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SCIENTIFIC SECTION

Temporomandibular disorders, occlusion and orthodontic treatment

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Abstract

Objectives: To prospectively and longitudinally study symptoms and signs of temporomandibular disorders (TMD) and occlusal changes in girls with Class II malocclusion receiving orthodontic fixed appliance treatment in comparison with untreated Class II malocclusions and with normal occlusion subjects.

Design: Prospective observational cohort.

Subjects: Sixty-five girls with Class II malocclusion who received orthodontic treatment, 58 girls with no treatment, and 60 girls with normal occlusion.

Method: The girls were examined for symptoms and signs of TMD and re-examined 2 years later. Additional records were taken in the orthodontic group during active treatment and 1 year after treatment

Results: All three groups included subjects with more or less pronounced TMD, which showed individual fluctuation during the ongoing study. In the orthodontic group, the prevalence of muscular signs of TMD was significantly less common post-treatment. Temporomandibular joint clicking increased in all three groups over the 2 years, but was less common in the normal group. The normal group also had a lower overall prevalence of TMD than the orthodontic and the Class II group at both registrations. Functional occlusal interferences decreased in the orthodontic group, but remained the same in the other groups over the 2 years.

Conclusions: (i) Orthodontic treatment either with or without extractions did not increase the prevalence or worsen pre-treatment symptoms and signs of TMD. (ii) Individually, TMD fluctuated substantially over time with no predictable pattern. However, on a group basis, the type of occlusion may play a role as a contributing factor for the development of TMD. (iii) The large fluctuation of TMD over time leads us to suggest a conservative treatment approach when stomatognathic treatment in children and adolescents is considered.

Index words:
Fixed appliance, occlusion, orthodontic treatment, temporomandibular disorders.

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Introduction

This paper is review of three published papers[1–3] that was presented at the British Orthodontic Society Spring meeting at Heythrop Park in May 2001. The material in this publication is used by permission of Oxford University Press and *Swedish Dental Journal*.

Symptoms and signs of temporomandibular disorders (TMD) are relatively common in children and adolescents.[4] These can appear, increase in frequency and severity during the second decade of life.[5,6] Importantly, about 30 per cent of the population of children and adolescents receive orthodontic treatment in most western European countries during this period. This has, arguably, led to claims that orthodontic treatment is a risk factor for the development of TMD have appeared in the literature.[7–11] These claims have been questioned and discussed in recent literature reviews.[12,13] However, previous studies analysing the role of orthodontic treatment in relation to TMD have often included large age variations and different malocclusions, both in the orthodontic treatment group and, if present, in the control group. Therefore, there is a need for controlled studies to further investigate the relationship between orthodontic treatment and TMD, especially since this relationship still is under debate.

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In view of the high prevalence of symptoms and signs of TMD in children and adolescents, it is likely that patients receiving orthodontic treatment could experience TMD before, during, or after their orthodontic treatment.

This encouraged us to carry out a series of prospective studies to study symptoms and signs of (TMD), and occlusal changes in girls with Class II malocclusion receiving orthodontic treatment in comparison with untreated Class II malocclusions and with normal occlusion subjects.

Material and methods

Sixty-five Class II subjects received orthodontic fixed straight-wire appliance treatment (orthodontic group), 58 subjects were orthodontically untreated (Class II group), and 60 subjects had a normal occlusion (normal group). The orthodontic treatment goal was to normalize the sagittal, vertical, and transversal dental relationships, and to eliminate crowding or spacing. This was achieved in most treated subjects. All the subjects in the Orthodontic group were treated with fixed appliances, straight-wire technique. Fifty-three subjects wore Class II elastics, and nine subjects had extra-oral traction to enforce the anchorage and/or to correct the sagittal relationships. In addition, eight subjects were treated with activators during the treatment period. Thirty subjects (46 per cent) were treated without extractions, while 35 subjects (54 per cent) underwent premolar extractions. In 31 subjects, four premolars were extracted, while the remaining four subjects had two maxillary premolars extracted. The active treatment period varied between 14 and 23 months. Comparisons were made between girls who received orthodontic treatment, girls who had untreated Class II malocclusions, and girls with normal occlusion.

