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Longitudinal trends in temporomandibular joint disorder symptoms, the impact of malocclusion and orthodontic treatment: A 20-year prospective study

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Abstract

Background: Studies on **the** association between malocclusion and temporomandibular joint disorder (TMD) have reported conflicting results.

Objectives: To determine the impact of malocclusion and orthodontic treatment on symptoms of TMD.

Methods: At 12 years, 195 subjects fulfilled a questionnaire regarding TMD symptoms and participated in an oral examination including preparation of dental casts. The study was repeated at ages 15 and 32. The occlusions were assessed by applying the Peer Assessment Rating (PAR) Index. Associations between the changes in PAR scores and TMD symptoms were analysed with the chi-square test. A multivariable logistic regression was used to calculate the odds ratios (OR) and 95% confidence intervals (CI) of TMD symptoms at 32 years predicted by sex, occlusal traits and orthodontic treatment history.

Results: One in three subjects (29%) was orthodontically treated. Sex was associated with more self-reported headaches by females at 32 years (OR 2.4, 95% CI 1.05–5.4; $p = .038$). At all time points, any crossbite was significantly associated with greater odds for self-reported temporomandibular joint (TMJ) sounds at 32 years (OR 3.5, 95% CI 1.1–11.6; $p = .037$). More specifically, association occurred with posterior crossbite (OR 3.3, 95% CI 1.1–9.9; $p = .030$). At 12 and 15 years, boys whose PAR score increased were more likely to develop TMD symptoms ($p = .039$). Orthodontic treatment had no impact on the number of symptoms.

Conclusions: Presence of crossbite may increase the risk of self-reported TMJ sounds. Also, longitudinal changes in occlusion may have an association with TMD symptoms while orthodontic treatment is not associated with the number of symptoms.

KEYWORDS
cohort study, malocclusion, orthodontics, Peer Assessment Rating Index, questionnaire, temporomandibular joint disorders

1 | INTRODUCTION

Temporomandibular disorders (TMDs) form a heterogeneous group of disorders involving masticatory muscles, temporomandibular joints (TMJs) and their associated structures.[1,2] The most common signs and symptoms include TMJ sounds, pain in the area of TMJ and in muscles of mastication, and limited or asymmetric mandibular movements.[1,2] Temporomandibular disorders are common in the adult population and most symptoms improve without treatment. Therefore, only 5% to 10% of those with symptoms require treatment.[1,3,4] The female-to-male ratio of patients has been reported to range between 3:1 and 9:1.[1] The aetiology of TMD is reportedly multifactorial involving behavioural, environmental, biological, social and emotional factors, genetic domains, parafunctional habits and malocclusion, however, the cause-and-effect relationship remains unclear.[1,3,5–9]

The overall prevalence of TMD varies between 10%–31% for adults and 4%–11% for adolescents.[10–12] TMD remains the most common source of non-dental orofacial pain[2,13] and is characterised by fluctuations in symptoms over time.[3,9] The symptoms are usually worse in the morning, especially in patients who clench or grind their teeth at sleep.[1] The pain usually affects temporal and peri-auricular areas as well as cheek and is provoked by chewing, yawning or talking.[10] Treatment modalities for TMD include combinations of home self-care, counselling, physiotherapy, pharmacotherapy, occlusal splint, physical medicine, behavioural medicine and surgery.[1]

The evidence supporting an association between malocclusions and TMD is controversial.[14–17] It has been hypothesized that unilateral posterior crossbite increases the risk for myofascial pain, arthralgia and TMJ clicking.[6,13,18–21] This link is based on the hypothesis that the abnormal occlusal contacts may affect the relationship between the mandibular condyle and fossa and thus create an asymmetric activation of the masticatory muscles.[13] In contrast, TMJ symptoms can persist after the correction of crossbite.[22] Besides posterior crossbite, mediotrusive interferences have been suggested to predispose to TMD.[18,23–25] Orthodontic treatment is not indicated for TMD management.[10,13] In summary, some connection between occlusal traits and TMD has been described; however, results remain inconsistent across studies.[18] Moreover, orthodontic treatment, regardless of the type of intervention, has neither been reported to prevent nor to predispose to TMD.[13,26,27]

Since the introduction of the Primary Health Care Act 1972,[28] free, population-based dental visits have been provided to all children and adolescents in Finland. These enable occlusal screening and monitoring of dental development in municipal health care. Orthodontic treatment need is assessed using a 10-grade assessment method by Heikinheimo[29] and its updates.[30] Orthodontic treatment is provided to the children and adolescents in health centres according to the severity of malocclusion. This context provides the opportunity to evaluate in population-based longitudinal material, whether malocclusions or orthodontic treatment are associated with TMD symptoms. We hypothesized that neither orthodontic treatment, nor malocclusion, nor longitudinal changes in occlusion are associated with the number of experienced TMD symptoms.

