Anterior Disc Displacement with Reduction and Symptomatic Hypermobility in the Human Temporomandibular Joint: Prevalence Rates and Risk Factors in Children and Teenagers

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Aims: *To assess the prevalence rates and risk factors of anterior disc displacement with reduction (ADDR) and symptomatic hypermobility in a large sample of children and teenagers. Prevalence rates were also established in samples of young adults and adults.* ***Methods:*** *Children from 7 Dutch primary and secondary schools (n = 1,833) aged 4 to 18 years (mean age ± SD 10.8 ± 3.9 years), 220 dental students aged 19 to 30 years (mean age ± SD 21.9 ± 3.6 years), and 100 dental school employees more than 30 years old (mean age ± SD 43.5 ± 9.8 years) were examined. The presence of ADDR or symptomatic hypermobility was scored using well-defined clinical criteria. For the children only, an additional standardized oral history and clinical examination were performed to assess possible risk factors. Odds ratios (ORs) were calculated with the use of logistic multivariate regression analysis.* ***Results:*** *The prevalence rate of ADDR in at least 1 of the 2 joints increased during childhood and adolescence and stabilized into adulthood at about 26.6%. In children and teenagers, besides age (OR = 1.06 for boys, OR = 1.23 for girls), risk factors for ADDR were a history of orthodontics (OR = 1.57), an increasing overbite (OR = 1.15), and protrusion (OR = 1.12). In children and teenagers, the prevalence rate of symptomatic hypermobility was higher for girls (13.8%) than for boys (8.2%). Besides gender (OR = 2.07), risk factors for symptomatic hypermobility were race (OR = 2.61 for non-Caucasians), masticatory muscle pain (OR = 1.95), and increasing maximum mouth opening (OR = 1.08).* ***Conclusion:*** *In children and teenagers, ADDR and symptomatic hypermobility have different prevalence rates and risk factors.* J OROFAC PAIN 2007;21:55–62

Key words: anterior disc displacement, prevalence rate, risk factors, symptomatic hypermobility, temporomandibular joint

An internal derangement (ID) of the temporomandibular joint (TMJ) is described as a deviation in position or form of the tissues within the capsule of the joint.[1] Clinically it can only be noted when it interferes with the execution of smooth TMJ movements. Two examples of internal derangements are anterior disc displacement with reduction (ADDR) and symptomatic hypermobility. ADDR is characterized by an anterior displacement of the disc in the closed mouth position, which improves its relation with the condyle during mouth opening. Clicking sounds are its main clinical manifestation.[2]

Manifestations of symptomatic hypermobility are jerky mandibular movments and clicking sounds at wide opening are indicators that the condyle has difficulties passing the apex of the articular eminence.[3]

Although the aforementioned IDs are considered harmless and cause little or no discomfort to patients, they occasionally develop into a more serious clinical condition. In rare cases, an anteriorly displaced disc suddenly stays permanently displaced with respect to the condyle, and the patient has difficulty in opening the mouth (ie, a closed lock). In patients with hypermobility symptoms, the condyle may pass the crest of the eminence on wide opening and suddenly have difficulties re-entering into the fossa, so that the patient cannot close the mouth (ie, a condylar luxation). Unfortunately, it is largely unknown why these complications occur,[4] because so far, most epidemiological studies have focused more on the main symptom of IDs, TMJ clicking on movement, and less on the underlying causes. More insight into the prevalence rates and risk factors of ADDR and symptomatic hypermobility may be a first step to gain more insight into the possible long-term complications of these internal derangements.

Studies suggest that the prevalence rate of clicking sounds from the TMJ increases during childhood and adolescence.[5–7] These studies, however, did not differentiate different types of IDs; furthermore, they divided patients into comparatively large age groups[6] or included orthodontic patients.[5] These aspects may have compromised the external validity of the results. To evaluate the prevalence rates and risk factors of ADDR and symptomatic hypermobility, large population samples are needed. Therefore, the aim of the present study was to assess the prevalence rates and risk factors of IDs with well-defined clinical criteria in a large sample of children and teenagers. In addition, prevalence rates were also established in samples of young adults and adults.