Signs and symptoms of TMD, mandibular function, and the functional occlusion were registered at each examination by either one of two specialists in stomatognathic physiology.[1–3,14, 15]

Anamnestic and clinical registrations were made at the start and after 2 years in all three groups. In the orthodontic group, additional registrations were made during orthodontic treatment (after 1 year) and 1 year post-treatment (3 years). One subject in the Class II group moved away from the region and was not able to participate in the second examination. One subject discontinued the orthodontic treatment and did not want to participate in the re-examination, and a further three subjects were impossible to reach at the follow-up after 3 years.

Statistical methods

Differences within the groups between the first and second measurement were calculated as follows:

- for binary variables McNemars test was used;
- for ordinal data the Wilcoxon´s matched pairs signed rank test.

Differences between the groups were calculated as follows:

- for binary variables the Pearson´s chi square test with Yates correction for continuity was used;
- for ordinal data the Mann–Whitney rank sum test;
- for numerical variables the analysis of variance (ANOVA).

P-values below 0.05 were considered as statistically significant. The actual *P* values are given in the text.

Results

Clinical findings

Clinical signs of TMD and functional occlusal interferences. The prevalence of clinical signs of TMD at the start and after 2 years is presented in Table 1. In the normal group, the overall prevalence of signs of TMD was numerically lower than in the other two groups at both registrations. The general trend was an increased prevalence of signs of TMD over the 2 years. Exceptions to this trend were found in the Orthodontic group, where the prevalence of pain on maximal mandibular movements ($P = 0.03$) and muscle tenderness to palpation grade 2–3 ($P = 0.004$) decreased significantly over the 2 years. All three groups had an increased prevalence of TMJ clicking over the 2 years. Only two subjects had reciprocal clicking at both the first and second registration, and no subject developed a closed lock during the 2-year period.

The longitudinal changes of tenderness to palpation of the masticatory muscles and statistical differences between the groups are shown in Figure 1.

The prevalence of functional occlusal interferences decreased over the 2 years within the orthodontic group, while the Class II and the normal group had minor changes (Table 2). At the first registration, non-working side interferences were commoner in the Orthodontic

Table 1 Signs of TMD in per cent at the start of the study and after 2 years

Clinical signs of TMD	Class II group (%)		Class II group (%)		Normal group (%)	
	Start $n = 65$	2 years $n = 64$	Start $n = 58$	2 years $n = 57$	Start $n = 60$	2 years $n = 60$
Muscles tender to palpation grade 2 and 3 *						
One or more sites	45	20	38	44	15	18
Two or more sites	26	14	21	21	5	10
Pain on mandibular movement						
One or more movements	31	16	26	23	3	8
Joint sounds						
TMJ clicking at opening and/or closing	15	20	12	18	3	10
Reciprocal clicking	9	9	2	5	2	2
Crepitating	2	2	2	3	0	0
TMJ tender to palpation						
grade 2–3	2	3	3	5	2	3

*Muscle/joint tenderness to palpation: Grade 2 = palperbral reflex. Grade 3= defence reaction.

Table 2 Functional occlusal interferences in per cent at the start of the study and after 2 years

Functional occlusal interferences	Class II group (%)		Class II group (%)		Normal group (%)	
	Start $n = 65$	2 years $n = 64$	Start $n = 58$	2 years $n = 57$	Start $n = 60$	2 years $n = 60$
Working side interferences	14	9	5	9	3	7
Non-working side interferences						
≤ 3 mm lateral excursion	31	13	9	9	8	10
Protrusion interferences	11	6	3	4	5	7
Sagittal distance						
RCP and ICP > 1 mm	6	3	5	3	7	5
Lateral sliding RCP to ICP ≥ 0.5	26	14	17	14	7	5

group than in the Class II group ($P = 0.005$) and the normal group ($P = 0.004$), while at the second registration there was no significant difference of non-working side interferences between any of the groups. Lateral sliding between RCP and ICP ≥ 0.5 mm was commoner in the orthodontic than in the normal group ($P = 0.007$) at the start.

Anamnestic findings

Symptoms of TMD, headaches and oral parafunctions. The prevalences of anamnestic findings are presented in Table 3. The overall longitudinal trend, over the 2 years, was an increased prevalence of symptoms of TMD in the Class II group and a slight decrease in the orthodontic group, while the normal group had minor changes. The longitudinal changes within the groups were not significant.

