Long-term follow-up of early treatment of unilateral forced posterior cross-bite with regard to temporomandibular disorders and associated symptoms

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Forty-four subjects, who at the age of 4 years had been treated for unilateral forced cross-bite by grinding or by maxillary arch expansion, were 16–19 years later followed-up by means of a questionnaire about their present condition with regard to temporomandibular disorders (TMD). Twenty-two of them had received only early treatment *(early questionnaire group)* and 22 had received late treatment *(late questionnaire group)*. Fourteen of the subjects who received late treatment also received early treatment. Twenty-nine of the subjects were also examined clinically. Eighteen of these had only received early treatment at 4 years of age *(early clinical group)*, whereas 11 of them also received later treatment in the mixed or permanent dentition because of relapse *(late clinical group)*. No significant differences were found between the early and late groups with regard to signs and symptoms of TMD. Most of the young adults who had undergone orthodontic treatment had well-functioning masticatory systems, and severe TMD signs and symptoms were rare. The results of this study suggest that relapse of early orthodontic treatment and further need of treatment does not influence the later status of subjective symptoms or clinical signs of TMD in young adults. □ *Headache; malocclusion; orthodontic treatment; temporomandibular disorders; young adults*

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Temporomandibular disorders (TMD) are generally considered to have a multifactorial etiology (1). Occlusal interferences have been claimed to play a part together with emotional disturbances (2), general joint/muscle diseases, and impaired general health (3). Since some of the malocclusions are claimed to cause neuromuscular disturbances in the masticatory system (4), their orthodontic treatment has been considered important. After orthodontic treatment improvements in signs and symptoms of TMD have been reported in patients with anteriorly and laterally forced cross-bites (5), which indicate that malocclusions are associated with the development of TMD (6). However, later studies have not found strong evidence of a relationship between orthodontic treatment and symptoms and signs of temporomandibular disorders (7–9).

The main reason for this study was to follow up subjects in the age range of 18–22 years who were treated for unilateral forced cross-bite in the deciduous dentition. The long-term results with regard to orthodontic treatment outcome in these subjects have already been published (10).

The aim was to determine whether there are differences in prevalence and duration of temporomandibular disorders and associated symptoms such as headache and parafunctions between individuals subjected only to early treatment (orthodontic appliance or occlusal adjustment) and individuals who also received additional late treatment (orthodontic appliance) because of relapse of the cross-bite. Our hypothesis was that a failure of early orthodontic treatment leading to need for later retreatment would lead to an increased prevalence of TMD.

Subjects and methods

Subjects

The subjects included were 44 young Swedish adults, 26 female and 18 male, with a mean age and standard deviation of 21 ± 1.5 years. As 4-year-olds they had participated in two different studies comprising together 105 children (11, 12) (Table 1). Of these children, 75 (71%) could be reached by mail, and a questionnaire was sent to them. Forty-nine of them answered and gave their consent to participate in the study. The response rate to the questionnaire was thus 65%. The questionnaire used is part of a routine questionnaire at the Department of Clinical Oral Physiology about the current condition with regard to TMD symptoms (13). Five of the 49 subjects were excluded because they had not received any treatment at all.

Twenty-two of the remaining 44 subjects (14 female and 8 male) received only early treatment and formed the *early questionnaire group*, and 22 (12 female and 10 male) received late treatment and formed the *late questionnaire group*. Of these latter 22 subjects, 14 had late retreatment because of relapse of the cross-bite, and 8 subjects who in the original study (12) belonged to a control group received only late treatment. The late group thus includes 14 subjects with early treatment.

Twenty-nine of the 44 subjects (66%) included in this study were also examined clinically (18 female and 11 male, with a mean age and standard deviation of 20 ± 2 years). Of the 29 clinically examined subjects 18 (12 female and 6 male) were only subjected to early treatment and

Table 1. Selection of the subjects

	No. of subjects	% of subjects
Two earlier studies	29 + 76	100
↓		
Total	105	100
↓		
Could be reached by address	75	71
↓		
Answered the questionnaire	49	47
↓		
Five untreated excluded	**44**	**42**
↓		
Early group: Only early treated	22	21
Late group: Majority also treated early	22	21
↓		
Clinically examined (15 did not come)	**29**	**28**
↓		
Early group	18	17
Early appliance, QH	9	9
Early occlusal adjustment	9	9
+		
Late group	11	10
Early and late appliance	6	6
Early occlusal adjustment and late appliance	5	5

constitute *the early clinical group*. The other 11 subjects (6 female and 5 male) required later orthodontic treatment as well because of cross-bite relapse in the mixed or permanent dentition, and these constitute *the late clinical group* (10).