Materials and Methods

Participants

Three groups of participants were recruited. The first group, henceforth referred to as "children," comprised a total of 1,833 children and teenagers between 4 and 18 years old (mean age ± SD 10.8 ± 3.9 years), who were recruited from 7 Dutch primary and secondary schools. The second group comprised 220 dental students between 19 and 30 years old (mean age ± SD 21.9 ± 3.6 years) and is henceforth referred to as "young adults." The last group was a group of 100 employees of the dental school, all more than 30 years old (mean age ± SD 43.5 ± 9.8 years) and is henceforth referred to as "adults."

All participants gave informed consent (for children attending primary school, their parents gave consent).

The scientific and ethical aspects of the protocol were reviewed and approved by the review board of the Netherlands Institute of Dental Sciences.

Protocol

For all participants, the presence of ADDR or symptomatic hypermobility was scored by 1 of 2 trained dentists using palpation and auscultation, while the participants performed the following, maximally performed tasks, which all started from and ended in the intercuspal position:

- Opening and closing
- Laterotrusion to the right and left
- Protrusion

There were at least 3 trials per task. If a click was reproducible (ie, present on at least 2 of 3 consecutive trials), the following, additional tasks were performed:

- Opening that started from and ended in a protruded incisor edge-to-edge position
- Free opening and loaded closing

For the children, an additional oral history and clinical examination were performed by 1 of 2 trained dentists. For the youngest children the phrasing of the questions was adjusted for clarification.

Techniques

For auscultation, the bell of an infant stethoscope (3M Littmann) was placed over the lateral pole of the TMJ. Palpation was performed with the index and middle fingers. Both joints were palpated simultaneously. Clicks were noted when observed with either technique. The interrater reliability of this protocol[3] (qualified as "almost perfect") and the validity of criteria[8] used have been tested and published previously. The loaded closing movements were performed while the dentist loaded the participant's mandible with a manually applied, downward directed force of about 30 N on the chin, which was calibrated beforehand using a weight scale.

Clinical Diagnosis

The clinical criteria for the recognition of an ADDR were modified from the criteria suggested by the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD)[9] and have been described in detail elsewhere.[3,8] One of the RDC is that the interincisal distance should be at least 5 mm greater at the time of the opening click than at the time of the closing click. However, a recent study has indicated that this 5-mm criterion is not very specific for an ADDR[10] and for that reason, this criterion was not included in the clinical ADDR criteria for the present study. Furthermore, it is the authors' clinical experience that the closing click is usually much softer than the opening click and is often hardly audible. This can be compensated for by loading the mandible during closing movements. Loading reduces the intra-articular distance within the TMJ[11] and strongly enhances the closing click. The closing click, as a sign of dislocation of the disc from the condyle, usually occurs just before the condyle re-enters the fossa.[2,10] During protruded incisor edge-to-edge opening and closing movements, the condyle will not re-enter the fossa, and ADDR clicking sounds will be eliminated.

Therefore, the clinical ADDR criteria used in this study were:

- Clicking on opening and (loaded) closing, reproducible on at least 2 of 3 consecutive trials
- Elimination of clicking on protruded incisor edge-to-edge opening and closing

Symptomatic hypermobility in the TMJ can clinically only be noted when it interferes with smooth mandibular movements. These interferences manifest themselves as jerky mandibular movements and clicking sounds as signs of the condyle 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.

Therefore, the clinical criteria for the recognition of symptomatic hypermobility were:

- Clicking in the late part of opening and the early part of closing, in combination with jerky jaw movements, reproducible on at least 2 of 3 consecutive trials
- No elimination of clicking on protruded incisor edge-to-edge opening and closing

When the ID did not meet 1 of these 2 sets of criteria, eg, due to a posteriorly displaced disc, the derangement was classified as "other." Crepitation was not taken into account.

Data Analysis

Clenching, tiredness in the masticatory muscles, pain in the masticatory muscles, pain during function, use of chewing gum, and smoking were originally scored on a 5-point scale (never, sometimes, often, regularly, always). Answers were recoded into dichotomous variables by pooling the answers *sometimes, often, regularly,* and *always*. Body height, originally measured in millimeters, was recoded into a 3-point scale (–1, 0, and 1), and was called "deviation in growth." A score 0 was given to children who had a height that was within 1 standard deviation of the Dutch age-related mean.[12] A score of 1 or –1 was given to those who were taller or shorter, respectively. Dental development stage was similarly recoded[13] and was called "deviation in dental development."