A decreased prevalence of reported tooth grinding was found in all three groups over the 2 years. At the start, the normal group had a significantly lower prevalence of reported clenching than the orthodontic group ($P = 0.002$) and the Class II group ($P = 0.017$). After 2 years there were no significant differences of either clenching or grinding between any of the groups.

When comparing the self-rated level of anxiousness on a VAS, no significant differences were found between the three groups at any of the two registrations.

Need of and demand for stomatognathic treatment. A total of 21 subjects at the first registration and 23 subjects after two years rated their overall symptoms of TMD as moderate, severe, or very severe (Figure 2). These subjects were judged to be in need of some treatment of their TMD, and given a diagnosis/diagnoses of TMD and headaches. A noteworthy finding was, that

among the 21 subjects with TMD diagnoses at the first registration, only four subjects rated their symptoms as moderate, severe, or very severe 2 years later. Three of these four subjects had unchanged TMD diagnoses.

Subjects from the normal and the Class II group who were in need of and demanded stomatognathic treatment were given this after the second registration. One subject from the normal group and three subjects from the Class II group were treated with information, counselling, and occlusal splint therapy. Except for

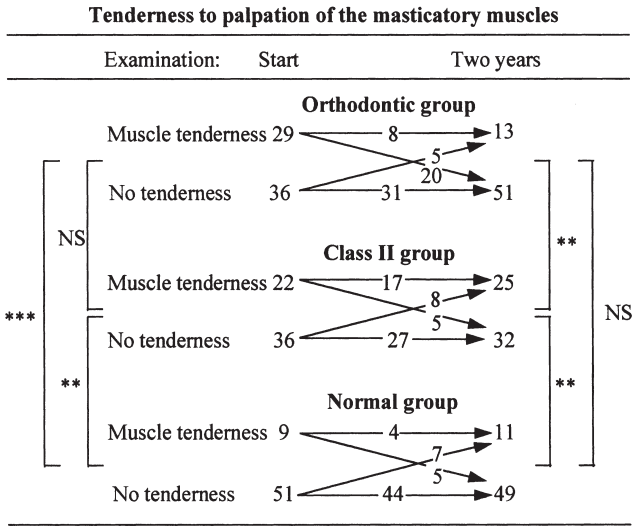

Fig. 1 Individual longitudinal changes over the 2 years in subjects with muscle tenderness to palpation grade 2–3. One subject from the orthodontic group and one subject from the untreated Class II group did not take part at the second registration. The figures indicate the number of subjects at each registration. The vertical bars show significances of differences between the groups at the first and second examination. NS, $P > 0.05$; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

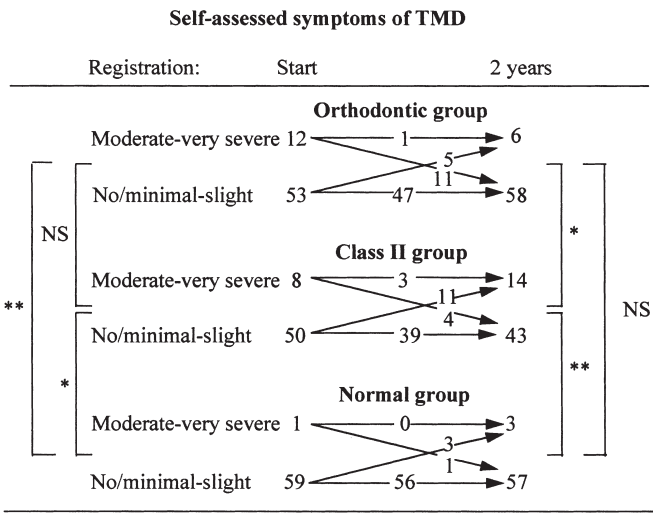

Fig. 2 Individual longitudinal changes of the self-rating of overall symptoms of TMD on a vertical scale. The figures indicate the number of subjects. One subject from the orthodontic group and one from the untreated Class II group did not take part at the second registration. The vertical bars show significances of differences between the groups at the first registration and after 2 years. NS, $P > 0.05$; *$P < 0.05$; **$P < 0.01$.

