

A survey of craniomandibular disorders in 500 19-year-olds

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SUMMARY This study examines the development of signs and symptoms of craniomandibular disorders (CMD), and some effects of orthodontic treatment from the age of 12-19 years of age. The data is drawn from a special sample of adolescents recruited at 11 years of age by random stratified sampling to contain a high prevalence of malocclusions of particular orthodontic interest. The sample does not reflect malocclusion in a normal population.

The prevalence of frequent headache and TMJ disorders shows a major increase from 12 to 15 years of age. From 15 to 19 years of age, there is some increase in the prevalence of TMJ disorders in girls, but altogether the prevalence of signs and symptoms of CMD is much more stable.

When the data from subjects who received orthodontic treatment were compared with data from subjects who had not received orthodontic treatment, only small differences were found.

Introduction

Prevalence of CMD in a large sample of Welsh children at 12 and 15 years of age has been presented earlier (Mohlin *et al.*, 1991; Pilley *et al.*, 1992). Both studies are part of a longitudinal study of the consequences of malocclusion on oral health and psychosocial wellbeing which began in 1981 in Cardiff, Wales. Study design and reproducibility of recordings have been discussed in previous papers (Shaw *et al.*, 1986; Mohlin *et al.*, 1991). The individuals in this study were selected to form a sample which had a high prevalence of malocclusion especially those of particular orthodontic interest (for example, Class III malocclusions); thus, this sample does not represent a random sample of malocclusions in the general population.

Clinical signs of CMD were found in almost half of the children when the initial recordings were made at the age of 12 years (Mohlin *et al.*, 1991). In general, the severity of CMD was low. Despite the fact that all children had malocclusion, the prevalence of CMD was slightly lower than has been found in random samples of children of approximately the same age in which malocclusion has not been used as a selection factor (DeBoever and van der Berghe, 1987; Egermark-Eriksson, 1982;

Heikinheimo *et al.*, 1989, 1990; Könönen *et al.*, 1987; Magnusson *et al.*, 1985, 1986; Wänman, 1987; Egermark-Eriksson *et al.*, 1990). Several associations were found between signs and symptoms of CMD and headache, in agreement with the studies by Egermark-Eriksson (1982), Magnusson *et al.* (1985, 1986), and Wänman (1987).

The overall prevalence of the signs of CMD changed only a little between 12 and 15 years of age. Only a few individuals had serious problems. However, the prevalence of dysfunctions of the temporomandibular joint was clearly greater at 15 and this represents the main difference between these two age groups. Headache (weekly or daily), as well as dental clenching and clicking from the TMJ increased in prevalence from 12 to 15 years of age according to the anamnestic examination (Pilley *et al.*, 1992). The prevalence of CMD relative to most of the other symptoms, was low, usually less than 5 per cent. Sex differences were found in the prevalence of headache and clicking, with more girls than boys affected.

The aim of this report is to present the prevalence of craniomandibular disorders in 19-year-old individuals and discuss the development of signs and symptoms from 12 to 19 years of age.

Subjects and methods

Sampling

The selection methods have been described previously (Shaw *et al.*, 1986). The sample consisted of children with malocclusion, chosen by use of preselected screening criteria from a group of 3420 children. The selection was made with a view to creating groups of children large enough to study the reasons and motivation for orthodontic treatment in both common and also in more unusual malocclusions (Shaw *et al.*, 1986; Mohlin *et al.*, 1991). A total of 1018 children were finally selected for examination in 1981 at the age of 12 years. Of these 791 subjects were available for re-examination in 1984 at the age of 15 years and 456 were successfully recalled in 1989 at the age of 19 years (Table 1). The variables recorded at 15 and at 19 are the same and defined identically. Further observations were made, for example, muscular endurance.

Table 1 Sample composition at the examinations at 12, 15, and 19 years of age.

	12 years	15 years	19 years
Girls	508	398	236
Boys	507	393	220
Total	1015	791	456

Clinical examination

Study casts and four standardized photographs were taken of each individual. Clinical recordings of the subjects' functional status are listed in Table 2. The examination methods have been described previously (Mohlin, 1982; Mohlin *et al.*, 1991). At 19, bite force was recorded for the first time. This was used to calculate muscular endurance which was defined as the time the individual was able to bite with 50 per cent of maximal bite force until pain or obvious discomfort arose.

Anamnestic examination

The questions about dental conditions as well as those relevant to the social psychological assessment have been described earlier (Shaw *et al.*, 1986). At 19, for logistical reasons, anamnestic data were collected partly by questionnaire and partly by interview. Table 3 indicates which questions the subjects answered as a questionnaire and which they were asked by interview. All the questions were contained within the same document and this allowed the examiner (in this case one of the present authors who was not involved in the clinical examination) to review all the questions and resolve any misunderstandings. On this occasion, the interview also included questions concerning general health and general joint problems, back and shoulder pain as well as jaw injuries. Questions

Table 2 Clinical observations at 15 and 19 years of age.