For the young adults and adults, the prevalence rates of participants with ADDR or symptomatic hypermobility in at least 1 of their joints were calculated, and χ^2 tests were used to compare these prevalence rates with those of the oldest children in the children group (the 18-year-olds). For the children, risk factors for the presence of ADDR or symptomatic hypermobility in at least 1 of the 2 joints were also assessed. First, logistic univariate regression analyses were used to examine which factors were significantly ($P < .05$) related to the outcome variable under study. The Wald statistic (the overall Wald statistic for nondichotomous, categorical variables) was used to test the significance of the categorical factors in the model. Subsequently, the significant factors were entered into a forward selection logistic multivariate regression model (P value to remove = 0.1) to identify the subset of factors that was best associated with the outcome variable. The antilogarithm of the regression coefficient of a variable equals the odds ratio of that variable. Eight of the participants had both ADDR and symptomatic hypermobility in their joints, and these cases were used in both regression models. All analyses were carried out with SPSS for Windows version 14.0.0.

Results

For each age group, the total number of male and female participants is shown in Table 1. The number of participants with an ID in at least 1 of the joints is also shown.

For the children, logistic univariate regression analyses (Table 2) indicated that age, race, tiredness in the masticatory muscles, history of orthodontic

Table 1 No. of Participants and ID Classification for Each Group

Age (y)*	Female No	Female ADDR	Female SH	Female Other	Male No	Male ADDR	Male SH	Male Other
Children								
4	40	1	2	0	46	2	1	0
5	68	1	8	0	63	2	2	1
6	55	3	13	0	52	6	2	0
7	68	2	6	0	61	4	4	0
8	80	4	9	1	71	10	7	0
9	80	8	8	0	52	6	3	0
10	54	4	6	0	67	8	2	0
11	39	8	2	0	44	2	6	0
12	72	12	6	1	77	10	4	3
13	99	18	11	0	91	16	7	0
14	98	22	20	1	107	17	11	2
15	59	20	14	2	63	13	6	1
16	53	15	7	3	53	12	6	0
17	37	15	5	0	39	7	3	1
18	23	6	4	0	22	6	1	0
Young adults								
21.9	120	37	23	7	100	20	16	2
Adults								
43.5	52	17	7	4	48	11	6	0

*Mean age is given for young adult and adult groups.
SH = symptomatic hypermobility.

Table 2 Logistic Univariate Regression Analysis for ADDR (Children Group)

Variable	Value	Count (%)	Odds ratio	95% CI	*P*
Age (continuous)	Years		1.20	1.15 – 1.24	.00
Gender	Boys	49.5	Reference		
	Girls	50.5	1.15	0.88 – 1.50	.30
Race	Caucasian	92.2	Reference		
	Non–Caucasian	7.8	0.53	0.29 – 0.98	.04
Clenching	No	75.8	Reference		
	Yes	24.2	1.28	0.95 – 1.73	.10
Tiredness (masticatory muscles)	No	73.8	Reference		
	Yes	26.2	1.47	1.10 – 1.96	.01
Pain (masticatory muscles)	No	89.1	Reference		
	Yes	10.9	0.87	0.56 – 1.35	.54
Pain during function	No	94.5	Reference		
	Yes	5.5	1.01	0.57 – 1.81	.97
Use of chewing gum	No	20.4	Reference		
	Yes	79.6	1.16	0.83 – 1.63	.40
Smoking	No	93.7	Reference		
	Yes	6.3	1.23	0.74 – 2.06	.43
Sleeping position (categorical)	4 categories				.58
History of orthodontic treatment	No	70.8	Reference		
	Yes	29.2	2.88	2.20 – 3.76	.00
Overbite (continuous)	mm		1.18	1.09 – 1.27	.00
Overjet (continuous)	mm		1.00	0.92 – 1.07	.90
Protrusion (continuous)	mm		1.14	1.07 – 1.21	.00
Maximal mouth opening (continuous)	mm		1.05	1.03 – 1.07	.00
Molar relation (categorical)	6 categories				.06*
Deviation in growth (categorical)	3 categories				.32*
Deviation in dental development (categorical)					.02*
	–1	17.1	0.52	0.30 – 0.89	.02
	0	69.3	Reference		
	1	13.7	1.00	0.71 – 1.42	.98

*Overall Wald statistic.
Odds ratios were calculated relative to the reference value of the variable.