Table 3 Prevalence of anamnestic findings in per cent of the three groups at the start and 2 years later

Clinical signs of TMD	Class II group (%)		Class II group (%)		Normal group (%)	
	Start $n = 65$	2 years $n = 64$	Start $n = 58$	2 years $n = 57$	Start $n = 60$	2 years $n = 60$
Headaches						
Weekly	26	22	31	40	13	15
TMJ clicking						
Weekly	20	14	10	18	2	7
Pain from the TMJs and/or the masticatory muscles at						
At rest*	8	5	7	9	2	5
Wide opening*	14	9	9	14	2	8
Chewing*	17	16	24	26	13	20
Pain from the TMJs and/or the masticatory muscles						
Weekly	14	6	7	16	7	5
Feeling of fatigue in the jaws						
Weekly	7	3	10	11	0	3
Awareness of oral parafunctions						
Tooth grinding*	23	11	22	15	9	7
Tooth clenching*	25	18	19	27	3	15

*These questions were designed to give dichotomized, yes/no answers, while the remaining anamnestic questions were designed to evaluate the symptom frequency.

information and counselling, no stomatognathic treatment were given to any subject in the orthodontic group, since their occlusion were still settling after orthodontic treatment. After another year, the need and demand for stomatognathic treatment were re-evaluated in the orthodontic group, and two subjects were treated with information, counselling, and occlusal splint therapy.

Anamnestic and clinical findings before, during and after orthodontic treatment

Both symptoms and signs of TMD showed considerable fluctuations over the 3-year period within the individuals. The general tendency was a decreased prevalence of symptoms and signs of TMD over the 3 years (Table 4). The prevalence of pain on mandibular movement and tenderness to palpation of the masticatory muscles was significantly lower during, after active treatment, and 1 year post-treatment than before treatment ($P < 0.01$).

Clinically registered TMJ clicking increased from 15 to 23 per cent over the 3 years, but on an individual basis substantial fluctuations were seen over the 3-year period (Figure 3). A total of 39 per cent of the subjects had TMJ clicking on at least one out of the four registrations, but only 3 per cent (two individuals of 61) had TMJ clicking at all four registrations.

Anamnestic and clinical findings in relation to extraction and non-extraction treatment. The prevalences of anamnestic and clinical findings with regard to extraction or non-extraction treatment are presented in Table 5.

Table 4 Percentage distribution of symptoms and signs of TMD over the 3-year period

Anamnestic and clinical findings	Before treatment (%) $n = 65$	During treatment (%) $n = 64$	After active treatment (%) $n = 64$	1 year post-treatment (%) $n = 61$
Symptoms of TMD				
Weekly headaches	26	22	22	26
Weekly TMJ clicking	20	16	14	15
Weekly pain from the TMJs and/or the masticatory muscles	14	6	6	10
Weekly feelings of fatigue in the jaws	7	7	3	4
Signs of TMD				
Muscles tender to palpation grade 2 and 3 (one or more sites)	45	23	20	20
Pain on mandibular movement	31	11	16	12
TMJ clicking at opening and/or closing	15	19	20	23
Reciprocal clicking	9	9	9	12
Crepitations	2	3	2	2
TMJ tender to palpation grade 2–3	2	2	3	2

*Muscle/joint tenderness to palpation: Grade 2 = palperbral reflex; Grade 3 = defence reaction.

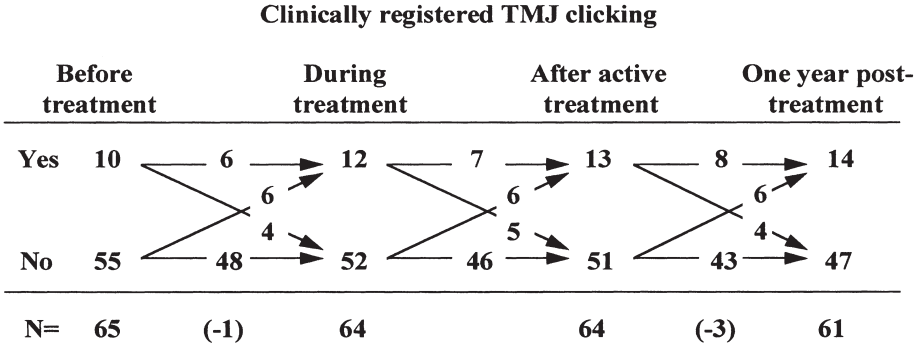

Fig. 3 Individual longitudinal changes over the 3 years in subjects with clinically registered TMJ clicking. The figures indicate the number of subjects. The figures within parenthesis indicate drop-outs during the study. N = the number of subjects at each registration.