Mobility	
Maximum opening	Maximum protrusion
Maximum laterotrusion left	Maximum laterotrusion right
TMJ function	
Deviation on opening	Clicking left and right
Crepitation left and right	Locking and/or luxation
Painful jaw movements	
Opening	Protrusion
Laterotrusion left	Laterotrusion right
Muscle and joint pain	(L&R always recorded separately)
Temporalis, anteriorly	Temporalis, posteriorly
Temporalis, insertion	Masseter, superficially
Masseter, deep fibres	Medial pterygoid
Lateral pterygoid	TMJ, posteriorly and laterally
Functional occlusion	
Unilateral contact in RP	Lateral deviation RP-IP
Horizontal deviation RP-IP	Vertical deviation RP-IP
Non-working side interferences	Working side contacts
Anterior forced bite	Lateral forced bite

Table 3 Anamnestic questionnaire for symptoms of CMD in 19-year-olds.

Mouth opening: 'Do you ever have difficulties in opening your mouth?'
0 = never, 1 = slightly, 2 = often or obvious difficulties.

TMJ clicking: 'When you open your mouth, do you ever hear a click from here?' (Examiner shows where TMJ is.)
0 = never/very seldom; 1 = sometimes/once a month; 2 = often/weekly.

Locking/luxation: 'When you open your mouth, does your jaw ever get stuck so that you cannot open fully? Do you ever feel that your jaw jumps out of place or do you find that you have to guide your jaw back into place by pushing on it with your hand?'
0 = no; 1 = yes.

Stiffness or fatigue: 'Do you ever feel that your jaw gets tired or stiff?'
0 = never or very seldom; 1 = yes, but only after chewing something like chewing gum; 2 = yes, but the fatigue arises spontaneously, without provocation from prolonged or vigorous chewing.

Pain on mouth opening: 'Do you ever feel that your jaw gets tired or stiff?'
0 = never, 1 = sometimes or mild pain; 2 = often (i.e. more than once/week) or severe pain.

Pain around the TMJ: 'Do you ever get pain in this region (examiner indicates the region of the TMJ) when you open wide?'
0 = never; 1 = sometimes or mild pain; 2 = often (i.e. more than once/week) or severe pain.

Pain in jaw muscles: 'Do you ever get pain in this region.' (Examiner indicates the temporalis and masseter muscles as examples of the masticatory muscles.)
0 = never/very seldom; 1 = sometimes/mild pain; 2 = often/severe pain.

Headache: 'Do you ever get a headache?'
0 = never/seldom; 1 = once or twice a month; 2 = once each week; 3 = every day.

Clenching teeth: 'Do you ever clench your teeth or hold them tightly together when you are not eating?'
0 = never/very seldom; 1 = sometimes (about once each month); 2 = often (approximately once each week or more).

Grinding teeth: 'Do you ever grind your teeth?'
0 = never/very seldom; 1 = sometimes (about once each month); 2 = often (about once each week or more).

Occlusal stability: 'When you put your teeth together, do they always fit together in the same way? Do you sometimes find it hard to fit them together?'
0 = no problems, they seem to fit well; 1 = they do not fit quite comfortably; 2 = it is difficult to find a comfortable position when I close together and I sometimes use different positions when I close.

Chewing side: 'Do you chew on both sides or mainly on one side?'
0 = don't know; 1 = both sides; 2 = mainly on the right; 3 = mainly on the left.

Table 3 (continued).

Chewing difficulties: 'Do you ever have difficulties in chewing your food?'
0 = don't know; 1 = no difficulty; 2 = sometimes its a little difficult; 3 = I have a great deal of trouble, I can hardly do it at all.

Biting difficulties: 'Do you ever have difficulties taking a bite out of something like a sandwich or an apple?'
0 = don't know; 1 = no difficulties; 2 = it is sometimes a little difficult; 3 = I have a great deal of trouble, I can hardly do it at all.

specifically relevant to oral function are listed in Table 3.

Orthodontic treatment

Orthodontic treatment given before 15 years of age was assessed by interview and additional information obtained from dentists responsible for the treatment. An evaluation of patient co-operation is shown in Table 4.

Statistical methods

Differences in movement capacity between boys and girls were analysed by use of a *t*-test. Sex differences and differences between the examinations at 15 and at 19 regarding categorical variables were tested by use of Chi-squared tests.

Results

Anamnestic examination

Figure 1 summarizes the subjects' replies to the anamnestic questionnaire. The figures for headaches represent the individuals who complained of weekly or daily headaches. The figures describing chewing and biting difficulties include subjects whose complaints ranged from moderate to severe impairment. Only one individual reported biting as being severely impaired. Figures for occlusal stability are only quoted

Table 4 Quality of orthodontic treatment given to the 15-year-old boys and girls in per cent (*n* = 721).

