Effect of Chewing Upon Disc Reduction in the Temporomandibular Joint

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Aims: *To test whether an intensive chewing exercise influences the moment of disc reduction in subjects with or without reports of intermittent locking of the jaw.* ***Methods:*** *This experimental study included 15 subjects with a reducing anteriorly displaced disc (ADD) and with symptoms of intermittent locking and 15 subjects with a reducing ADD without such symptoms. The moment of disc reduction (MDR), quantified using mandibular movement recordings, was recorded at baseline, and after maximally 60 minutes of chewing. Thereafter, MDR was recorded again after 20 minutes of rest, and if necessary after 72 hours, in order to document return of MDR to baseline values.* ***Results:*** *In subjects without intermittent locking, the MDR after chewing was not different from baseline (*P *= .25). However, in the subjects with intermittent locking, the MDR value had increased significantly after chewing (*P *= .008); two subjects showed a later moment of disc reduction, and four showed a temporary loss of disc reduction.* ***Conclusion:*** *While intensive chewing did not influence disc reduction in subjects without intermittent locking, it caused a delay or even hampered disc reduction in approximately half of the subjects reporting intermittent locking.* J OROFAC PAIN 2011;25:49–55

Key words: anterior disc displacement, human, internal derangement, mandibular movement recordings, parafunctional activities

An internal derangement (ID) of the temporomandibular joint (TMJ) is a deviation in position or form of the intra-articular tissues.[1] Clinically, IDs are manifested when they interfere with smooth mandibular movements.[2] The most common ID is anterior disc displacement with reduction (ADDR), accounting for more than half of the ID prevalence in the adult population.[3]

In a TMJ with an ADDR, in the closed mouth position, the articular disc is 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 again becomes anteriorly dislocated. Clinically, ADDR is characterized by reciprocal joint clicking at the moment of disc reduction and dislocation and is usually a nonproblematic condition.[4] Sometimes, however, disc reduction becomes gradually delayed or even impossible,[5,6] giving rise to an anterior disc displacement without reduction (ADDWoR). Then, clicking sounds are absent and, when acute, a severe and often painful jaw movement limitation is present (a closed lock).[7] This loss of reduction can be permanent or intermittent.[8]

Patients with an ADDR who reported periods of intermittent locking[6,8] have more pain, a greater frequency of loss of molar support, and tooth wear with occlusally exposed dentine,[7] and may also be at higher risk to develop a permanent ADDWoR. This suggests that increased TMJ loading may influence the moment of disc reduction during mouth opening and may also facilitate the development of an ADDWoR. However, so far, no experimental data are available of the influence of TMJ loading upon the reducing capacity of the disc.

Therefore, the aim of this study was to test whether an intensive chewing exercise influences the moment of disc reduction in subjects with or without reports of intermittent locking of the jaw. The hypothesis was that an intensive chewing exercise has no influence upon the reduction of the disc in subjects with an ADDR with or without symptoms of intermittent locking.

Materials and Methods

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

Participants

After giving a written informed consent, subjects were included who received the clinical diagnosis of ADDR, which was subsequently confirmed by the results of a mandibular movement recording (see below). Fifteen ADDR subjects reporting intermittent locking (mean age ± SD = 29 ± 7 years, 13 women) were recruited from among patients visiting the clinic for Oral Kinesiology at the Academic Centre for Dentistry Amsterdam (ACTA). The intermittent locking varied between patients in frequency (ranging from once in several months to several times every day) and in duration (ranging from half a minute to several hours). In three of the contralateral joints, a pain-free ADDR without intermittent locking was also present; these joints were not included in the analysis. Fifteen ADDR subjects without reports of intermittent locking (mean age ± SD = 32 ± 13 years, 10 women, two cases with a bilateral ADDR) were recruited from dental students, coworkers of ACTA, and dental patients without temporomandibular complaints. All subjects had complete dentitions, with the occasional exception of a loss of third molars.

Exclusion criteria for both groups were a history of pain in the masticatory system (with the exception of reported pain during intermittent locking), serious impairments in general health (eg, malignancies), and age below 18 years.