Table 5 Thirty subjects of the 65 (46%) were orthodontically treated without tooth extractions, while 35 subjects (54%) received orthodontic treatment in combination with tooth extractions. The prevalence in per cent of anamnestic and clinical findings over the 3-year period are presented with regard to extraction (ex) or no extraction (non-ex)

Anamnestic and clinical findings	Before treatment		During treatment		After active treatment		1 year post-treatment	
	non-ex $n = 30$	ex $n = 35$	non-ex $n = 29$	ex $n = 35$	non-ex $n = 29$	ex $n = 35$	non-ex $n = 27$	ex $n = 34$
Symptoms of TMD								
Weekly headaches	20	31	14	29	14	29	14	35
Weekly TMJ clicking	17	23	17	15	17	11	18	12
Weekly pain from the TMJs and/or the masticatory muscles	11	17	7	6	3	9	4	15
Signs of TMD								
Muscles tender to palpation grade 2 and 3 (one or more sites)	**30**	**57**	14	31	10	29	**7**	**29**
Pain on mandibular movement	**17**	**43**	10	11	10	20	4	18
TMJ clicking at opening and/or closing	20	11	17	20	21	20	22	24
Functional occlusal interferences								
Non-working side interferences ≥ 3 mm lateral excursion	20	40	10	20	17	9	19	9
Lateral sliding between RCP and ICP ≥ 0.5 mm	17	34	17	26	14	14	7	12

Figures in **bold** indicate significant differences between the non-extraction and extraction group.

Except for reported and clinically registered TMJ clicking, most anamnestic and clinical findings were numerically more common in the extraction group than in the non-extraction group. Significant differences were found at the pre-treatment registration where the extraction group had a higher prevalence of tenderness to palpation of the masticatory muscles ($P = 0.028$) and pain on mandibular movements ($P = 0.022$) than the non-extraction group. These differences were smaller during treatment and after active treatment. One year post-treatment, the prevalence of tenderness to palpation of the masticatory muscles was significantly higher in the extraction group than the non-extraction group ($P = 0.032$).

Discussion

These studies were performed by analysing an orthodontic treatment group, age-matched to control subjects with similar, but untreated Class II malocclusion, as well as age-matched subjects with normal occlusion. This model made it possible to control the influence of age, occlusal factors, and orthodontic treatment on TMD when comparing the three groups.

All three groups in these studies included subjects with more or less pronounced symptoms and signs of TMD, which fluctuated substantially in the individuals over the course of time. This finding was in agreement with several previous studies of children and adolescents.[5,6,16–20]

It was not possible, on an individual basis, to predict the risk of TMD based on the presence of malocclusion or not, but the normal group had less symptoms and signs of TMD than both the orthodontic and the untreated Class II group. The relatively low prevalence of symptoms and signs of TMD in the normal group was one of the most striking results these studies. On a group basis, it seemed that the type of occlusion may play a role as a contributing factor for the development of TMD, although this influence is difficult to quantify and predict.

The Class II orthodontic group were treated with fixed appliance, as uniformly as possible, either with or without tooth extractions. The patients asked for orthodontic treatment of their malocclusion and not treatment of their TMD. No special attempts were made to individualize the orthodontic treatment in those subjects who had complaints of pre-treatment symptoms of TMD.

Orthodontic treatment with fixed appliance did not increase the prevalence of symptoms and signs, or worsen pre-existing symptoms and signs of TMD. On the contrary, subjects with Class II malocclusion and muscular signs of TMD seemed to benefit from orthodontic treatment in a 3-year perspective. The decreased prevalence of tenderness to palpation of the musculature

in the orthodontic group has been the subject of discussion in earlier publications.[21,22] Whether this is a muscular response due to altered use of the masticatory muscles or due to occlusal changes has been difficult to say. Egermark-Eriksson and Rönnerman[21] suggested that the decrease in muscle tenderness was due to a reduced activity of masticatory muscles during orthodontic tooth movement because of tender teeth. The present prospective study showed an early decrease of the prevalence of tender muscles, before the new occlusion had settled, which might indicate an explanation due to altered activity of the muscles. The prevalence of tenderness to palpation of the masticatory muscles seemed to be stable during the post-treatment year. The reason for the decreased prevalence of muscular signs of TMD is not well understood, but a better occlusal stability with less functional interferences and more occlusal contacts was found in the orthodontic group after treatment than before, might be one explanation. Psychological aspects of an improved dental appearance could be another explanation in some individuals.