	Males	Females
Discontinued treatment	6	4
Poor co-operation	13	15
Fairly good co-operation	31	28
Very good co-operation	18	33
No treatment	299	274

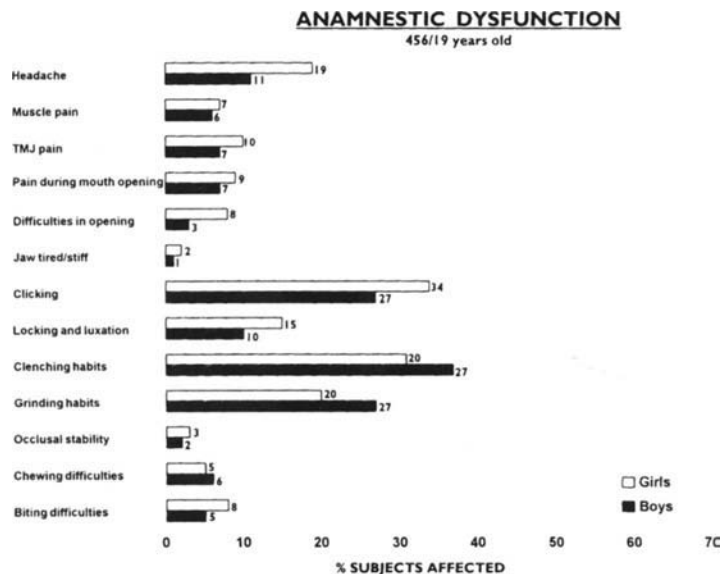


Figure 1 Anamnestic dysfunction. 'Headache' refers to weekly or daily episodes. 'Jaw tired/stiff' refers to fatigue which appears to arise spontaneously and not after exercise. As to the other variables, the percentages describe the proportion of subjects who reported the symptoms to be present. A comparison is made between 19-year-old males and females. The prevalence is quoted in per cent.

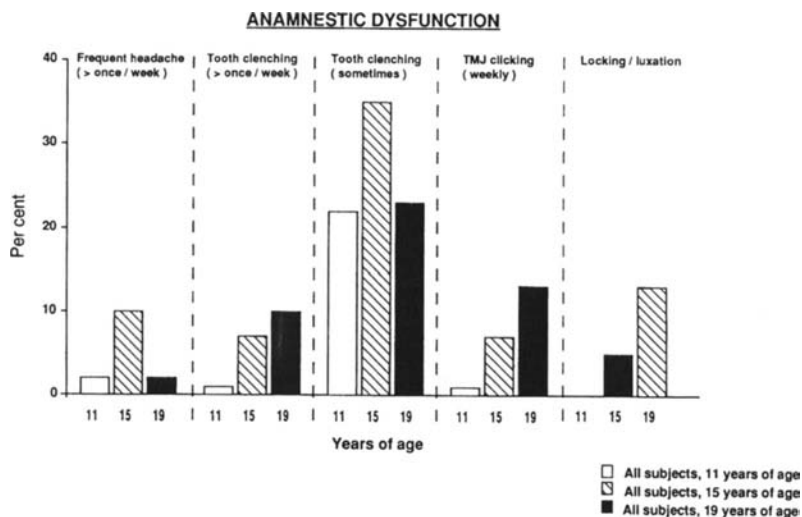


Figure 2 Anamnestic dysfunction. Comparison of reported symptoms between examinations in 1981 (12 years), 1984 (15 years), and 1989 (19 years). Prevalence in per cent.

when the impairment was sufficient to provide difficulties for the subjects. The prevalence of occlusal instability rose by 10–15 per cent between 15 and 19 years of age, and this increase is significant.

A comparison of the responses made at 12, 15, and 19 years of age is shown in Figure 2. A

detailed comparison between 15 and 19 years is made in Table 5. Most of the symptoms of CMD show an increase in prevalence from 12 to 19 years of age. The most marked is the increase in the prevalence of locking/luxation and of frequent clicking. Locking and luxation increased from 7 to 15 per cent in girls and

Table 5 Symptoms of CMD according to the anamnestic examination in the 19-year-old males and females ($n=456$) in comparison to the subjects at the age of 15 years ($n=791$). Prevalence in per cent.

	Females		Males	
	15 years	19 years	15 years	19 years
Difficulty with mouth opening				
none	97	92	98	96
slight	2	6	2	2
often	1	2	0	1
Jaw feels tired or stiff				
no	36	61	37	71
yes-chewing	64	37	62	28
yes at any time	1	2	1	1
Locking or luxation				
no	93	85	97	90
yes	7	15	3	10
Clicking				
never	66	66	76	73
sometimes	26	17	19	18
often	8	17	5	9
Pain when opening mouth				
never	98	91	99	94
occasionally	2	8	1	6
often	0	1	0	1
Pain around the TMJ				
never	89	90	94	92
sometimes/mild	10	7	6	6
often/severe	1	3	0	1
Muscle pain				
no	96	93	96	95
yes	4	7	4	6
Headache				
never	36	24	56	50
monthly	48	57	37	39
weekly	15	17	6	10
daily	1	2	1	1

from 3 to 10 per cent in boys. Frequent clicking increased from 8 to 17 per cent in girls and from 5 to 9 per cent in boys. However, a feeling of tiredness or stiffness of the jaw was reported only half as frequently by the 19-year-olds as it was in the 15-year-olds. Apart from TMJ function and frequent headache, the prevalence of most of the symptoms was reported as less than 10 per cent.

