Predictors of signs and symptoms of temporomandibular disorders: a 20-year follow-up study from childhood to adulthood

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The aim of this study was to find possible predictors of signs and symptoms of temporomandibular disorders (TMD) in a long-term perspective. Baseline questionnaire and clinical examinations focusing on function and dysfunction of the masticatory system were performed in a sample of 402 subjects 7, 11, and 15 years old. After 20 years, 320 subjects (80% of the original sample) completed a similar questionnaire as at baseline. From the oldest age group, now aged 35 years, 100 subjects (74% of the original sample) also attended a clinical examination. Three variables from the 20-year follow-up were chosen as dependent variables in logistic regression analyses, with independent variables selected from the baseline examinations. Three variables at baseline were significant predictors for reported TMJ clicking at the 20-year follow-up, tooth wear index being the strongest (odds ratio = 4.3). Reported TMJ clicking at the start was the only significant predictor for TMD symptoms without clicking 20 years later (odds ratio = 2.3). The third logistic regression model, using the Helkimo Clinical Dysfunction Score as dependent variable, resulted in four significant predictors from the baseline examinations (bruxism, oral parafunctions, TMJ clicking, and deep bite). The results indicated that some signs and symptoms might predict TMD signs and symptoms in a long-term perspective. However, it cannot be concluded from this study whether these symptoms recorded in childhood—oral parafunction, tooth wear, TMJ clicking, and deep bite—can be used for predicting *manifest TMD* in adult age. □ *Bruxism; epidemiology; orofacial pain; temporomandibular joint clicking; tooth wear*

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The prevalence of signs and symptoms of temporomandibular disorders (TMD) has been the focus of interest of many epidemiological surveys. The results of such studies have varied considerably, but it has been concluded that signs and symptoms of TMD are common in the population, with a higher prevalence in women than in men. However, the prevalence of manifest TM disorders is seldom investigated (1). Longitudinal studies often report a great fluctuation of TMD signs and symptoms over time (2–7), but little is known about the risk factors for development of TMD (8). The etiology of TMD has for long been a controversial issue and there are great divergences in treatment concepts (9–11).

When acknowledging the existing variation in opinion about TMD, it has been suggested that TMDs comprise a substantial health problem and represent a major cause of non-dental pain in the orofacial region (11–13). We have recently presented results of the development of TMD signs and symptoms over a 20-year period from childhood to adulthood, emphasizing the longitudinal fluctuation, but we have failed to find conclusive results regarding the etiology (5, 7). More studies regarding development and etiology of TMD are warranted. To be able to predict future development and demand for treatment of TMD would lead to improved diagnostic and treatment approaches.

Considering the inconclusive information about long-term development of TMD, it was the aim of the present study to analyze possible predictors of TMD signs and symptoms reported at the last examination in a series of longitudinal studies by using data recorded at the first examination 20 years earlier. We hypothesized that the presence of TMD signs and symptoms in childhood would lead to increased levels of TMD signs and symptoms in a long-term perspective.

Materials and methods

A detailed description of the subjects examined and the examination methods used has been presented recently (5, 7). A short summary is given here.

Subjects

Originally, 402 randomly selected 7-, 11- and 15-year-old subjects were examined by means of a questionnaire on TMD symptoms, headaches and oral parafunctions, and clinically regarding signs of TMD and occlusal factors. Twenty years after the first examination, an attempt was made to find the addresses of the original participants, who by that time had reached the age of 27, 31, and 35 years,

respectively. The 378 individuals (94%) of the original group who could be traced were all sent a questionnaire. The response rate was high; 320 (80% of the original sample, 85% of the traced subjects) (167 F and 153 M) completed and returned the questionnaire. The response rate varied between the three age groups: 74%, 80%, and 84% for the 27-, 31-, and 35-year-old subjects, respectively, calculated for the original samples.

The oldest group also received an invitation to participate in a clinical examination. Of the original 135 subjects of 15 years of age, 124 could be traced after 20 years; 114 completed and returned the questionnaire and 100 (81% of the traced subjects) were also examined clinically, with a focus on function and dysfunction of the masticatory system.