Clinical Examination

During a clinical examination, the presence of an ADDR was assessed according to the guidelines recently described in detail[9]:

- Reproducible reciprocal joint clicking during opening and free or loaded (ie, with a manually applied, downward directed force of about 30 N on the chin) closing; and
- Elimination of clicking during maximal open-close movements from protrusion (the elimination test). During this test, the subjects were instructed to open wide, beyond the open click (ie, the moment of disc reduction). Then they had to close into a protruded incisal end-to-end position. Thereafter they had to open and close maximally from this protruded position several times.

Optoelectronic Mandibular Movement Recordings

Movement recordings were made with the Oral Kinesiology Analysis System (OKAS-3D system).[10] OKAS-3D is an optoelectronic system capable of recording jaw movements with six degrees of freedom at a sampling frequency of 300 Hz per coordinate. It also depicts the occurrence of joint sounds, recorded simultaneously using small condenser-type microphones placed over the palpated lateral poles of the TMJs. Specialized software graphically visualizes in three dimensions the movement traces of the incisal point and those of the kinematic centers of the condyles.[11,12] During a movement recording, the participant was sitting upright and performed several types of jaw movements according to a standardized protocol, eg, maximal open-close movements starting from the intercuspal position, maximal open and loaded (ie, with a manually applied, downward directed force of about 30N on the chin) close movements also starting from the intercuspal position, and maximal open-close movements starting from a protruded incisal end-to-end position (elimination test). Each type of movement was recorded during registrations of 20 seconds, containing six movements on average.

The clinical diagnosis of ADDR was confirmed by the OKAS-3D movement recordings when the reciprocal joint sounds were accompanied by deflections in all the otherwise smooth sagittal movement traces of the condylar kinematic center (Fig 1)[9,13] and when the joint sounds and movement deflections were eliminated on protrusive open-close movements.

Moment of Disc Reduction

Movement recordings with OKAS-3D were also used to quantify the moment of disc reduction (MDR) in the ADDR joints. MDR was measured on the sagittal condylar traces of maximal open-close movements as the length of the condylar translation vector at the time of the opening click (ie, disc reduction), expressed as a percentage of the length of the condylar translation vector at maximal mouth opening (Fig 1a). The later the disc reduction occurred, the higher the MDR value was. If disc reduction was not possible anymore, an MDR value of 100% was noted.

In a pilot study, the reliability of the MDR was found to be excellent (intraclass correlation coefficient = 0.989) and its smallest detectable difference (SDD) was 10%.[14] For that study, OKAS-3D recordings were obtained twice within an average period of 12 days in 15 subjects (mean age ± SD = 32 ± 11 years, 12 female) with a stable ADDR.

Experimental Protocol

Each experiment lasted about 3 hours. MDR was quantified from three movement recordings: Before (baseline) and immediately after the intensive chewing exercise (see below), and after a resting phase of 20 minutes. Each recording consisted of six, 20-second registrations of maximal open-close movements, with a rest period of 1 minute between registrations. When the movement recording after the 20-minute rest period showed no return of MDR to baseline values, a fourth recording of three 20-second registrations was scheduled 72 hours later.

The chewing phase had a maximum duration of 60 minutes. Each participant chewed upon a large bolus of seven pieces of hard “Elma” chewing gum (Chios Gum Mastic Growers Association) at his or her habitual chewing pace. This chewing pace was kept constant throughout the 60 minutes of chewing with the use of a metronome. Participants had to change chewing sides every 5 minutes to achieve a balanced loading of the joints. During the chewing exercise, the OKAS equipment was not in place, and changes in the reduction of the disc could only be monitored clinically. Every 15 minutes, the participant’s maximum mouth opening was visually checked by observing the movement pattern and range of motion. Also the TMJs were palpated for the presence of joint sounds, and the interincisal opening at the time of the opening click (ie, disc reduction) was measured. The participants were then also asked whether they perceived any change as compared to baseline. If changes were suspected, the chewing phase was discontinued and the second movement recording was made. If the first 20-second registration of this recording failed to show a change in MDR, then chewing was resumed until the period of 60 minutes was completed.