The prevalence of bruxism as an occasional, as well as a frequent habit showed minor variation from 15 to 19 years of age. There was a slight decrease in prevalence of occasional dental clenching (Table 6).

The prevalence of problems concerned with

chewing and biting was approximately the same at 15 and 19 years of age. Moderate occlusal instability was more commonly reported by the 19-year-olds. Difficulties with chewing and biting when reported were almost always modest (Table 6).

Mandibular movements

There was no major change in mandibular mobility during the period 1984–1989 (Table 7). Ten per cent of the males and 11 per cent of the females were considered to have an impaired movement capacity and only 2–3 per cent of the individuals complained of pain provoked by mandibular movements.

Table 6 Comparison of parafunctional habits, chewing and biting function between the 15 year ($n=791$) and the 19-year-old subjects ($n=456$). Prevalences in per cent.

	Females		Males	
	15 years	19 years	15 years	19 years
Tooth clenching				
no	58	69	59	63
sometimes	34	23	32	25
often	8	8	9	12
Tooth grinding				
no	78	80	80	74
sometimes	16	14	16	18
often	6	6	4	9
Occlusal stability				
good	96	83	97	87
unstable	3	15	3	11
providing difficulties	1	3	1	2
Chewing difficulties				
don't know	0	3	1	5
no	97	92	97	89
moderate	3	5	1	6
severe	0	0	0	0
Biting difficulties				
don't know	0	5	1	7
no	93	87	95	89
moderate	7	7	4	4
severe	0	1	0	1
Chewing side				
don't know	5	18	5	14
both sides	46	50	49	51
right only	33	23	35	28
left only	16	7	11	8

Table 7 Mandibular movements in 788 individuals at the age of 15 years and in 456 individuals at the age of 19 years. Measurements for the 15-year-olds within brackets (all measurements in mm).

	Mean	Median	Maximum	Minimum	Range	SD
Opening						
Males	54 (55)	(55)	74 (73)	37 (35)	34 (38)	6 (6)
Females	49 (53)	(53)	64 (69)	28 (34)	36 (35)	6 (6)
Laterotrusion						
right						
Males	11 (9)	(9)	16 (15)	4 (3)	12 (12)	2 (2)
Females	10 (9)	(9)	16 (15)	6 (5)	10 (11)	2 (2)
Laterotrusion left						
Males	11 (9)	(9)	17 (15)	5 (4)	12 (11)	2 (2)
Females	10 (9)	(9)	17 (15)	5 (5)	12 (11)	2 (2)
Protrusion						
Males	9 (9)	(9)	15 (14)	4 (3)	11 (11)	2 (2)
Females	8 (9)	(9)	14 (15)	4 (1)	10 (14)	2 (2)

Tenderness to palpation

Tenderness to palpation in different muscles of mastication is given in Table 8. There was a high degree of agreement between the recordings at 15 and at 19 years of age with the lateral pterygoid muscle, and the insertion of the temporal muscle as those most commonly showing tenderness to palpation. Prevalence of tenderness to palpation of the TMJ remained almost unchanged from 15 to 19 years of age.

TMJ function

Deviation on opening and locking/luxation and clicking has, especially in girls, increased in prevalence between the examinations at 15 and 19. Prevalence of joint sounds, on the other hand, showed only minor differences when these age groups were compared (Table 9). However, on both occasions, clicking from the temporomandibular joint was found more often in girls than in boys.

Dysfunction index

Clinical dysfunction signs examined at both 12, 15, and 19 years are given in Figure 3. The major change that can be observed is an increase in prevalence of impaired TMJ function from the age of 12 to the age of 15 years and a further increase, especially in females, from 15 to 19 years of age. Muscle tenderness decreased in prevalence from 12 to 19. The distribution of scores for these subjects in the Helkimo dysfunction index (Helkimo, 1974) are presented in Figures 4 and 5. Only very minor changes have occurred between 15 and 19 years.

Table 8 Areas tender to palpation in 788 subjects aged 15 years and 456 individuals aged 19 years. Prevalence in per cent (percentages rounded to the nearest whole figure).

	Males		Females	
	15 years	19 years	15 years	19 years
Temporalis right				
anterior	3	1	5	1
posterior	1	1	1	0
insertion	17	18	15	22
Temporalis left				
anterior	2	0	4	2
posterior	1	2	1	1
insertion	15	10	13	17
Masseter right				
superior	3	2	4	3
deep	2	1	4	4
Masseter left				
superior	2	4	3	4
deep	2	3	4	2
Medial pterygoid right	1	0	3	0
Medial pterygoid left	1	1	3	0
Lateral pterygoid right	26	23	28	30
Lateral pterygoid left	26	22	29	27
TMJ right				
laterally	6	5	7	6
posteriorly	2	0	1	0
TMJ left				
laterally	4	5	5	4
posteriorly	2	0	2	0

Table 9 TMJ function in 456 males and females aged 19 years, in comparison to the 788 boys and girls at the age of 15 years according to the clinical examination. Prevalence in per cent.