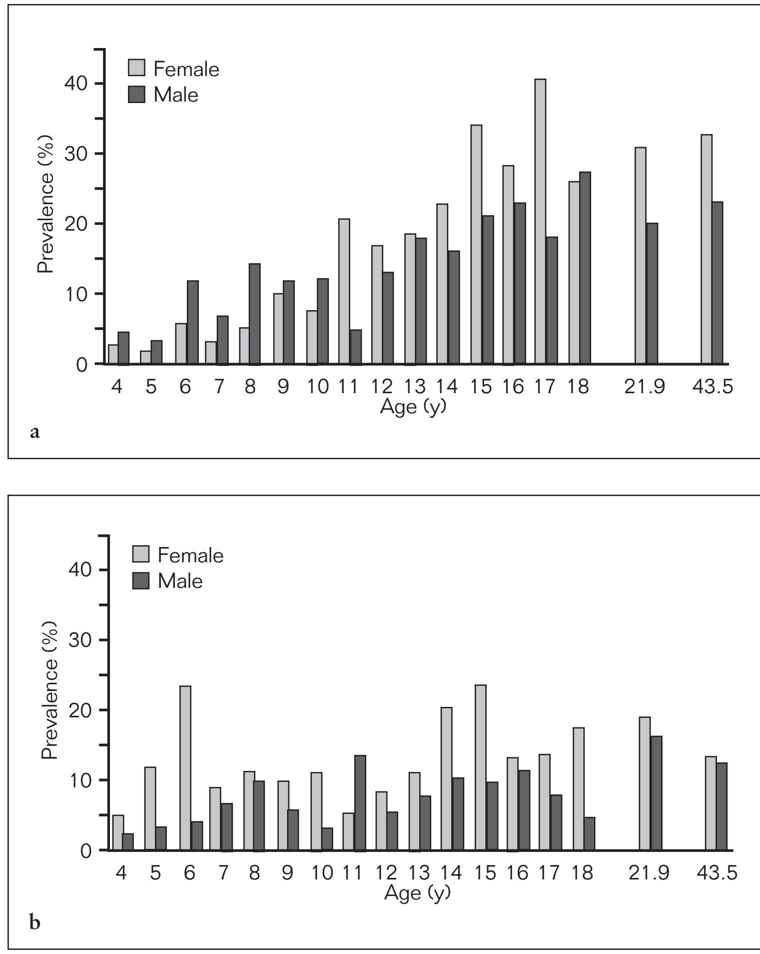

Fig 1 Prevalence rates (%) of *(a)* ADDR and *(b)* symptomatic hypermobility for the children, young adults (mean age 21.9 y), and adults (mean age 43.5 y).

treatment, overbite, protrusion, maximal mouth opening, and deviation in dental development could be associated with the presence of an ADDR. These variables were entered into the logistic multivariate regression model. Based upon the results shown in Fig 1, the factor "gender" and its interaction term with age were also included in the model. The logistic multivariate regression analysis (Table 3) showed that age, history of orthodontic treatment, overbite, and protrusion were significantly associated with the presence of an ADDR. The interaction term of gender with age was also significant (P = 0.00), and a gender-stratified analysis for age was chosen. No difference was found in ADDR prevalence rate between the 18-year-old teenagers within the children group and the young adults and adults (χ^2; $P > .05$). This indicates that the ADDR prevalence rate stabilized into adulthood at a rate of about 26.6%. The calculated explained variance of the logistic multivariate regression model for ADDR was 12.2%.