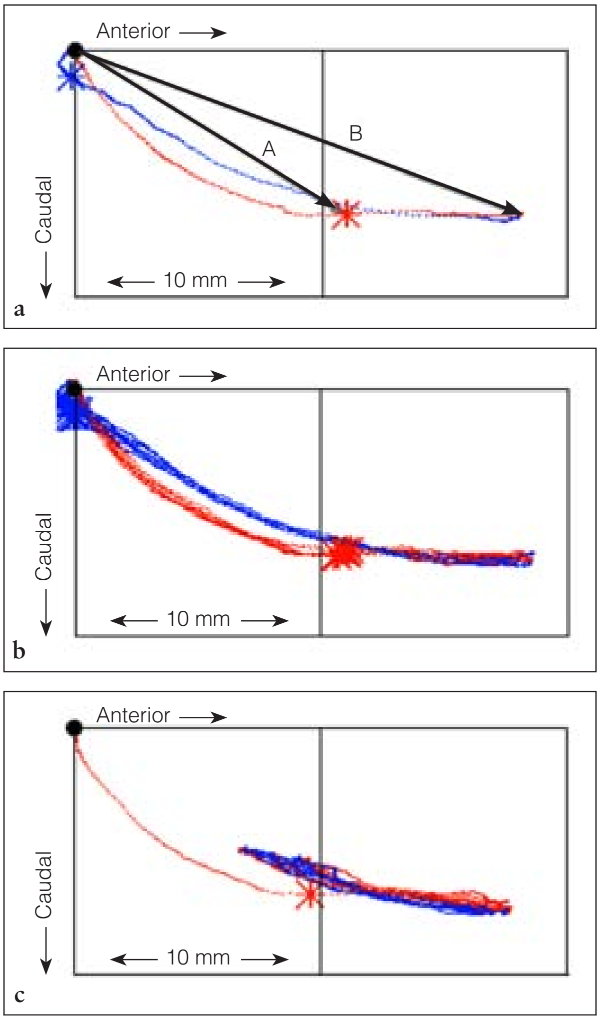

Fig 1 Example of a single *(a)* and of the superimposed *(b and c)* sagittal movement traces of the kinematic center of a TMJ with an ADDR while the patient performed six maximal open-close movements starting from the intercuspal position (a and b), or starting (apart from the first movement) from a protruded incisal end-to-end position (the elimination test) *(c)*. The MDR is the length of the condylar translation vector at the moment of the opening click, expressed as a percentage of the length of the condylar translation vector at maximum mouth opening (A/B*100%). The superimposed movement traces *(b)* illustrate the reproducibility of the movement traces and of 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 intercuspal position. Opening and closing clicking sounds are indicated with red and blue asterisks (*).

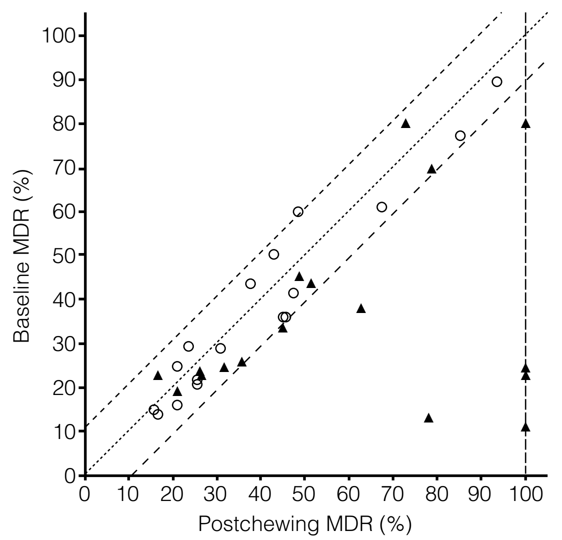

Fig 2 Baseline MDR and postchewing MDR of subjects without (○) and with (▲) reports of intermittent locking. Data points of the joints of all the subjects without intermittent locking lie within the area of nonsignificant differences (area demarcated by the two lines located at a distance of 10% from the 45° line), indicating that the MDR was not influenced by the chewing exercise. Data points of six subjects with intermittent locking lie outside this area of nonsignificant differences. Two subjects showed a later disc reduction after chewing while, in four subjects, temporary locking was provoked, as noted by an MDR of 100%.