	Males		Females	
	15 years	19 years	15 years	19 years
Clicking				
right	9	12	16	25
left	14	17	22	26
Creptitation				
right	0	0	0	0
left	0	0	0	0
Deviation				
to the right	2	6	3	8
to the left	5	9	9	20
Locking or luxation	3	5	4	10

Occlusal interferences

Table 10 reports the prevalence of various anomalies in the subjects' functional occlusion. The prevalence of these anomalies was very similar at 15 and 19 years of age. The most common type of interference was found to be unilateral contacts in RP and non-working side interferences. An increased distance between RP and IP (≥ 2 mm), as well as lateral deviation between RP and IP was only found in a small number of subjects.

Occlusal contacts

The dental contact pattern on closing and laterotrusive movements is shown in Table 11. There were no appreciable changes from 15 to 19 years of age. Sixty per cent of the subjects enjoyed a canine protected occlusion on the working side.

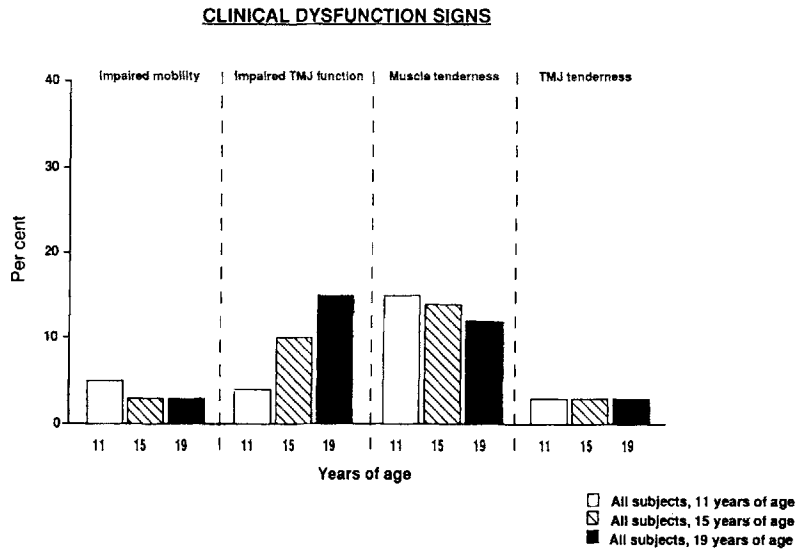


Figure 3 Clinical dysfunction signs. Comparison of signs recorded in the 12-, 15-, and 19-year-olds.

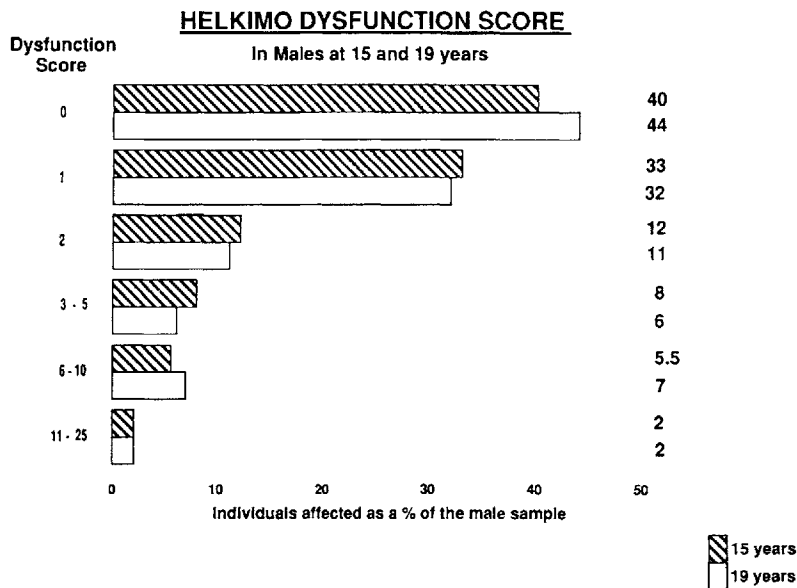


Figure 4 Dysfunction score, males. Changes in dysfunction score in the Helkimo dysfunction index (Helkimo, 1974) from 15 to 19 years of age. Percentage distribution.

Orthodontic treatment

The histograms for levels of dysfunction were similar for all treated and untreated subjects, with a slight excess of subjects suffering from measurable dysfunction who had not cooperated well with orthodontic treatment. This result was most marked for TMJ function.

However, the difference was not large between groups.