For children, the logistic univariate regression analyses (Table 4) showed that age, gender, race, pain in the masticatory muscles, protrusion, and maximal mouth opening may be significantly associated with the presence of symptomatic hypermobility in at least 1 of 2 joints. The logistic multivariate regression analysis (Table 5) showed that symptomatic hypermobility was generally more common in girls (prevalence rate of 13.8%) than in boys (prevalence rate of 8.2%) but did not increase with age either within the children group or into adulthood (χ^2; $P > .05$). Besides gender, other risk factors for symptomatic hypermobility were non-Caucasian race, pain in the masticatory muscles, and a greater maximal mouth opening. The calculated explained variance of the logistic multivariate regression model for symptomatic hypermobility was 9.6%.

Table 3 Logistic Multivariate Regression Analysis for ADDR (Children Group)

Variable	Value	Odds ratio	95% CI	*P*
Age (continuous)	Boys*	1.06	1.00 – 1.13	.06
	Girls*	1.23	1.15 – 1.32	.00
History of orthodontic treatment	No	Reference		
	Yes	1.57	1.13 – 2.17	.01
Overbite (continuous)	mm	1.15	1.05 – 1.27	.00
Protrusion (continuous)	mm	1.12	1.04 – 1.20	.00

*Significant interaction effect between gender and age (*P* = .00), stratified analysis for variable gender (ie, boys, girls).
Odds ratios were calculated relative to the reference value of the variable.

Table 4 Logistic Univariate Regression Analysis for Symptomatic Hypermobility (Children Group)

Variable	Value	Count (%)	Odds ratio	95% CI	*P*
Age (continuous)	Years		1.05	1.01 – 1.10	.01
Gender	Boys	49.5	Reference		
	Girls	50.5	1.95	1.42 – 2.68	.00
Race	Caucasian	92.2	Reference		
	Non-Caucasian	7.8	2.61	1.69 – 4.0	.00
Clenching	No	75.8	Reference		
	Yes	24.2	1.33	0.95 – 1.88	.10
Tiredness (masticatory muscles)	No	73.8	Reference		
	Yes	26.2	1.33	0.95 – 1.87	.09
Pain (masticatory muscles)	No	89.1	Reference		
	Yes	10.9	1.94	1.28 – 2.95	.00
Pain during function	No	94.5	Reference		
	Yes	5.5	1.30	0.69 – 2.43	.42
Use of chewing gum	No	20.4	Reference		
	Yes	79.6	1.43	0.94 – 2.18	.10
Smoking	No	93.7	Reference		
	Yes	6.3	1.29	0.72 – 2.32	.39
Sleeping position (categorical)	4 categories				.39*
History of orthodontic treatment	No	70.8	Reference		
	Yes	29.2	1.09	0.78 – 1.51	.62
Overbite (continuous)	mm		1.02	0.93 – 1.10	.74
Overjet (continuous)	mm		0.94	0.86 – 1.03	.17
Protrusion (continuous)	mm		1.12	1.05 – 1.21	.00
Maximal mouth opening (continuous)	mm		1.07	1.05 – 1.10	.00
Molar relation (categorical)	6 categories				.86*
Deviation in growth (categorical)	3 categories				.24*
Deviation in dental development (categorical)	3 categories				.64*

*Overall Wald statistic.
Odds ratios were calculated relative to the reference value of the variable.

Table 5 Logistic Multivariate Regression Analysis for Symptomatic Hypermobility (Children Group)

Variable	Value	Odds ratio	95% CI	*P*
Gender	Boys	Reference		
	Girls	2.07	1.48 – 2.88	.00
Race	Caucasian	Reference		
	Non-Caucasian	2.61	1.65 – 4.14	.00
Pain (masticatory muscles)	No pain	Reference		
	Pain	1.95	1.27 – 3.00	.00
Maximal mouth opening (continuous)	mm	1.08	1.06 – 1.11	.00

Odds ratios were calculated relative to the reference value of the variable.

Discussion

In the present study, assessments were made of prevalence rates and risk factors for ADDR and symptomatic hypermobility in a large sample of children. Moreover, prevalence rates were compared with those in young adults and adults.