Table 1 Mean (± SD) of the Baseline and Postchewing MDR of the TMJs of the Subjects Without and With Reports of Intermittent Locking

	Without intermittent locking, 17 ADDR joints	With intermittent locking, 15 ADDR joints	*P* value
Baseline MDR	39.0 ± 22.2	36.5 ± 23.0	.748
Postchewing MDR	40.9 ± 23.0	62.7 ± 30.0	.027
P value	.250	.008	

Statistical Analysis

After the data was tested for normality of distribution, an independent *t* test was used to determine whether the baseline MDR (calculated as the mean MDR of the six, 20-second baseline registrations) was different between the subjects with and without intermittent locking. A paired *t* test was used to determine within each group of subjects whether a significant difference existed between the baseline MDR (calculated as the mean MDR of the six, 20-second baseline registrations) and the postchewing MDR (the MDR with the most deviating value from baseline, measured on the registrations immediately after chewing or after 20 minutes of rest, eg, Fig 3a). *P* values below .05 were considered statistically significant. At an individual level, significant effects of the chewing exercise upon the moment of disc reduction were noted only if the change in MDR exceeded the SDD value of 10%. Differences in age and baseline MDR between subjects with or without a change in disc reduction after gum chewing (responding and nonresponding subjects, respectively) were analyzed using an independent *t* test. Differences in frequency of intermittent locking between the responding and nonresponding subjects were analyzed using a chi-square test.

Results

No significant difference in baseline MDR was found between the joints of subjects with or without reports of intermittent locking (*P* = .748, Table 1). In the subjects without intermittent locking, no difference between postchewing and baseline MDR was found (*P* = .250; Fig 2, Table 1). However, in the subjects with intermittent locking, the postchewing MDR was significantly higher than at baseline (*P* = .008), showing that disc reduction was delayed after the chewing exercise (Fig 2, Table 1). Also, the postchewing MDR in the subjects with intermittent locking was significantly higher in comparison to the postchewing MDR in the subjects without intermittent locking (*P* = .027, Table 1).

At an individual level, in none of the subjects without intermittent locking did the postchewing MDR