Analysis of subjects lost to follow up

After the examination at 19 years, an exhaustive study was undertaken to see whether the patients lost to follow-up had biased the sample. Thus,

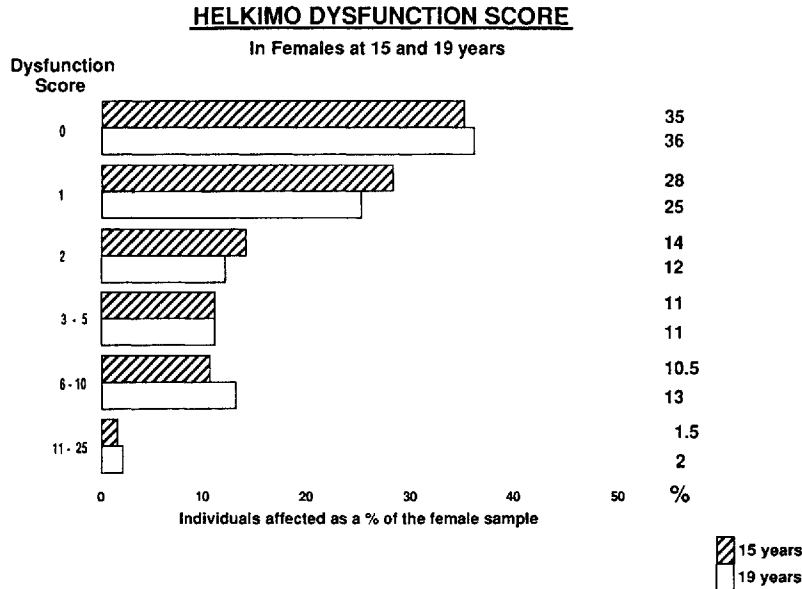


Figure 5 Dysfunction score, females. Changes in dysfunction score in the Helkimo index from 15 to 19 years of age. Percentage distribution.

the data for the subjects who left the survey after the first examination was compared with those who remained for follow up at 15 years.

Data for subjects who were lost to follow-up after the 15 years examination were compared with those who remained for re-examination at 19 years of age.

The data was first compared by direct inspection then all categorical variables were cross-tabulated and subjected to Chi-squared tests for the significance of differences. Finally, all continuous variables (for example, mandibular opening) were compared using Student's *t*-test.

No systematic significant differences were found between those who left the survey and those who remained, although some small differences between some variables existed. For example, there was a 9 per cent difference between the number of subjects lost to follow-up from social classes 3 and 4 at 15 years of age.

When the subjects were classified according to the original screening categories used to select them, no one group had suffered a disproportionately large number of subjects lost to follow-up. The results are summarized in Table 12.

Discussion

The subjects examined in the study were originally selected because they had a malocclusion.

Thus, one would expect a fairly large proportion of subjects to have received orthodontic treatment during the course of the study. Almost one in five had orthodontic treatment by 15 years of age and another 8 per cent were actively under treatment when they were recalled at 15. The proportion of subjects who were treated with fixed appliances and the proportion treated with removable appliances was fairly similar. In as many as one out of four of the treated cases, problems with patient co-operation or discontinuation of treatment was reported. As has been mentioned in previous papers, no attempts were made to allocate children into treatment and no treatment groups for ethical and practical reasons.

The drop in the number of subjects examined during the course of the study can be explained in part by the limited time available for recall and re-examination. It was considered important to use the same examiners throughout the study in order to reduce variations in the recordings due to disagreement between observers. The examiners were thus called in from different parts of England and from abroad. Thus, subjects not available in the Cardiff area during the examination period could not be included for practical reasons. The overall conclusion from the analysis of differences between the longitudinal group, i.e. the subjects seen at

Table 10 Comparison of prevalence of occlusal interferences, in per cent, between 788 subjects aged 15 years and 456 subjects aged 19 years.

	Males		Females	
	15 years	19 years	15 years	19 years
Unilateral contacts in RP				
right	21	16	23	22
left	33	23	30	21
Lateral deviation RP-IP right				
0 mm	97	91	95	98
<0.5 mm	3	2	5	2
≥0.5 mm	0	1	1	0
Lateral deviation RP-IP left				
0 mm	93	98	95	94
<0.5 mm	6	2	5	6
≥0.5 mm	1	0	1	1
Distance RP-IP				
0 mm	39	27	32	24
1 mm	55	70	63	73
2 mm	5	3	4	3
>2 mm	1	1	1	1
Non-working side interferences: right				
<3 mm	7	10	12	14
>3 mm	14	16	26	16
Non-working side interferences: left				
<3 mm	11	13	11	11
>3 mm	15	16	19	16

19 years of age and the exit groups, i.e. the subjects lost to follow-up at 11 and 15 years is that there is no extensive systematic difference between the groups, although some small differences exist between some variables. None of these are clinically significant. At first sight the degree of sample attrition over the 11 years of the survey is disappointing and 45 per cent of the original sample remain. However, this still represents a sample of 456 subjects followed for 11 years and this is the largest continuously monitored group of subjects for mandibular dysfunction available anywhere. Furthermore, the degree of sample attrition appears not to have biased the results and thus the remaining sample still permits valid analytical conclusions to be drawn.

Anamnestic observations

An increase in prevalence of headache, TMJ clicking and locking, and parafunctional habits from 12 to 15 years of age is followed

Table 11 Comparison of functional occlusal contacts between the 788 subjects aged 15 years and the 456 subjects aged 19 years. Percentage distribution.