Methods

The questionnaire included questions about the presence of symptoms from the masticatory system, including headaches, whether the subject often felt stress or was worried or depressed, and about oral parafunctions, previous trauma to the face, experience of TMD treatment during the observation period, and current demand for TMD treatment.

The standardized clinical examination (11, 14) comprised measurements of range of movement of the mandible, presence of deflection during mouth opening, registration of TMJ sounds, locking or luxation, pain on movement of the mandible, TMJ or muscle pain on palpation, number of teeth and number of occluding tooth pairs, occlusal interferences, and, finally, the degree of occlusal wear. All three authors took part in the clinical examination after calibration as described previously (15). The calibration was repeated at each follow-up.

TMJ sounds were recorded as grade 1 (palpable clicking when the TMJs were palpated laterally) and grade 2 (audible clicking). The muscles palpated were the origin and the insertion of the temporal muscle, the lateral pterygoid muscle, the superficial portion of the masseter muscle and the posterior belly of the digastric muscle. All muscles were palpated bilaterally.

Tooth wear was classified in accordance with a 5-point scale: 1 = no or slight wear, 2 = wear of enamel only, 3 = wear into the dentin in single spots, 4 = exposure of dentin in an area of more than 2 mm^2, 5 = wear of more than one-third of the clinical crown. The following findings were registered as occlusal interferences: lateral deflection ($\geq$0.5 mm) between RCP and intercuspal position (ICP), great sagittal or vertical distance ($\geq$1.5 mm) between RCP and ICP, unilateral contact on the non-working side preventing contact on the working side in lateral excursions. An interference score was calculated by adding the number of interferences registered. Orthodontic variables such as post- and pre-normal occlusion, inverted incisors, cross and scissors bite, deep bite (>5 mm), anterior or lateral open bite were also recorded.

The Clinical Dysfunction Score according to Helkimo (16) was calculated from the five clinical parameters—mandibular mobility, TMJ function, pain on movement of the mandible, TMJ pain on palpation and muscle pain on palpation.

Statistical methods

Descriptive statistics used to characterize the results of the questionnaire and clinical examinations are presented elsewhere (5, 7). Logistic regression was used for analyses of predictors of TMD signs and symptoms recorded at the last examination. As these variables were categorical, dichotomies were constructed for use as dependent variables.

The following variables from the 20-year follow-up examination were selected as dependent variables: 1) reported clicking of the TMJ; 2) reported TMD symptoms excluding TMJ clicking; 3) Clinical Dysfunction Score according to Helkimo (16). The first two variables were calculated for all participants (n = 320) who had answered the questionnaire at the 20-year follow-up, whereas variable 3 was based on the clinical examination performed only in the oldest group (n = 100; 35 years of age at the last follow-up). Because of missing data for some of the variables, the numbers of subjects in the various analyses were lower than the total number of participants.

The bivariate analyses between the three dependent dichotomous variables at the 20-year follow-up and a selection of variables from the first investigation were performed by Fisher's non-parametric permutation test for ordered variables (17) and by Fisher's exact test for dichotomous variables. All significant variables from these bivariate analyses, and some other variables considered to be of special interest, were entered as independent variables into three multivariate stepwise logistic regression models. The results from these analyses were given as β (beta)-coefficients with standard errors (SE), odds ratios with 95% confidence intervals (CI) and adjusted P values. All significance tests were two-tailed and conducted at the 5% significance level.

Results

Based on the bivariate analyses of association between the first dependent variable, reported TMJ clicking at the final examination, and recorded variables 20 years earlier, 7 variables were statistically significant and selected as independent variables for a stepwise logistic regression analysis (Table 1). Three variables were from the questionnaire part of the first examination (reported TMJ clicking, TMD symptoms, tooth grinding at night), whereas four were recorded at the clinical examination (TMJ clicking, tooth wear index, Clinical Dysfunction Score and TMJ dysfunction from the Helkimo Index (16). Two further occlusal variables that did not reach significance level (P > 0.05) were also included in the

Table 1. Bivariate analyses of predictors from the first examination of the dependent variable reported temporomandibular joint clicking at the 20-year follow-up

