(a)*. The superimposed movement traces *(b)* illustrate the reproducibility of the movement traces and the moments of joint clicking. During protruded open-close movements *(c)*, a clicking sound was noted only on the first movement, which started in the intercuspal position. Opening traces are in red; closing traces are in blue. ● denotes the starting point of the movement traces. Opening and closing clicking sounds are indicated with red and blue asterisks (*).

the MDR was found to be excellent (intraclass correlation coefficient [ICC] = .989), and its smallest detectable difference (SDD)[11] was 10%. For that study, OKAS-3D recordings were obtained twice within an average period of 12 days in 15 subjects with a stable ADDR (mean age 32 ± 11 years, 12 female).

MRI

Proton density images were made with a 1.5 T MRI system (Toshiba Medical Systems) with a surface coil used as receiver. The repetition time was 3,320 msec; the echo time was 18 msec. In the closed mouth position, imaging was performed with 10 interleaved 2.2-mm sagittal scans (perpendicular to the mediolateral axis of the condyle). Thereafter, a similar imaging was performed in the maximally opened mouth position, which was controlled with a resin bite block. The data matrix was 192 × 256 pixels, and the imaging time was 2 minutes and 46 seconds.

A single observer blinded to the purpose of the study, and to the patient's history, interpreted the disc-condyle relations according to previously described MRI criteria.[12] An anterior disc displacement was noted when, on the closed mouth sagittal planes, the inferior surface of the intermediate disc zone was anterior to and not in contact with the anterior prominence of the condyle. Presence of a disc reduction was noted when, on all opened mouth sagittal scans, the condyle was underneath the intermediate disc zone. Absence of disc reduction was noted when, on all opened mouth sagittal scans, the inferior surface of the intermediate disc zone stayed in front of the condyle. Partial reduction was noted when the latter was only the case on some of the opened mouth sagittal scans.

Statistical Analysis

One-way ANOVAs with repeated measures, followed by pair-wise comparisons, were used to assess MDR values at baseline and at the first and second year follow-ups. At the individual level, changes in MDR were only considered significant when they exceeded the SDD value of 10%. Between subjects with and without intermittent locking, differences in age and baseline MDR were analyzed using independent *t* tests, and differences in reported frequency and duration of intermittent locking were analyzed using chi-square tests. Changes in the maximum mouth openings in subjects who lost ADDR signs over time were tested using paired *t* tests. *P* values below .05 were considered statistically significant.

Results

Twenty-five (mean age 26.7 ± 13 years, 20 women, 26 TMJs with an ADDR) of the 26 subjects without intermittent locking and 30 (age 29.5 ± 12 years, 24 women, 30 ADDR TMJs) of the 35 subjects with intermittent locking completed the follow-up study. Six

Table 1 Mean Values (± SD) of the MDR* for the Subjects With or Without Reports of Intermittent Locking				
	MDR at baseline	MDR after 1 year	MDR after 2 years	
With intermittent locking (n = 30)	41.2 ± 26.6	56.0 ± 33.4	62.1 ± 33.8	$P = .000$
Without intermittent locking (n = 25)	40.4 ± 24.6	40.6 ± 25.0	40.3 ± 24.9	$P = .950$
	$P = .906$			

*MDR was defined as the distance travelled by the condylar kinematic center until the opening click, expressed as a percentage of the distance travelled until maximum mouth opening.

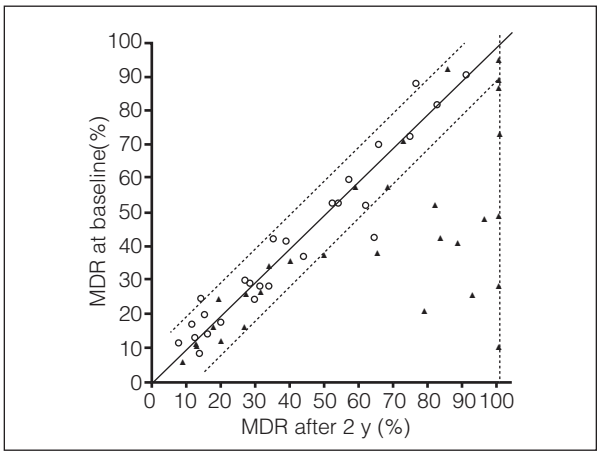

Fig 2 For the subjects with (▲) or without (○) intermittent locking, the relation between the MDR obtained at baseline and after the follow-up period of 2 years is shown. The two lines located at a distance of 10% from the 45° line demarcate the area of nonsignificant differences.