	Males		Females	
	15 years	19 years	15 years	19 years
Canine protection				
right	53	58	48	62
left	54	60	47	61
Incisor contact only				
right	7	5	9	6
left	8	12	9	9
Working side contact pairs: right				
0	11	22	12	23
1	63	59	75	61
2	12	6	13	7
3	8	5	8	5
4	4	6	3	4
5	2	3	2	1
6	0	0	0	0
Working side contact pairs: left				
0	7	24	12	27
1	68	62	61	61
2	15	6	15	4
3	6	5	7	3
4	3	3	3	4
5	1	1	2	1
6	0	1	0	0

by a fairly stable period regarding development of symptoms of CMD. The most prevalent symptoms at 15 as well as at 19 years of age are TMJ disorders and headache, and a slight increase in prevalence of frequently occurring symptoms up to 19 years of age is observed. There is a similar female dominance in prevalence at 19 years as was observed 4 years earlier. These observations agree mainly with those reported in follow-up studies by Egermark-Eriksson (1982), Kirveskari *et al.* (1986); and Magnusson *et al.* (1985, 1986). Prevalence of frequent headache, once per week or more often, in the 19-year-olds is in fairly good agreement with figures reported by Molin *et al.* (1976), Magnusson *et al.* (1986), Nilner (1981), and Wänman (1987) for the same age. Difficulties with mouth opening were reported with almost the same frequency as in the study by Magnusson *et al.* (1986), while Wänman (1987) found a much lower prevalence. TMJ clicking was reported more often in this study than in the studies by Magnusson *et al.*

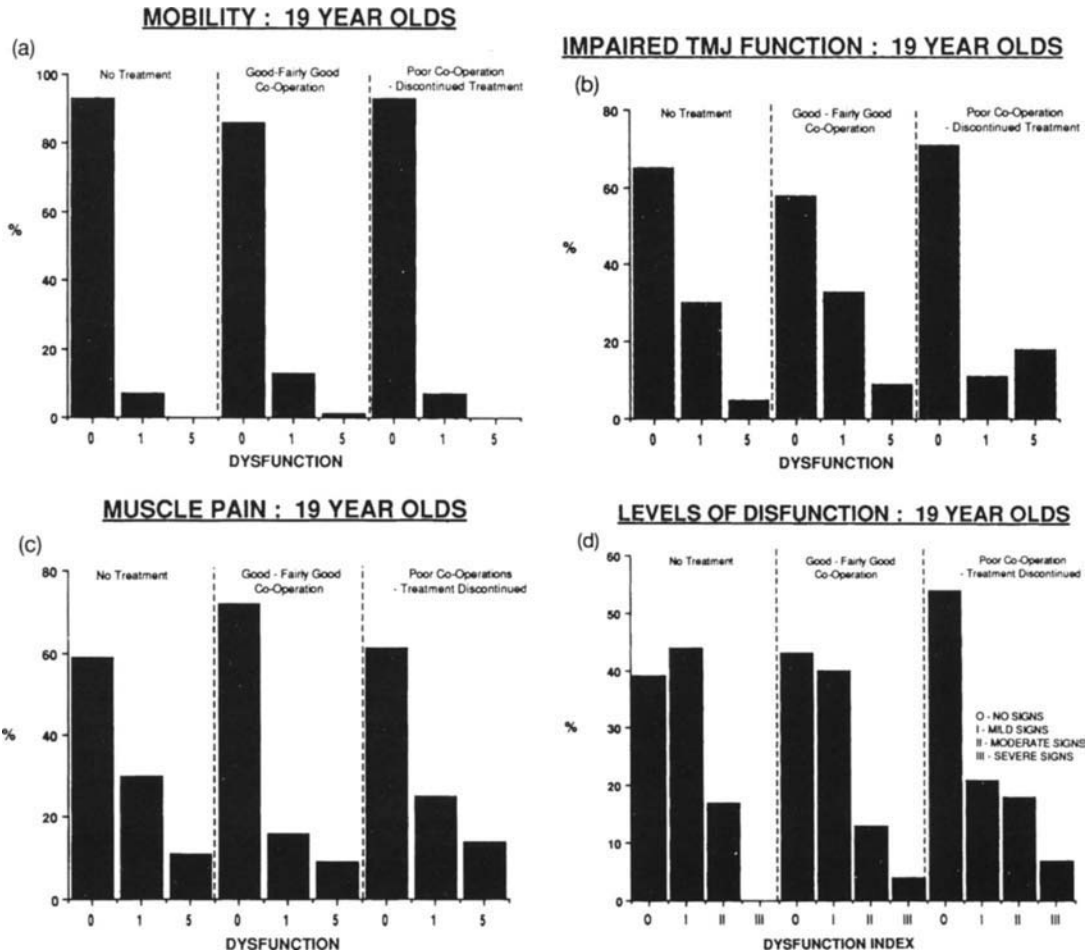


Figure 6 Orthodontically untreated children compared with those who received orthodontic treatment and co-operated well and those who received orthodontic treatment and co-operated poorly. Their functional status is assessed using the Helkimo index (1974) as: 0=no signs, I=mild signs, II=moderate signs and III=severe signs. (A) Mobility. (B) Impaired TMJ function. (C) Muscle tenderness. (D) Dysfunction index.