Fifteen (11 female and 4 male) of the clinically examined subjects received expansion treatment of the maxillary arch for unilateral forced posterior cross-bite with a modified quad-helix (QH) appliance at the age of 4 years (11), whereas 14 of these subjects (7 female and 7 male) were treated with occlusal adjustment at the same age (12).

Methods

Written questionnaire. The presence and degree of TMD symptoms and associated factors were assessed with a self-administered questionnaire as follows.

How often do you have headache, pain in the face or jaws, pain when moving the jaws, difficulties opening the mouth, tiredness in the jaws, temporomandibular joint (TMJ) clicking, locking of the jaws, dizziness (vertigo), or noises in the ear (tinnitus)? Alternative answers: 1 = never, 2 = 1–2 times per month, 3 = once a week, 4 = several times a week, 5 = daily.

How long have you had any of the above symptoms? Alternative answers: 1 = less than 1 month, 2 = 1–6 months, 3 = 7–12 months, 4 = more than 1 year, up to 2 years, 5 = more than 2 years.

The degree of subjective symptoms was assessed by the following question:

How disturbing are your symptoms according to the following scale? Alternative answers: 1 = no complaints, 2 = few complaints, 3 = moderate complaints, 4 = severe complaints, 5 = very severe complaints.

Are you aware of clenching or grinding your teeth, of cheek- or nail-biting, or of tongue-thrusting? Alternative answers: 0 = no, 1 = yes.

Clinical examination. All the subjects were examined by the same investigator (M. Tullberg).

The clinical examination included digital palpation for tenderness of the following muscles: anterior and posterior portion and the insertion of the temporal muscle, superficial and deep part of the masseter muscle, lateral and medial pterygoid muscles, trapezius muscle, sternocleidomastoid muscle, and posterior digastric muscle. The total number of muscle sites that presented tenderness to digital palpation was counted into a score, with a maximum of 16 tender points. The anterior and posterior portions of the temporal muscle were not included in the score owing to the low prevalence of tenderness of this muscle. No differentiation between tenderness to palpation with or without a pain reflex was made.

The presence of tenderness of the temporomandibular joint (TMJ) laterally and posteriorly (via the external auditory meatus), clicking, locking, and crepitation in the TMJ during mandibular movement was assessed by digital palpation.

The mandibular mobility was assessed by the maximum voluntary mouth opening, which was measured in millimeters with a ruler and calculated as the sum of the interincisal distance and the vertical overbite. Protrusion was measured as the sum of the horizontal overjet and the distance between the incisors with the mandible in a maximally protruded position. The excursion in laterotrusion was measured as the distance between a point on the upper and the lower first incisor in laterotrusion.

The dental occlusion was examined with regard to the sagittal, vertical, and lateral deviation of the mandible during the slide from retruded contact to intercuspal position. This slide was obtained with the patient in a horizontal position, the muscles relaxed, and pushing the mandible carefully into retruded position. By means of a thin 8-μm color ribbon, the first tooth contact received a mark. A steel ruler was used to measure the mandible deviations. Laterotrusion (LTR) interference was recorded when contacts were missing in the cuspid and premolar region on the laterotrusion side. Mediotrusion (MTR) interference was recorded when it caused loss of contact on the laterotrusion side, and protrusion (PTR) interference when incisal edge-to-edge contact in the front could not be established.

Ethical requirements

This study was approved by the Medical Ethics Committee at Huddinge University Hospital, Huddinge, Sweden, before initiation of the study.

Statistics

Since all the investigated variables showed a skewed distribution, non-parametric tests were used. Groups of

Table 2. Distribution of subjective symptoms of temporomandibular disorders and associated symptoms as reported by questionnaire for all 44 individuals (Total), 22 individuals subjected to early treatment (Early), and 22 to late treatment (Late)

Symptoms at least once a month	Total, %	Early, %	Late, %
Headache	68	73	64
Pain in the face or jaws	14	23	5
Pain when moving the jaws	16	18	14
Difficulties opening the mouth	11	14	9
Tiredness in the jaws	20	18	23
TMJ clicking*	32	36	27
Locking of the jaws	9	5	14
Vertigo	23	23	23
Tinnitus	9	9	9

* TMJ = temporomandibular joint.

subjects and sexes were tested for differences in prevalence of subjective symptoms and clinical signs by means of the Mann–Whitney U-test. Correlation between variables was tested with Spearman's rank correlation test (r_s). A P value less than 0.05 was considered significant.