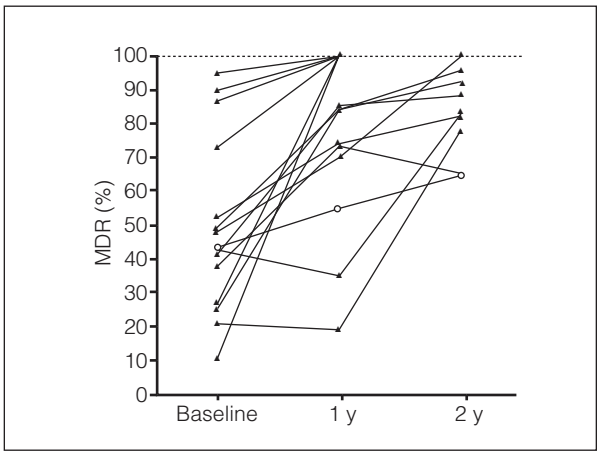

Fig 3 Time course of the MDR for subjects with a significant change of at least 10% in their MDR value with respect to baseline. Data of subjects with (▲) or without (○) intermittent locking are shown.

subjects dropped out due to lack of time. The 5 dropouts with intermittent locking did not differ from the remaining subjects with intermittent locking in age ($P = .535$), baseline MDR ($P = .725$), frequency of locking ($P = .696$), or duration of locking ($P = .652$). Also, no significant differences were found between subjects with or without intermittent locking in age ($P = .414$) and baseline MDR ($P = .906$, Table 1).

For the subjects without intermittent locking, no differences were found in the MDR values observed at baseline and at the first and second year ($P = .950$) (Table 1), whereas for the subjects with intermittent locking, significant differences were found ($P = .000$). The MDR values had increased significantly during the first ($P = .002$) and second year ($P = .031$).

None of the subjects returned to ACTA in between scheduled appointments because of a perceived change in joint condition; this included those who had lost their joint clicking sounds. Some of the latter patients were not aware that their clicking sounds had disappeared. At the 2-year follow-up, eight subjects (one without and seven with intermittent locking) showed disc reduction occurring later during mouth opening and seven subjects (all with intermittent locking) no longer had signs of a disc reduction (MDR=100%) (Fig 2). Thirteen of these 15 subjects showed changes in their MDR already at the first year follow-up, while in two subjects, MDR changes were only seen at the second year follow-up (Fig 3). None of the subjects revealed a significant shift to an earlier moment of disc reduction.

MRI scans taken at the disappearance of ADDR signs showed that in the seven subjects involved, the disc displacement was still present in five subjects without reduction and in two subjects with a partial reduction on mouth opening. The average maximum mouth opening at the disappearance of the ADDRs (46.8 ± 1.9 mm) was not different from baseline (43.5 ± 1.2 mm) ($P = .072$), and only one of the seven subjects reported pain on full mouth opening.

The 14 subjects with intermittent locking, whose MDR changed over time, did not differ from the oth-

er subjects with intermittent locking in age ($P = .084$), baseline MDR ($P = .067$), or duration of intermittent locking ($P = .749$). However, they reported a higher frequency of intermittent locking ($P = .023$).

Discussion

This study has shown that a loss of reducing capacity of the disc is responsible for the disappearance of clicking, often observed in ADDR subjects with intermittent locking.