Predictors at start	Grade	Reported TMJ clicking at 20-year follow-up		
		Code	*n* (%)	*P* value
Clinical TMJ clicking	No	1	56 (26)	
	Grade 1	2	19 (49)	
	Grade 2	3	11 (79)	<0.0001
Tooth wear index	1–2	1	73 (30)	
	3–5	2	13 (57)	0.0092
Reported ooth grinding at night	Frequent	1	3 (60)	
	Occasional	2	13 (46)	
	No	3	53 (29)	0.021
Reported TMJ clicking	Frequent	1	2 (100)	
	Occasional	2	22 (56)	
	No	3	61 (28)	<0.0001
TMJ dysfunction	No	0	53 (26)	
	Mild	1	32 (51)	
	Severe	5	2 (100)	<0.0001
Reported TMD symptoms	No	0	57 (29)	
	Yes	1	26 (46)	0.022
Dysfunction score	0	0	62 (29)	
	≥1	1	25 (45)	0.031

model (anterior forced bite, $P = 0.051$, and occlusal interference score, $P = 0.303$). The logistic regression procedure showed that 3 independent variables recorded at the start were significant predictors for reported TMJ clicking 20 years later (Table 2A). The strongest predictor was the tooth wear index with an adjusted OR of 4.3. The associations between these predictors from the first examination and reported TMJ clicking 20 years later are given in Table 1.

In the second logistic regression model, reported TMD symptoms excluding TMJ clicking (one or more of jaw fatigue, difficulties in mouth opening, pain or fatigue in the jaws or face during chewing, e.g. chewing gum) at the 20-year follow-up was the dependent variable. Six variables at the start were significantly correlated with the dependent variable (Table 3). These variables and one variable that did not reach a significant level (pain or fatigue during chewing, $P = 0.056$) were included as independent variables in the logistic procedure. Reported TMJ clicking at the start was the only significant predictor for TMD symptoms without clicking 20 years later, with an adjusted OR of 2.3 (Table 2B).

Table 2. Logistic regression models with (A) reported TMJ clicking (sometimes/often), and (B) reported TMD symptoms (excluding TMJ clicking) at 20-year follow-up as dependent variables, and variables from the first examination as independent variables. Odds ratios (OR) are presented together with 95% confidence intervals (CI) and adjusted significant level

Independent variables (at start)	OR	95% CI	Adjusted *P*
A. Tooth wear index	4.3	1.17–16.00	0.014
Clinical TMJ clicking	3.3	1.81–6.07	<0.0001
Reported tooth grinding at night	2.2	1.01–4.26	0.023
B. Reported TMJ clicking	2.3	1.19–4.41	0.011

The third logistic regression model using the Clinical Dysfunction Score (16) as dependent variable included 9 independent variables, 6 of which were significantly ($P < 0.05$) associated with the dependent variable (Table 4). Three further variables, which were close to but did not reach that significant level, were also included in the model (reported TMD symptoms, $P = 0.060$, unilateral contact in RCP, $P = 0.080$, deep bite, $P = 0.085$). The analysis resulted in four significant predictors, two from the questionnaire, two from the clinical examination (Table 5). The strongest predictor was deep bite with an adjusted OR of 12.5.

Discussion

In this long-term study, the purpose was to detect possible predictors of some signs and symptoms of TMD recorded at a 20-year follow-up of a non-patient sample of subjects aged 27 to 35 years. They were originally examined when they were 7–15 years old (14). In the bivariate analyses, to select independent predictors to the dependent variables at the 20-year follow-up, relatively few statistically significant ($P < 0.05$) variables were found, and among them was tooth wear the only occlusal factor (Tables 1, 3, 4). Logistic regression was used in an attempt to find predictors for the long-term development of TMD and possibly further elucidate the complex of TMD development.