2 | MATERIALS AND METHODS

2.1 | Subjects

The study sample comprised a previously described[31,32] prospective cohort with longitudinal follow-up of occlusal traits and temporomandibular disorders. The original cohort consisted of 200 Finnish children (100 girls and 100 boys) born in 1967 in the city of Jyväskylä, Finland (Figure S1). The children were chosen from classes of seven different elementary schools situated in different parts of the city. In an attempt to minimise possible selection bias and maintain sample size, in the two schools with poor attendance at the examination, additional children from parallel classes were included in the series. These children were chosen in alphabetical order until 100 girls and 100 boys were collected. Ethical approval was given by the Ethical Board of Central Finland Hospital Region, Dnro 33/2000. One parent or guardian signed an informed consent allowing their child to participate.

2.2 | Clinical examinations

Clinical examinations were carried out at ages 7, 12, 15 and 32 years and were complemented with registration of occlusion and intra- and extraoral inspection of soft tissues. Assessed occlusal traits are presented in Table 1. In addition, supernumerary or congenitally missing or extracted teeth were registered. Occlusal relationships were registered on both sides in molars and canines according to Angle's classification. Functional examination included assessments of maximal opening capacity, laterotrusion, mediotrusion and protrusion contacts and joint sounds. Two experienced orthodontists performed all clinical examinations at the same time. Alginate impressions for study models were taken at every time point and orthopantomograms were taken when needed.

2.3 | Questionnaire

During all appointments, subjects filled in a questionnaire on symptoms of TMD. The questionnaire was formulated for this study using commonly accepted and slightly modified questions included in the Helkimo index,[33] which is a validated tool for TMD assessment. The questionnaire and the response alternatives are listed in Table 2.

2.4 | Occlusal indices

Occlusal characteristics were analysed by applying the Peer Assessment Rating (PAR) Index.[34,35] It consists of five components (upper and lower anterior segments, left and right buccal occlusions, overjet, overbite and centre line) assessed from study models. The scores for each component are multiplied by respective weightings

TABLE 1 Occlusal features assessed at ages 12, 15 and 32.

	Age at follow-up visit		
	12 years ($n=189$)	15 years ($n=182$)	32 years ($n=133$)
	Mean (range)	Mean (range)	Mean (range)
Occlusal trait			
Overjet (mm)	4.4 (1.0–11.0)	3.8 (−1.0–10.0)	3.2 (−2.0–12.0)
Overbite (mm)	3.5 (−2.0–7.0)	3.3 (−2.0–8.0)	3.1 (0.0–11.0)
Maximal opening (mm)	51 (40–65)	55 (43–68)	52 (37–66)
PAR score	11.8 (1.0–32.0)	10.1 (0.0–44.0)	11.0 (1.0–42.0)
	n (%)	*n* (%)	*n* (%)
Overjet			
≤1 mm	1 (0.5)	4 (2.2)	11 (8.3)
2–4 mm	104 (55.0)	124 (68.1)	97 (72.9)
≥5 mm	84 (44.4)	53 (29.1)	25 (18.7)
Missing	0	1 (0.5)	0
Overbite			
≤1 mm	11 (5.8)	15 (8.2)	20 (15.0)
2–4 mm	125 (66.1)	130 (71.4)	91 (68.4)
≥5 mm	50 (26.4)	37 (20.3)	22 (16.5)
Missing	3 (1.6)	0	0
Crossbite			
No	164 (86.8)	155 (85.2)	115 (86.5)
Anterior[a]	3 (1.6)	5 (2.7)	3 (2.3)
Posterior	22 (11.6)	22 (12.1)	10 (7.5)
Unilateral with displacement	4	5	2
Unilateral without displacement	7	3	5
Bilateral with displacement	1	3	0
Bilateral without displacement	3	0	3
Missing	0	0	5 (3.8)

[a]Including 1 subject with anterior and unilateral posterior and 1 with anterior and bilateral posterior crossbite at 12 years and 1 subject with anterior and bilateral posterior crossbite at ages 15 and 32. In all age groups, 1 subject with anterior crossbite only was registered with displacement.