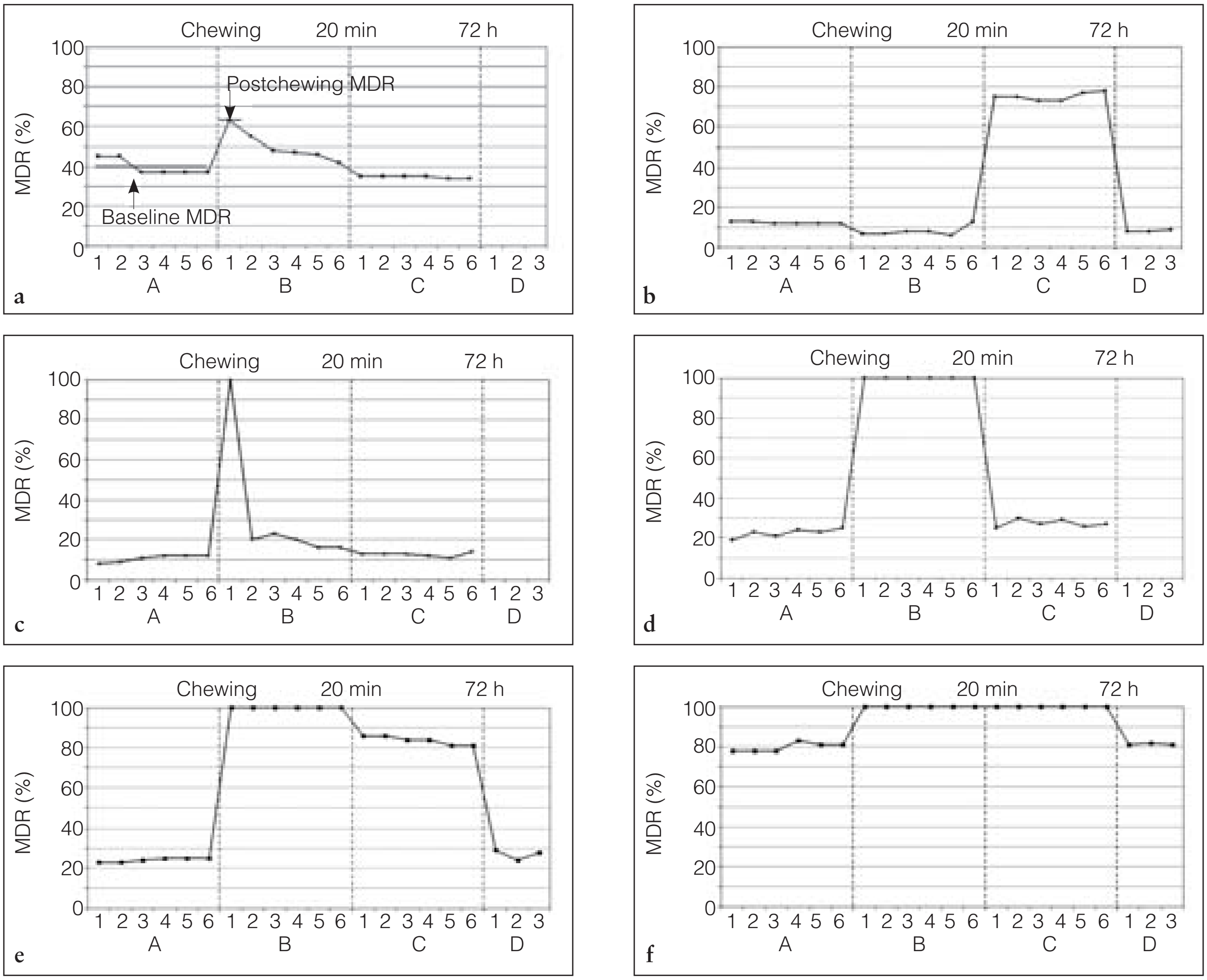

Fig 3 MDR of six subjects with reports of intermittent locking in whom the chewing exercise had a significant effect on disc reduction. On the vertical axes, MDR (%) is noted. On the horizontal axes, the different registrations throughout the experiment are noted. A: 1–6 = six, 20-second registrations at baseline; B: 1–6 = six, 20-second registrations immediately after the chewing exercise; C: 1–6 = six, 20-second registrations after 20 minutes of rest; D: 1–3 = three, 20-second registrations 72 hours after the chewing exercise. In two subjects, disc reduction was delayed after chewing *(a and b)*, while in four subjects, disc reduction was temporarily hampered, as noted by a shift of the MDR to 100% *(c through f)*. These effects resolved quickly in three cases *(a, c, d)*, and slowly (but within 72 hours) in the other three cases *(b, e, f)*. The postchewing MDR *(a)* was defined as the MDR of the postchewing registration with the most deviating value from baseline (in this example, B1).

deviate from baseline by more than 10%. However, in the subjects with intermittent locking, six joints (40%) had a postchewing MDR that was significantly higher than at baseline (Fig 3). In two of these joints, disc reduction occurred at a later moment during opening. In the other four joints, temporary locking was provoked. Locking was accompanied by a decrease in maximal mouth opening in all four subjects and by a report of pain in the TMJ area in three of them. The subjects with locking were the only subjects who could not complete the 60-minute chewing exercise. In two of them, locking was already noted after 5 minutes of chewing; in the other two subjects, after 30 minutes. The six subjects with reports of intermittent locking, whose MDR was influenced by the chewing exercise, did not differ in age ($P = .357$) or baseline MDR ($P = .499$) from the other subjects with reports of intermittent locking. However, there was a trend ($P = .057$) toward a higher frequency of self-reported intermittent locking in those six subjects compared to the other subjects with reports of intermittent locking, whose MDR was not influenced by the chewing.

All observed effects upon the moment of disc reduction (viz, delay or loss of reduction) were temporary. In three subjects, the effects resolved quickly, viz, within the experimental session (Figs

3a, 3c, and 3d). In the other three subjects, the effects resolved more slowly, within 72 hours (Figs 3b, 3e, and 3f).

Discussion

The hypothesis that an intensive chewing exercise has no influence upon the reduction of the disc in subjects with an ADDR with or without symptoms of intermittent locking was rejected. The chewing task influenced the MDR in subjects with reports of intermittent locking.