Results

There were no statistically significant differences between the two early and late groups for any of the investigated symptoms or signs of TMD or associated symptoms.

*Subjective symptoms (*n = *44)*

Questionnaire. The distribution of subjective symptoms reported is shown in Table 2. The frequency of subjects who reported some symptom involving the masticatory system was 80%.

The most common symptom was headache (once to twice a month or more). None of the subjects had daily headache, and headache once a week or more in all the subjects occurred in 30%. Female subjects were more affected (39%) than male (17%; $P < 0.05$).

Other common subjective symptoms occurring at least once a month were TMJ clicking, vertigo, and tiredness of the jaws.

Duration of subjective symptoms. Duration of symptoms for more than 1 year was found in 41% of the total patient sample, 50% in the *early group*, and 32% in the *late group*. The difference between the groups was not statistically significant. A duration of less than 1 year was found in 32% of the total sample; whereas a duration of more than 2 years was reported by 34%. Twenty-seven percent did not answer this question.

Degree of subjective symptoms. In the *early* group 50% and in the *late* group 27% had few or moderate complaints. The difference between the groups was not statistically significant. None had a severe or very severe complaint. One subject in the late group did not answer this question.

Parafunctions. The most common parafunctions were nail- and cheek-biting and clenching of teeth, whereas grinding of teeth and tongue-thrusting were less frequently reported (Table 3).

Table 3. Distribution of parafunctions in the temporomandibular system as reported in the questionnaire by all individuals (Total), 22 individuals subjected to early treatment (Early), and 22 to late treatment (Late)

Parafunctions	Total, %	Early, %	Late, %
Clenching	27	36	18
Grinding	11	14	9
Cheek-biting	27	32	23
Nail-biting	36	36	36
Tongue-thrusting	2	0	5

*Clinical signs (*n = *29)*

The clinical signs of temporomandibular disorders are shown in Table 4.

The frequency of subjects showing one clinical sign involving the masticatory system was 83%. The most frequent signs were jaw muscle tenderness and a large sagittal distance between retruded and intercuspal position.

Muscle tenderness. Among the subjects in the early and late groups combined, 8 of 29 (28%) showed 4 or more tender muscle points. Another nine had no tender points at all.

The lateral pterygoid muscle (52%) was most frequently tender. The temporal muscle insertion (41%), medial

Table 4. Distribution of clinical signs of temporomandibular disorders assessed in 29 individuals (Total), 18 subjected to early treatment (Early), and 11 subjected to late treatment (Late)

Clinical signs	Total, %	Early, %	Late, %
TMJ signs			
TMJ tenderness	7	6	9
TMJ clicking	10	11	9
Locking	3	6	0
Crepitation	3	0	9
Tender muscle points			
0 tender points	31	17	55
1–3 tender points	41	50	27
4–9 tender points	21	28	9
10–16 tender points	7	6	9
RP–IP distance			
Sagittal direction, >0.5 mm	24	17	36
Vertical direction, >0.5 mm	17	6	36
Lateral deviation, >0.5 mm	17	17	18
LTR interferences	21	17	27
MTR interferences	10	6	18
PTR interferences	7	0	18

TMJ = temporomandibular joint; LTR = laterotrusion; MTR = mediotrusion; PTR = protrusion.

Table 5. Correlations between symptoms ($n = 44$) and signs ($n = 29$)

Correlations	Headache	Pain in the face or jaws	Vertigo	Degree of complaints	Tooth grinding
Symptom					
Locking			0.58***		
Vertigo		0.42**			
Difficulties opening the mouth			0.54**	0.54**	
Degree of complaints	0.59***				
Tooth-clenching	0.34*	0.61***			
Tongue-thrusting					0.43**
Sign					
Temporal muscle insertion	0.56***				
Deep portion of masseter muscle	0.42*				
Superficial portion of masseter muscle			0.53**		
No. of muscle tender points		0.49**			
Vertical distance between RP and IP			0.48**		

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.
RP = retruded position; IP = intercuspal position.

pterygoid (24%), trapezius (17%), and deep masseter (14%) muscles were also commonly involved. Only one subject in the late group showed tenderness to palpation of the anterior and posterior part of the temporal muscle.