(1–6, depicting the degree of severity) and summed. Sum score zero refers to an ideal occlusion, whereas higher scores indicate larger deviations from normal. The difference between the pre- and post-treatment PAR scores reflects the degree of improvement.

All assessments were performed by one experienced orthodontist who was calibrated with the use of occlusal indices. A total of 21%–31% of all assessments were repeated after an interval of 4–5 weeks. The reliability for PAR scores was good to excellent, with Chronbach's α .932 (12 years), .968 (15 years) and 0.894 (32 years) and Spearman correlations .820, .913 and .898, respectively. All p values were <.001.

For each subject, longitudinal changes in PAR scores were analysed between ages 12–15, 15–32 and 12–32 years. Based on the PAR score changes, patients were categorised into three groups: worse occlusion, no difference and improved occlusion. The PAR scores (mean values and range) are presented in Table 1, Figure S2.

2.5 | Outcome

A categorical variable (TMD dysfunction score) was created merging the seven TMD symptoms: locking of the jaw, experienced pain in the area of TMJ, pain during mouth opening and/or chewing, headache, TMJ clicking and/or crepitation. Each of these variables was first dichotomized into non-symptomatic (score 0—including response alternatives 'no', 'do not know', 'never', 'rarely') and symptomatic categories (score 1—including response alternatives 'yes', 'sometimes', 'almost daily', 'once a week', 'two or three times per month') after which the final scores were summed.

2.6 | Statistical methods

Comparisons between the longitudinal changes in groups were made according to the patients' sex, TMD dysfunction score, PAR

TABLE 2 List of TMD symptoms included in the questionnaire and their prevalence at 12, 15 and 32 years as a percentage of the age cohort ($n = 195$, $n = 190$ and $n = 135$, respectively).

	12 years			15 years			32 years		
	Sample	Treated[a]	Untreated	Sample	Treated[a]	Untreated	Sample	Treated[a]	Untreated
Headache									
Almost daily	2.3	5.3	1.1	0.8	0	1.1	1.5	0	2.0
Once a week	4.6	2.6	5.4	5.4	2.6	6.7	10.4	11.8	10.1
Two or three times per month	19.2	15.8	20.7	17.1	23.1	14.4	22.4	14.7	24.2
Rarely	60.8	71.1	56.5	62.8	64.1	62.2	55.2	70.6	50.5
Never	13.1	5.3	16.3	14.0	10.3	15.6	10.4	2.9	13.1
Pain during mouth opening	3.1	5.3	2.2	3.9	7.7	2.2	5.2	8.8	4.0
Pain during chewing	8.8	8.3	9.0	5.6	2.7	6.7	12.8	15.2	12.1
Pain in the area of TMJ	18.9	20.6	18.2	13.4	10.5	14.6	23.9	26.5	23.2
Locking of the jaw	3.2	0	4.4	8.7	5.2	10.1	15.8	12.1	16.2
TMJ clicking or crepitation	22.0	25.7	20.5	30.5	37.8	27.2	43.4	42.4	43.2
Tiredness or stiffness of the jaws	15.5	17.1	14.8	20.3	15.8	22.4	36.8	35.3	36.7

Note: The response alternatives were 'yes', 'sometimes', 'no' and 'do not know' excluding the question about headache (how often the symptom appeared). For this table, the subjects were divided into non-symptomatic (response alternatives 'no' and 'do not know') and symptomatic groups (response alternatives 'yes' and 'sometimes'). Regarding headache, the respondent was asked how often it appears.