The etiology of TMD is controversial, especially regarding the role of occlusion. Several recent literature reviews emphasize that occlusal factors play only a minor etiological role in TMD and that the etiology is in fact still unknown (8–10, 18, 19). However, other authors maintain that the question is not adequately answered, scientific evidence is still lacking, and associations between occlusal

Table 3. Bivariate analyses of predictors from the first examination of the dependent variable reported TMD symptoms (excluding TMJ clicking) at the 20-year follow-up

		Reported TMD symptoms at 20-yr follow-up		
Predictors at start	Grade	Code	*n* (%)	*P* value
Clinical TMJ clicking	No	1	61 (28)	
	Grade 1	2	12 (31)	
	Grade 2	3	9 (64)	0.015
TMJ dysfunction	No	0	58 (27)	
	Mild	1	22 (35)	
	Severe	2	2 (100)	0.020
Reported TMJ clicking	Frequent	1	1 (50)	
	Occasional	2	19 (49)	
	No	3	59 (26)	0.0045
Dysfunction Index	0	0	33 (24)	
	I	1	37 (33)	
	II	2	11 (46)	
	III	3	1 (25)	0.042
Headache	Never	1	14 (22)	
	Occasional	2	39 (28)	
	1–2 times/mo	3	17 (39)	
	1–2 times/we	4	9 (36)	
	Daily	5	3 (60)	0.017
Reported TMD symptoms including pain during chewing	No	0	26 (24)	
	Occasional	1	46 (32)	
	Frequent	2	10 (48)	0.031

factors and TMD signs and symptoms continue to be reported (20, 21). Occlusion changes dramatically from childhood to adulthood in most subjects, and a long-term association between the original occlusion and TMD symptoms 20 years later was not expected. It was therefore a somewhat surprising finding in this study that besides tooth wear one more occlusal factor, deep bite recorded in childhood, turned out to be a significant predictor of increased clinical dysfunction score 20 years later according to the logistic regression analysis (Table 5). It was included in the model although it was not significant in the bivariate analysis (Table 4, $P = 0.085$). This finding

Table 4. Bivariate analyses of predictors from the first examination of the dependent variable (Clinical Dysfunction Score (0-1/ $\geq$2) at the 20-year follow-up)

		Reported TMD symptoms at 20-yr follow-up		
Predictors at start	Grade	Code	*n* (%)	*P* value
Clinical TMJ clicking	No	1	7 (10)	
	Grade 1	2	4 (21)	
	Grade 2	3	6 (55)	0.0004
TMJ dysfunction	No	0	7 (11)	
	Mild	1	9 (27)	
	Severe	2	1 (100)	0.0025
Reported TMJ clicking	Frequent	1	2 (100)	
	Occasional	2	8 (35)	
	No	3	7 (10)	<0.0001
Headache	Never	1	1 (6)	
	Occasional	2	5 (11)	
	1–2 times/mo	3	5 (22)	
	1–2 times/we	4	6 (43)	
	Daily	5	0 (0)	0.0076
Bruxism*	No	0	11 (13)	
	Occasional	1	5 (31)	
	Frequent	2	1 (100)	0.011
Bruxism* + other oral	No	0	1 (6)	
Parafunctions	Occasional	1	6 (11)	
	Frequent	2	10 (33)	0.0075
Deep bite	No	0	12(14)	
	Yes	1	5 (38)	0.085

* Reported tooth clenching and/or tooth grinding.

Table 5. A logistic regression model with Clinical Dysfunction Score (0–1/ ≥2) at 20-year follow-up as dependent variable. Odds ratios (OR) are presented together with 95% confidence intervals (CI) and adjusted significant level

Independent variables (at start)	OR	95% CI	Adjusted *P*
Bruxism*	5.3	1.1–25.0	0.016
Bruxism* + other oral parafunctions	7.7	2.1–25.0	0.0031
Clinical TMJ clicking	8.3	2.6–25.0	0.0020
Deep bite	12.5	1.6–100.0	0.025

* Reported tooth clenching and/or tooth grinding.

warrants further investigation, since previous analyses in general have failed to find clinically significant associations between occlusal variables and TMD signs and symptoms.

Besides deep bite, there were three more significant predictors of TMD signs at the follow-up examination of the 100 subjects 35 years of age. Those who exhibited TMJ clicking and reported bruxism and other oral parafunctions as children had an increased risk having two or more TMD signs (a clinically recorded dysfunction score ≥2) 20 years later (Table 5). The relationship between oral parafunctions and TMD has often been found in cross-sectional studies, and it may be important also in a long-term perspective.