One of the 29 subjects had a maximum voluntary mouth opening less than 40 mm, which is considered to be the lower normal value for young adults (5). Twenty-one percent had reduced protrusion movements, four subjects in the early and two in the late group. The same figures, four in the early and two in the late group, were found for reduced laterotrusion.

Dental occlusion. There was no significant difference between the early and late groups with regard to mandible deviation and occlusal interferences.

Correlations

The correlations are presented in Table 5. Headache was positively correlated to the degree of complaints and tooth clenching. No significant correlations were found between tinnitus and the other variables investigated.

Discussion

The aim of this study was to investigate individuals treated for unilateral forced posterior cross-bite and to ascertain whether there are differences with regard to TMD or associated symptoms after early treatment, as compared with early and additional late treatment.

This study was thus undertaken to answer the question whether failure of early orthodontic treatment and need for further treatment at a late stage result in a higher risk for development of symptoms and signs of TMD.

The whole group of subjects in this study seems to have more TMD symptoms as compared with a healthy population in Skellefteå in the north of Sweden (14–16) but not when compared with groups of patients treated by orthodontists (and an associated control group in Halmstad in the west of Sweden) (17). However, with regard to parafunctions the figures for all the studies were similar.

Clinical findings for different studies are difficult to compare because of a considerable interobserver variation. Frequency figures of tenderness to palpation of masticatory muscles are difficult to compare because of the different amounts of pressure applied at digital palpation, but it is a highly relevant clinical sign, since most patients consult a dentist because of pain.

Nevertheless, the most common site of muscle tenderness, the lateral pterygoid muscle region, and the second most common, the temporal muscle insertion, were the same in the Skellefteå and our study. The frequency figures of muscle tenderness in the Halmstad study cannot be compared because the different muscles were not specified.

In the studies by Wänman & Agerberg (14–16) 28% showed mediotrusion interferences, compared with 10% in our and 31% in the Halmstad study.

Observer variation affects the assessment of all clinical variables used. The intraobserver variability is generally lower than the interobserver variability (18). In this study one investigator (M. Tullberg) made all the recordings. Measurement of sagittal distance between retruded and intercuspid position, for instance, is associated with a considerable intraobserver error. The standard deviation of a single measurement has been reported to be 0.3 mm, whereas the corresponding relative variation was 45% (18). Therefore, 0.5 mm was used as the limit in this study for deviations between retruded and intercuspid position.

In this study vertigo was associated with the vertical distance between retruded and intercuspid position and reduced mouth opening capacity, but not with pain, which indicates that the position and function of the mandible may somehow be associated with vertigo.

We did not expect that vertigo occurring at least once a month would be as common as 23% in this young age group. However, in an epidemiological study (19) vertigo was shown to be a very common symptom. It was reported

by 26% of 26-year-old women and by 3% of 30-year-old men. In women this frequency was equally common regardless of age, whereas in men the frequency increased with age.

In this study headache and facial pain were found to be associated with tooth clenching behavior and muscle tenderness. Tooth grinding, which is an involuntary muscle activity during sleep, was associated with tongue thrusting.

This study was undertaken to answer the question whether failure of early orthodontic treatment and need for further treatment at a late stage result in a higher risk for development of symptoms and signs of TMD. No differences were found between the early and late groups with regard to TMD and associated symptoms, and this study thus does not prove that early intervention has any drawbacks. This is in agreement with the Halmstad study with regard to signs and symptoms of TMD in 19-year-old individuals who had been subjected to orthodontic treatment (17). In that study no significant correlation was found between TMD symptoms and signs and occlusal conditions; most of the 19-year-olds had well-functioning masticatory systems, and severe signs and symptoms of TMD were rare. In line with our study, in a cross-sectional study Mohlin & Kopp (20) reported no correlation between TMD and cross-bite.

This study indicates that unsuccessful early orthodontic treatment that has to be continued later is not associated with increased risk of future development of TMD. The results of this study indicate that the choice of early orthodontic treatment does not, even if it fails and has to be continued at a later stage, result in an increased risk of future subjective symptoms or clinical signs of TMD.

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