Although individuals showed both improvement and impairment of clinically registered TMJ clicking, all three groups in this study showed a similar increase in the prevalence of TMJ clicking over the two years. Since this increase was seen in all three groups, it was concluded that the orthodontic treatment did not have any influence on TMJ clicking. The increased prevalence of TMJ clicking over the 2-year period in this study was in agreement with earlier studies, reporting that TMJ clicking increased from childhood to adolescence and to an even higher prevalence in adults.[5,6,23–26] Substantial fluctuations of clinically registered TMJ clicking were found in the orthodontic group over the 3 years (Figure 6). This was in agreement with Sadowsky *et al.*,[27] but differed from the findings of Egermark-Eriksson and Rönnerman,[21] who reported that, among 50 subjects, aged 7–15 years, almost all of their patients with TMJ sounds before orthodontic treatment had these sound unchanged after treatment.

In the present studies, eight subjects at the start and 10 after 2 years had reciprocal TMJ clicking, which has been suggested to be a clinical sign of disc displacement.[28,29] It noteworthy is that only two subjects had reciprocal TMJ clicking at both registrations, which implies that natural fluctuations also exist in adolescents with reciprocal TMJ clicking. Sadowsky *et al.*[27] found less reciprocal clicking after orthodontic treatment than before on a group basis, but reported individual fluctuations of reciprocal clicking similar to the findings in this study. Lundh *et al.*[30] followed 70 adult patients with reciprocal clicking during a 3-year period, and found an unchanged status in 71 per cent and that 29 per cent of the reciprocal clicking disappeared.

It has been suggested that TMJ clicking is progressive.[28,31] Our finding of individual fluctuation over time and that none of the subjects in the three groups developed a closed lock of the TMJ during the observation period is more in line with those of Wänman and Agerberg[32] and Könönen *et al.*[24] The fluctuations over time of both TMJ clicking and reciprocal clicking found, in this and previous studies, is important knowledge for the orthodontist and the general dentist if a patient reports TMJ clicking during orthodontic treatment. Patient information that TMJ clicking may come and go spontaneously and a conservative treatment approach are recommended.

Comparison between the extraction and non-extraction group

About 50 per cent of the subjects were orthodontically treated in combination with tooth extraction. A numerically higher prevalence of registered symptoms and signs of TMD was found in the extraction group compared with the non-extraction group. The prevalence of tenderness to palpation of the masticatory muscles was significantly higher in the extraction group than in the non-extraction group both before treatment and 1 year post-treatment. Reported and clinically registered TMJ clicking, however, did not differ between the groups. These differences between the extraction and non-extraction groups concerning signs and symptoms of TMD in this study corroborate the findings of Janson and Hasund,[33] but were unexpected since several other studies have not indicated differences between extraction and non-extraction groups.[34–36] In this study, since the increased prevalences of symptoms and signs of TMD in the extraction group were found before the orthodontic treatment started, it appears to be the selection criteria for extraction, rather than the orthodontic extraction-treatment itself that contributes to the higher prevalences of symptoms and signs of TMD. The results from this study underline the importance of a prospective and longitudinal study design.

Conclusions

In the individuals, symptoms and signs of TMD and TMD diagnoses fluctuated substantially over time with

no predictable pattern. On a group basis, the type of occlusion may play a role as a contributing factor for the development of symptoms and signs of TMD, although this influence is difficult to quantify and predict.

Orthodontic treatment with fixed appliance either with or without tooth extractions did not increase the prevalence of symptoms and signs, or worsen pre-existing symptoms and signs of TMD. Subjects with Class II malocclusion and pre-existing signs of TMD of muscular origin seemed to benefit functionally from orthodontic treatment in a 3-year perspective.

One orthodontic treatment effect when normalizing Class II malocclusions with fixed appliances was a decreased prevalence of functional occlusal interferences, while the changes in subjects with untreated Class II malocclusion and normal occlusion were minor.

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