(1986), Nilner (1981) and Wänman (1987), whereas the prevalence corresponds rather well with the studies by Grosfeld *et al.* (1985) and Molin *et al.* (1976).

Differences in interview technique may, of course, make comparisons between studies uncertain.

It is difficult to tell whether the increase in complaints concerning unstable occlusion between 15 and 19 years of age reflects true occlusal changes or whether it is because the individuals affected have become more conscious of the condition. The clinical recordings do not give the impression of any major occlusal changes taking place during the 4-year period.

Clinical observations

The clinical recordings of the development of CMD signs from 15 to 19 years of age confirm, in general, the anamnestic observations. The main change during this 4-year period is an increased prevalence of impaired TMJ function, while only minor variations were noted regarding, for instance, mobility and tenderness of masticatory muscles on palpation. The findings in this study are broadly in agreement with those of previous studies which dealt with the development of CMD recorded clinically up to 20 years of age (Molin *et al.*, 1976; Egermark-Eriksson, 1982; Grosfeld *et al.*, 1985;

Table 12 The occlusal screening categories used to select subjects at 11 years: the subjects lost to follow up at 11, 15, and 19 years. A comparison with the proportion of subjects in each category.

	Exits 11 years		Exits 15 years		Longitudinal group	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Control	65	6.4	123	12.2	164	16.2
Deep overbite	13	1.3	22	2.2	30	3.0
Prominent incisors	18	1.8	23	2.3	38	3.8
Partial anterior crossbite	40	4.0	51	5.0	71	7.0
Total anterior crossbite	9	0.6	11	1.1	5	0.5
General anterior spacing	8	0.8	9	0.9	20	2.0
Median diastema	2	0.2	4	0.4	7	0.7
Missing incisors	17	1.7	19	1.9	32	3.2
Exposed upper gingiva	8	0.8	12	1.2	18	1.8
Severe anterior crowding	47	4.7	58	5.7	69	6.8
Total subjects						
Chi-squared test: 147						
Degrees of freedom: 18						
Minimum expected frequency: 2.9						
Cells with expected frequency < 5: 3 of 30						
Significance: 0.7						

Magnusson *et al.*, 1986; Wänman, 1987). Nilner (1981), on the other hand, found a higher prevalence of muscle and TMJ tenderness.

The distribution on dysfunction scores in the Helkimo dysfunction index shows only minor differences between the 15- and the 19-year-olds. At the 19 years examination, only about 2 per cent of the subjects have severe signs of CMD. The proportion of subjects without any signs of CMD is similar to those reported by Magnusson *et al.* (1986) and Wänman (1987).

When the recordings of occlusal interferences at 15 and 19 were compared, very small variations were seen. The only difference seemed to be a slight decrease in prevalence of unilateral contacts in RP. Most types of occlusal interferences showed lower prevalence than has been reported in other studies (Nilner, 1981; Egermark-Eriksson *et al.*, 1990; Wänman, 1987). This seems somewhat surprising bearing in mind the selection based on presence of malocclusion in the present study.

There are no major differences in functional contacts recorded between 15 and 19 years of age except a slight increase in the occurrence of canine protection on laterotrusive movements.

This may be a result of orthodontic treatment carried out during this time interval.

Orthodontic treatment

A belief has arisen, that orthodontic treatment frequently causes CMD. Successful legal action has been based on this belief which is in reality based on anecdotal evidence. When studies of the causal effects of orthodontic treatment on the development of CMD are reviewed, there seems to be no support for such an opinion (Larsson and Rönnerman, 1981; Sadowsky and Polson, 1984; Dibbets and van der Weele, 1987, 1992; Greene, 1988; Nielsen *et al.*, 1990; Egermark and Thilander, 1992). Not only did these studies indicate that patients who had received orthodontic treatment were not more severely affected by CMD than those people who had not been orthodontic patients, the studies also showed that orthodontic patients had a somewhat better functional status. When interpreting the effects of orthodontic treatment on function it is important to consider the development of signs and symptoms shown by the present study. The most obvious is an increase in the prevalence of CMD between 12

and 15 years of age. Effects of orthodontic treatment in this context may be confused with what we believe to be normal changes. The histograms for levels of dysfunction were similar between the three co-operating groups. The graphs for muscle pain and mobility are almost identical. The clearest difference is seen in impaired TMJ function where a higher proportion of subjects who had not co-operated well with orthodontic treatment had Helkimo Grade 5 impairment.

Conclusions

The prevalence of signs and symptoms of CMD in subjects with malocclusion followed from 12 to 19 years of age showed the following developments. There is an increase in the prevalence of CMD, especially impaired TMJ function and headache, in the period from 12 to 15 years. From 15 to 19 years, there is continued increase of TMJ disorders in females, but no major changes in the prevalence of CMD in the sample overall. There are only modest differences in the experience of CMD when treated and untreated subjects are compared on the basis of their co-operation with treatment.

Further analysis of changes in CMD as it affects individuals (as opposed to the sample as a whole) and the effects of occlusal changes (including orthodontic treatment) is under way at the present time.

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