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 not-reducing disc, eg, fear of movement or a myofascial pain, may have been responsible for the reported movement limitations. However, it is unlikely that fear of movement was involved, because this would have resulted in a longer-lasting movement limitation than is the case in intermittent locking. Furthermore, reports of pain from the masticatory system (with the exception of reports of pain at the time of intermittent locking) was an exclusion criterion, thereby minimizing the chance of a myogenous limitation of mouth opening.

In the clinical diagnosis of an ADDR, the interincisal distance at the time of clicking is usually used for the diagnosis of an ADDR.[15] However, evaluation of the interincisal distance is a difficult task that strongly depends upon the examiner's skills. Moreover, the interincisal distance is more a reflection of rotation than of translation of the mandible,[16,17] making it a less suitable measure to use. The use of OKAS-3D overcomes these problems. It allows the objective recording of mandibular movements, in particular those of the kinematic centers of the condyles. In this way, the moments of disc reduction can be quantified as the kinematic center translation until the time of the opening click.

In this study, intensive gum chewing, a common oral habit,[18] was used to provoke TMJ loading. That the joints were loaded is an assumption because the joint load was not actually recorded. However, biomechanically, the mandible acts as a class III lever with, as a consequence, loading of the joints during activities such as chewing. Oral habits have already been associated with signs and symptoms of temporomandibular disorders.[18,19] As far as disorders within the TMJ are concerned, the frequency of joint clicking and the reports of a movement limitation were found to be correlated to signs and symptoms of bruxism[20] and to the duration of masseter muscle activity during sleep.[21] However, whether these relationships are causal is not yet clear. The present results suggest that intensive gum chewing can facilitate intermittent locking within TMJs with an ADDR. This makes it plausible that oral habits play a role in the development of a permanent ADDWoR. Although it is likely that the observed MDR changes were the result of the loading of the joints during the gum-chewing exercise, it cannot be excluded that other factors may have played a role as well, eg, the condylar movements during the chewing exercise may have been responsible for the changes in the disc reduction.

Why some displaced discs temporarily lose their capacity to reduce is unknown. Because magnetic resonance imaging was not used in this study, it is not possible to hypothesize whether differences in the intra-articular relations of the TMJ (eg, thickness of the disc, sideways disc displacement) may have been responsible for the different behaviors of the disc in the two groups of subjects. Maybe factors such as an increased intra-articular friction due to an increased TMJ loading[22,23] or hyperactivity of the lateral pterygoid muscle[24] were involved in the temporary loss of reduction capacity of the disc.

This study also showed large differences between subjects in their reaction to the chewing exercise. While locking was provoked already after a short period of chewing in some subjects, in others, only a later reduction or no change in the moment of reduction at all was observed after a whole hour of chewing. No difference in baseline MDR value was found between the joints with intermittent locking that showed a change in disc reduction in response to the gum-chewing exercise and the joints with intermittent locking that showed no response. This shows that the risk for temporary locking was unrelated to the moment of disc reduction (early, intermediate, or late) at baseline. The trend ($P = .057$) toward a higher frequency of self-reported intermittent locking in the subjects whose MDR was influenced by the chewing exercise compared to the other subjects reporting intermittent locking suggests that subjects with a higher frequency run a higher risk of temporarily losing their disc reducing capacity. Interestingly, only two subjects with a coexisting symptomatic TMJ hypermobility[25] were found among the subjects responding to chewing. Whether ADDR joints with hypermobility run a higher risk of intermittent locking remains to be answered.

In conclusion, excessive TMJ loading by means of an intense chewing exercise did not influence the MDR in subjects without complaints of intermittent locking. However, it affected the disc-reducing capacity in approximately one half of the subjects with reports of intermittent locking.