[a]Subjects with a history of orthodontic treatment.

score category and orthodontic treatment history. Differences between the groups were analysed using cross-tabulation and the chi-square test. A multivariable logistic regression model was applied with subjective TMD symptoms (headache, pain symptoms and TMJ sound—all dichotomous variables) at 32 years as dependent variables, and sex, occlusal traits and orthodontic treatment as independent variables. Separately for 12, 15 and 32 years old, a univariable logistic regression model was applied with the crossbite (including all types of crossbites) at 12, 15 or 32 years old as independent variable and subjective TMD symptoms (headache, pain symptoms and TMJ sound) as dependent variables. For statistically significant associations, the logistic regression was repeated with dichotomized crossbite (A) anterior crossbite only or anterior and posterior crossbite (including all anterior crossbites); (B) posterior crossbite only or anterior and posterior crossbite (including all posterior crossbites) versus no crossbite. Results of the logistic regression model were reported as odds ratios (OR) and 95% confidence intervals (CI). The association of categorised longitudinal changes in PAR scores and the crossbite were examined with the chi-square test. *p* value .05 was used as a cut-off point for statistical significance. Data were analysed with IBM SPSS Statistics 27.

3 | RESULTS

A total of 97.5%, 95% and 67.5% of subjects were evaluated at 12, 15 and 32 years, respectively (Figure S1). At age 32 years, there were 22 subjects who could not be reached; 10 subjects declined to participate at the last follow-up. The most common malocclusions were crowding, Angle Class II division 1 malocclusion and posterior crossbite alone or in combination with other deviations. A total of 57 subjects (29%) had received orthodontic treatment by the end of the follow-up. In addition, there were seven subjects who had had tooth extractions to relieve crowding. At 12 years, 23 orthodontic treatments were completed and 5 were ongoing; at 12–15 years, the numbers were 20 and 9, respectively. Twelve treatments were completed after the age of 15. Two patients discontinued orthodontic treatment during the follow-up. At the last follow-up, three patients were excluded from the study due to a history of jaw surgery (two orthognathic surgery patients and one trauma patient).

In general, subjective symptoms of TMD were common and their prevalence seemed to increase with age (Table 2). Although 26% of 12-year-olds, 23% of 15-year-olds and 34% of 32-year-olds respondents reported headache at least twice a month, headache on a daily basis was reported by 0.8%–2.3% of respondents in these age groups. The mean PAR score in the 12-year-olds was 12, in the 15-year-olds 10 and in the 32-year-olds 11.

Boys whose PAR score increased between 12 and 15 years had a simultaneous increase in the number of TMD symptoms as well. This change was statistically significant ($p = .039$). Among all participants, no other change reached statistical significance. According to the logistic regression model, female sex was significantly associated with more self-reported headache at 32 years of age (OR 2.4, 95% CI 1.05–5.4; $p = .038$, Table 3). Any crossbite at 12, 15 or 32 years of age, whether treated or untreated, was significantly associated with TMJ sounds (clicking or crepitation) at 32 years of age (OR 3.5, 95% CI 1.1–11.6; $p = .037$). The association was not found with anterior crossbite only (OR 0.9, 95% CI 0.1–5.8; $p = .874$), while with posterior crossbite association was found (OR 3.3, 95% CI 1.1–9.9; $p = .030$).

TABLE 3 Adjusted odds ratios (OR) with 95% confidence intervals (CI) in multinomial logistic regression models by symptoms as predicted by sex, occlusal traits and orthodontic treatment history.

	Headache at 32 years	Pain symptoms at 32 years	TMJ sound at 32 years
Characteristic	OR (95% CI)	OR (95% CI)	OR (95% CI)
Female sex	**2.4 (1.05–5.4)**	1.4 (0.6–3.4)	0.9 (0.4–2.1)
Prior orthodontic treatment	0.6 (0.3–1.5)	1.0 (0.4–2.6)	0.8 (0.3–1.9)
Crossbite	1.1 (0.4–3.3)	0.4 (0.1–1.8)	**3.5 (1.1–11.6)**
Anterior			0.9 (0.1–5.8)
Posterior			**3.3 (1.1–9.9)**
Overjet (reference = normal, 2 to 4 mm)			
Low <1 mm	0.8 (0.1–4.6)	1.1 (0.2–6.8)	2.6 (0.4–15.7)
High >5 mm	1.1 (0.5–2.5)	1.5 (0.6–3.6)	0.5 (0.2–1.1)
Overbite (reference = normal, 2 to 4 mm)			
Low <1 mm	1.4 (0.4–4.6)	1.3 (0.4–4.6)	0.4 (0.1–1.3)
High >5 mm	1.0 (0.4–2.4)	1.5 (0.6–3.6)	1.5 (0.6–3.7)

Note: Values with $p < .05$ bolded.