For practical and financial reasons, in studies of prevalence rates and risk factors of ADDR and symptomatic hypermobility in large population samples, study methods are restricted to clinical examination techniques and oral history taking. In this study, sets of clinical criteria were used which have recently been described and tested for their reliability.[3] Also, their concurrent validity has been assessed in comparison with opto-electronic movement recordings and magnetic resonance imaging (MRI).[8] Based on the outcome of these studies, it was concluded that these clinical criteria enable the clinician to recognize different types of IDs and that these criteria can reliably be used in large-scale clinical studies.

In a small percentage of clicking TMJs, the characteristics of the ID did not meet the clinical criteria for either ADDR or symptomatic hypermobility (see "other," Table 1). Although an ADDR was diagnosed as the underlying cause of the joint sound in a majority of cases, symptomatic hypermobility was also diagnosed relatively often. This demonstrates that not every click on TMJ movement should be regarded indicative of an anteriorly displaced disc, and it stresses the need for a proper diagnosis in studies evaluating the long-term clinical implications of IDs.

Among other theories,[4,14] it has been suggested that gradual degeneration of the TMJ (ie, an increasing failure of its adaptive capacity) is a risk factor for the development of an ADDR.[15] If this is true, it may be expected that ADDRs will develop as patients age, causing the prevalence rate to rise with increasing age. However, the results of this study show that its prevalence rate increases specifically during childhood and adolescence, a stage of life during which degeneration of the TMJ is unlikely to play a significant role. This study also shows that its prevalence rate has a tendency to stabilize into adulthood, which also is not in line with the role of an increasing failure of the adaptive capacity of the TMJ. The results of this study suggest that growth and development of the TMJ are factors associated with the development of an ADDR rather than TMJ degeneration.

Pullinger et al[14] suggested that the development of an ADDR probably has to do with the form and position of the various articular tissues within the TMJ. This, in combination with the observation that the closing click usually occurs just before the condyle re-enters the fossa,[2,10] has led to the suggestion that the development of an ADDR may be related to a space insufficiency within the joint that prevents the condyle and disc from being jointly accommodated in the fossa upon reentrance.[10] As a compromise, the disc then gets anteriorly displaced with respect to the condyle at the end of mouth closing. That the development of an ADDR especially occurs during childhood and adolescence corroborates this suggestion, since it is during that period that the articular eminence gets its more pronounced anatomical shape.[16,17] The finding that girls develop ADDR at a somewhat earlier age than boys also supports this suggestion, since girls mature earlier than boys.

The 2 odds ratios for the continuous variable age, given in Table 3, are for an increase of 1 unit of the variable, in this case for an increase of 1 year in age. Thus, within the children group, the odds ratio for an 18-year-old girl for getting an ADDR in reference to a 4-year-girl is $1.23^{(18-4)} = 18.1$. The odds ratio of an 18-year-old boy in reference to a 4-year-old boy is $1.06^{(18-4)} = 2.26$. This would make age, in comparison to the other variables listed in Table 3, the most important explanatory variable for getting an ADDR. How the observed associations with the other variables (a history of orthodontic treatment and the amount of overbite and protrusion) fit within the theory of "space insufficiency" for the development of an ADDR is, at this stage, difficult to say and needs further investigation.

Maximal mouth opening was not part of the set of clinical criteria used to diagnose symptomatic hypermobility. Therefore, the observed association between symptomatic hypermobility and maximal mouth opening can be regarded as an illustration that flexibility of the TMJ plays a role in this ID. The finding that the prevalence rate of symptomatic hypermobility was higher for female participants also supports this suggestion, since women are generally more flexible in their joints than men. The observed race effect may be due to the observation that non-Caucasians have a less pronounced articular eminence,[18] which may render these TMJs less stable. Lastly, the relation of muscle pain to symptomatic hypermobility may be the result of a muscular reaction to this joint condition.

This study has identified risk factors which are statistically related to ADDR or symptomatic hypermobility. However, the comparatively low explained variances of the logistic multivariate regression models underscore the fact that the explanatory power of these risk factors is low. Other as yet unknown factors are also involved in the development of these IDs. Further research is needed to unravel these unknown factors and to get a better understanding of the circumstances under which these IDs develop into a more serious closed-lock or open-lock condition.

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