TMJ clicking is a frequently reported symptom and clinically recorded sign in epidemiological investigations. In longitudinal studies, a great fluctuation of TMJ clicking and other TMD symptoms has been observed (2–7). Over a 9-year period, only a few subjects (2%) consistently reported and had clicking recorded, and none developed locking (22). Even if most patients with TMD can be successfully treated, TMJ clicking often remains (23, 24). Whether clicking is a serious sign indicating TMJ pathology (disk interference disorder) or a benign symptom is a controversial issue (5, 25). In this study, clinically recorded TMJ clicking at the first examination was a significant predictor of reported clicking 20 years later. It indicates that TMJ clicking may be persistent over long periods in several subjects (Table 1), even if it is also a fluctuating symptom in others and rarely develops to TMJ locking (7, 22).

The tooth wear index recorded at the start was the strongest predictor, and nocturnal tooth grinding was another significant predictor of reported TMJ clicking 20 years later. It is well established that bruxism can lead to increased tooth wear, even if other etiological factors must also be considered (26, 27). The association between oral parafunctions, including bruxism, and TMD is in general accepted, and therefore the established predictors of TMJ clicking may seem logical. It is nevertheless surprising with respect to the long observation period, since it has been reported that bruxism in children is often a temporary or fluctuating phenomenon (28, 29). However, in the last study (29) it was documented that 17 out of 126 juvenile bruxers had retained their bruxing habit after 5 years. In the present investigation, several subjects repeatedly reported oral parafunctions at the follow-up examinations over 20 years (7). This may explain the finding that oral parafunction is a long-term predictor of TMD signs.

TMJ clicking reported at the start was the only significant predictor of TMD symptoms, excluding clicking, 20 years later. These variables recorded at the same examination have been found to be weakly but significantly correlated in many studies (5, 14, 30). The long-term association may be interpreted so that TMJ clicking in many subjects may be a more persistent symptom indicating some disturbance in the masticatory system. This interpretation was further supported by the results of the third logistic regression model (Table 5), discussed above.

The dichotomy chosen for the dependent variable Clinical Dysfunction Score (0–1/≥2) is not a present–absent dichotomy, but differentiates between those with no or one mild sign and those with two or more signs of dysfunction. Subjects with more severe dysfunction were rare in this material (5). The subjects who sought care for manifest TMD problems during the follow-up period were not specifically analyzed in this study but have been presented elsewhere (31). In a 6-year longitudinal study, it has been shown that those with masticatory muscle tenderness and tooth clenching habit at baseline more often requested treatment for TMD during the observation period than those without these symptoms at baseline (19). However, the predictive values of these findings were considered too low to be clinically useful.

The longitudinal course of TMD symptoms has been found to differ between men and women. Over a 10-year period, men seemed to recover from TMD symptoms to a greater extent than women (6). In the present analyses, possible gender differences have not been investigated, but as already presented from this investigation, women reported more TMD symptoms (7) and had more often TMD signs (5) than men.

Based on previous longitudinal studies, it has repeatedly been emphasized that there is a substantial fluctuation of TMD signs and symptoms over time and that progression to severe pain and dysfunction is rare (2–5, 7). The findings in the present study indicated, in accordance with our hypothesis, that some signs and symptoms may be risk factors and predict TMD signs and symptoms in a long-term perspective. However, it cannot be concluded from this study whether these symptoms—oral parafunction, tooth wear, TMJ clicking, and deep bite in childhood—can be used for predicting *manifest TMD* in adult age, i.e. subjects becoming TMD patients.

In the orthopedic literature, it has recently been demonstrated that early back pain in 18-year-old men was a significant predictor of back pain and other pain problems 20 years later (32). It is well established that there are multiple risk factors for musculoskeletal pain, which is relevant not only for back pain (33, 34) but also for orofacial pain (8, 10, 11, 35). The picture is complicated and physiological, physical and psychosocial risk factors are probably involved. The present study has indicated some possible predictive factors that may be identified at

anamnestic and clinical examination, but further studies are needed to establish their predictive value for long-term development of signs and symptoms of TMD, and especially for a possible transition of such signs and symptoms to manifest TMD.

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