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References

1. The glossary of prosthodontic terms. J Prosthet Dent 2005; 94:10–92.
2. McNeill C. Temporomandibular Disorders: Guidelines for Classification, Assessment, and Management. Chicago: Quintessence, 1993.
3. Huddleston Slater JJ, Lobbezoo F, Onland-Moret NC, Naeije M. Anterior disc displacement with reduction and symptomatic hypermobility in the human temporomandibular joint: Prevalence rates and risk factors in children and teenagers. J Orofac Pain 2007;21:55–62.
4. Okeson JP. Orofacial Pain: Guidelines for Classification, Assessment, and Management. Chicago: Quintessence, 1996.
5. Farrar WB, McCarty W. A Clinical Outline of the Temporomandibular Joint Diagnosis and Treatment. Montgomery, AL: Normandie, 1982.
6. Kalaykova S, Lobbezoo F, Naeije M. Two-year natural course of anterior disc displacement with reduction. J Orofac Pain 2010;24:373–378.
7. Lundh H, Westesson PL, Kopp S. A three-year follow-up of patients with reciprocal temporomandibular joint clicking. Oral Surg Oral Med Oral Pathol 1987;63:530–533.
8. Westesson PL, Lundh H. Arthrographic and clinical characteristics patients with disk displacement who progressed to closed lock during a 6-month period. Oral Surg Oral Med Oral Pathol 1989;67:654–657.
9. Naeije M, Kalaykova S, Visscher CM, Lobbezoo F. Focus article: Evaluation of the research diagnostic criteria for temporomandibular disorders for the recognition of an anterior disc displacement with reduction. J Orofac Pain 2009;23:303–311.
10. Naeije M, van der Weijden JJ, Megens CCEJ. OKAS-3D: Optoelectronic jaw movement recording system with six degrees of freedom. Med Biol Eng Comput 1995;33:683–688.
11. Naeije M. Measurement of condylar motion: A plea for the use of the condylar kinematic centre. J Oral Rehabil 2003;30:225–230.
12. Yatabe M, Zwijnenburg A, Megens CCEJ, Naeije M. The kinematic center: A reference for condylar movements. J Dent Res 1995;74:1644–1648.
13. Huddleston Slater JJR, Lobbezoo F, Van Selms MK, Naeije M. Recognition of internal derangements. J Oral Rehabil 2004;31:851–854.
14. Fleiss JL, Kingman A. Statistical management of data in clinical research. Crit Rev Oral Biol Med 1990;1:55–66.
15. Dworkin SF, LeResche L. Research diagnostic criteria for temporomandibular disorders: Review, criteria, examinations and specifications. J Craniomandib Disord 1992;6:301–355.
16. Naeije M. Local kinematic and anthropometric factors related to the maximum mouth opening in healthy individuals. J Oral Rehabil 2002;29:534–539.
17. Travers KH, Buschang PH, Hayasaki H, Throckmorton GS. Associations between incisor and mandibular condylar movements during maximum mouth opening in humans. Arch Oral Biol 2000;45:267–275.
18. Gavish A, Halachmi M, Winocur E, Gazit E. Oral habits and their association with signs and symptoms of temporomandibular disorders in adolescent girls. J Oral Rehabil 2000;27:22–32.
19. Winocur E, Gavish A, Finkelshtein T, Halachmi M, Gazit E. Oral habits among adolescent girls and their association with symptoms of temporomandibular disorders. J Oral Rehabil 2001;28:624–629.
20. Magnusson T, Egermark I, Carlsson G. A prospective investigation over two decades on signs and symptoms of temporomandibular disorders and associated variables. A final summary. Acta Odontol Scand 2005;63:99–109.
21. Baba K, Haketa T, Sasaki Y, Ohyama T, Clark GT. Association between masseter muscle activity levels recorded during sleep and signs and symptoms of temporomandibular disorders in healthy young adults. J Orofac Pain 2005;19: 226–231.
22. Nickel JC, Iwasaki LR, Feely DE, Stormberg KD, Beatty MW. The effect of disc thickness and trauma on disc surface friction in the porcine temporomandibular joint. Arch Oral Biol 2001;46:155–162.
23. Tanaka E, Hirose M, Koolstra JH, et al. Modeling of the effect of friction in the temporomandibular joint on displacement of its disc during prolonged clenching. J Oral Maxillofac Surg 2008;66:462–468.
24. Tanaka E, Hirose M, Inubushi T, et al. Effect of hyperactivity of the lateral pterygoid muscle on the temporomandibular joint disk. J Biomech Eng 2007;129:890–897.
25. Kalaykova S, Naeije M, Huddleston Slater JJ, Lobbezoo F. Is condylar position a predictor for functional signs of TMJ hypermobility? J Oral Rehabil 2006;33:349–355.