MRI visualizes the condyle-disc relationship in the closed and open mouth position and is often regarded as the gold standard technique to diagnose a disc displacement.[13] However, this technique cannot be used to assess the exact MDR during mouth opening. As an alternative, the technique of mandibular movement recordings was used. This technique enables the recognition of an ADDR[6,14] and allows the objective assessment of the MDR. Clinically, the interincisal distance at the time of the opening click is used to assess the MDR.[15] However, movements of the lower incisal point are more a reflection of rotation than of translation of the mandible,[16] making the interincisal distance a less suitable measure to use. With six-degrees of freedom recording systems, the movements of the kinematic center of the condyles can also be reconstructed and used for the assessment of the MDR. In this study, the MDR was defined as the distance travelled by the condylar kinematic center until the opening click, expressed as a percentage of the distance travelled until maximum mouth opening.

Earlier studies[17,18] have indicated that clicking sounds vary considerably over time but rarely develop into a serious TMJ condition, such as locking. However, in these studies, no attempt was made to discriminate ADDR clicking from other joint sounds, such as those due to symptomatic hypermobility.[1] This study has shown that an ADDR is a stable TMJ condition over time, as long as it is not accompanied by reports of intermittent locking in the oral history. If it is, the ADDR shows a tendency to gradually progress to later stages of disc reduction or to lose its reducing capacity altogether. A loss of ADDR clicking sounds has also been reported in earlier follow-up studies,[3–5] but in these studies, it was not determined which functional and/or morphological alterations within the TMJ were responsible for this loss of sounds. In this study, the MRI scans made at the disappearance of ADDR signs showed that the disc displacement was still present in all subjects involved, but that it had lost its capacity to reduce (ADDWoR) or that it showed only a partial reduction. Restoration of a normal condyle-disc relation as an explanation for the loss of the clicking sounds was never observed.

None of the subjects (including those who had lost their joint clicking sounds) returned to ACTA in between scheduled appointments because of a perceived change in joint condition. Some of the latter were not aware that their clicking sounds had disappeared. Others were aware of it but did not consider it necessary to return to ACTA before the scheduled appointment because they were still free of complaints (no limited mouth opening or pain). This indicates that the counseling had been successful in reassuring the patients about the harmless nature of the ADDR and that the subjects had no tendency to somatize or to be anxious about their joint condition. It also confirms the observation that the loss of the disc's capacity to reduce is only rarely accompanied by the classical symptoms of a closed-lock (viz, a limited mouth opening and pain in the joint area).

No difference was found in age or baseline MDR values between subjects with and without intermittent locking, suggesting that the risk of developing an ADDWoR is unrelated to age or to the MDR at baseline (early, intermediate, or late). That the subjects with intermittent locking whose MDR changed over time reported a higher frequency of intermittent locking than other subjects with intermittent locking may indicate that the development of an ADDWoR is the end result of a sequence of temporary locking events, acting as a repetitive trauma inducing plastic changes in the soft tissues of the joint.

The observation that a recently developed, permanent ADDWoR is only rarely accompanied by signs of locking illustrates the difficulty to come to a clinical diagnosis of an ADDWoR. This diagnosis relies heavily on the patient's memory of reciprocal clicking and of short-lasting moments of locking in the past. This may account for the disagreement found between clinical and MRI studies regarding the presence of an ADDWoR in otherwise healthy subjects,[6,19] and it also sheds doubt on the prevalence rates of ADDWoR found in epidemiological clinical studies.[20]

It should be noted that only a comparatively small number of subjects participated in the study, and this should be taken into account in considering the results of the study. Another limitation of the study was that the subjects were recruited on the basis of self-reported occasions of intermittent locking. Inevitably, these reports are subjective, and it cannot be excluded that factors other than a temporarily non-reducing disc (eg, fear of movement or a myofascial pain) may have caused the reported move-

ment limitations. However, since it is likely that these factors have a longer-lasting influence on the maximum mouth opening than is the case with intermittent locking, they probably played no role in the present study. Because no MRI scans were taken at the beginning of the study, it is also not possible to hypothesize which differences in the intra-articular relations of the TMJ (eg, thickness of the disc, sideways disc displacement) may have been responsible for the different behavior of the disc in the two groups of subjects.

Within the limits of the study, it can be concluded that reports of intermittent locking in subjects with an ADDR are indicative of the development of a disc displacement without reduction. The latter condition is only rarely accompanied by symptoms of permanent locking.

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