4 | DISCUSSION

Considerable fluctuation of all TMD symptoms could be seen during the long follow-up period. These findings are in line with few previous longitudinal studies on TMD signs and symptoms: Magnusson et al.[36] followed subjects over two decades from childhood to adulthood and Mohlin et al.[37] investigated the development of signs and symptoms of TMD between age 11 and 30 years. Könönen et al.[38] studied TMJ clicking in young adults over 9 years. In these studies, substantial fluctuations in TMD signs and symptoms were observed and some severe TMD symptoms showed reduced severity or even complete recovery over time.[36,39] The current association between female sex and self-reported headache is in agreement with prior epidemiological studies showing female predominance in the life-long prevalence of headache.[40] Migraine is two to three times more common in women than in men possibly because of different sex hormones and genetic factors.[41] The results of this study may be confounded by the inclusion of headache in the TMD dysfunction score. Prior studies have indicated a close relationship between headache and TMD.[42–44] However, besides TMD, headache can be related to other health problems like infections, vascular diseases and traumas.[40]

Certain types of malocclusion, such as unilateral posterior crossbite, have been suggested to predispose to TMD symptoms.[6,13,18–20] We found that crossbite was associated with greater odds for self-reported TMJ sounds at 32 years. This finding is not supported by recently published studies. Manfredini et al.[18] concluded that the evidence supporting associations between malocclusions and TMD is scarce, weak and inconsistent, and Farella et al.[45] found no association between unilateral posterior crossbite and TMJ clicking. Further, based on the results of a 10-year follow-up of unilateral crossbite patients, Michelotti et al.[22] concluded that the prevalence of self-reported TMJ clicking did not differ between subjects who received or did not receive orthodontic treatment during the follow-up. Olliver et al.[46] suggested that high overbite during adolescence is negatively associated with TMJ clicking later in life. Thus, a growing body of evidence suggests no role for occlusion and orthodontic treatment in the aetiology of TMD.

On closer inspection, there was a statistically significant association between the longitudinal changes in PAR score and the TMD symptom score for boys; subjects whose PAR score increased had an increase in the number of TMD symptoms as well. Similar finding was reported by Mohlin et al.,[39] concluding that subjects with the most severe TMJ dysfunction had significantly higher PAR scores compared to subjects without signs and symptoms of TMD.[39] However, there is still no consistent evidence supporting a causal relationship between these two variables.[13,18]

The major strengths of this longitudinal study are the prospective design and the length of follow-up time. The vast majority of previous studies investigating associations between occlusion and TMD have been cross-sectional[19,20,23,24,47] and therefore they have not been able to follow individual changes occurring in occlusion and TMD symptoms over time. The few other longitudinal studies with longer follow-up times[36,39,46,48,49] support our finding that orthodontically treated subjects do not have a higher risk of TMD.

From the current perspective, the lack of a validated TMD assessment protocol can be seen as a methodological limitation. Today, the Diagnostic Criteria for TMD (DC/TMD) and the Helkimo Dysfunction Index (HDI) provide widely used and validated tools for TMD assessment.[8,33] At the inception of the current study, the HDI was published only 3 years earlier and it was not used widely; the DC/TMD was not yet established. Thus, there were no commonly accepted clinical tools to be used in the assessment of children or adolescents. Recently, a panel of experts has developed new instruments for the evaluation of TMD in children and adolescents by modifying the DC/TMD.[50] Moreover, due to the biopsychosocial background of TMD, abundant evidence has shown considerable intraindividual variability in TMD status and magnitude of symptoms over time.[9] This phenomenon behind the course of TMD may have had an impact on the results of the current study and thus, can be regarded as a limitation. Further, some participants may have received treatment for their TMD which may have had an influence on the prevalence of TMD symptoms. Therefore, the lack of data regarding the treatment history of TMD can be seen as a limitation. Thus, the results shall be interpreted with caution.

5 | CONCLUSION

Presence of crossbite may increase the risk of self-reported TMJ sounds. Longitudinal changes in occlusion like age changes or possible relapse may have an association with TMD symptoms. However, further studies are warranted to assess the clinical relevance of these associations. Previously received orthodontic treatment is not associated with the number of TMD symptoms.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflict of interest.

PEER REVIEW

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DATA AVAILABILITY STATEMENT

The data from this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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