# Changes in TMD signs and in mandibular movements from 10 to 15 years of age in relation to articulatory speech disorders

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This study is part of a longitudinal study on the associations between different orofacial dysfunctions. The aim was to determine changes in signs of temporomandibular disorders (TMD) and in mandibular movement capacity in subjects with articulatory speech disorders and in controls by re-examining a sample of 187 previously studied children from 10 to 15 years of age. Articulatory speech disorders were diagnosed by a phoniatrician. Mandibular movement capacity, signs of TMD, occlusal contacts/interference and slide between retruded and intercuspal positions were recorded by a dentist. The follow-up results showed that mandibular mobility mainly increased up to the age of 15, but there was a decrease in protrusion capacity in almost half of the cases. This fluctuation probably reflects the normal changes in growth pattern. Signs of TMDs proved to be inconsistent in nature, especially among the controls. With age, girls in the control group, more so than boys, were prone to new signs of TMD, but no gender difference was found in the group of subjects with misarticulations of speech. The findings indicate that in adolescence different orofacial dysfunctions are related. □ *dysfunction; follow-up study; speech disorders; temporomandibular disorders*

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Mastication, speech, and swallowing are physiological functionings of the masticatory system which are closely related to each other (1). These complex motor behaviors are centrally programmed and peripherically driven movements based on a system of feedback and feedforward information processing (2). Pathofunctions of the masticatory system are nonphysiological patterns of function with inadequate adaptation of one or more components in the orofacial area. Pathofunctions may be expressed as tissue changes, pain and/or abnormal functional patterns (1). In contrast to orthofunctions, parafunctions represent orofacial activities not needed for the normal functions of the masticatory system, such as bruxism.

The speech motor performance of normally developing children is known to improve with age, and children with misarticulations have been reported to have poorer oral motor skills (3) and difficulty in the motor control of speech (4). During recent decades, signs and symptoms of temporomandibular disorders (TMD) in children and adolescents have been studied intensively. Although the overall prevalence of TMD increases with age (5–7), single signs and symptoms are inconsistent in nature (5, 8, 9, 10). Previous results of the present longitudinal study have shown that different orofacial dysfunctions are cumulated to the same children (11–13).

In order to elucidate the aetiology of TMD and of speech misarticulations, and to determine the mechanisms that provoke such disorders in growing individuals, longitudinal investigations are essential. However, it is often difficult to define the borderline between ortho-, para-, and pathofunctions, since their definitions are more or less subjective. Since the prevalence figures of TMD in the literature are mainly high but variable, and single signs and symptoms of TMD fluctuate, the question has been raised whether TMD in children and adolescents should be considered as a health problem at all (14, 15).

The present study determines changes during growth in function of the masticatory system in adolescents with articulatory speech disorders and in the controls by re-examining a sample of 187 previously studied children. The aim of this study was to test the following hypotheses: (i) TMD signs in growing individuals are inconsistent in nature, and (ii) different orofacial dysfunctions such as articulatory speech disorders and signs of TMDs are related to each other in adolescence.

## Material and methods

The present investigation is part of a longitudinal study in which dentofacial growth and development and different orofacial functions, namely articulation of speech sounds, accuracy of oral motor movements, and function of the masticatory system, are being investigated in Finnish schoolchildren. All the children included had participated in the examinations 8 and 5 years earlier as 7- and 10-year-olds. The original study group consisted of two groups of 6 to 8-year-old schoolchildren in Kuopio: first, children diagnosed by special education teachers as having a considerable disorder of speech articulation and who were therefore referred to the Division of Phoniatrics, Department of Otorhinolaryngology, Kuopio University Hospital, and second, all students in the first class of two elementary schools. None of the participants had any additional organic or neurologic disorder. Since the controls were not selected by random sampling, but consisted of all pupils in the first class at two elementary schools in Kuopio, some of these children also had articulatory speech disorders, their occurrence corresponding to the number of misarticulations found in that age cohort of Finnish children. In the Hospital Referral Group (HRG) there were 157 children and in the control group 130 children. In both groups the mean age during the first examination was 7.5 years (SD 0.4). By the second examination, about 3 years later, 68 of these subjects could not participate in the study, which left 219 students for the intraindividual comparisons. At this time the mean age of the children was 10.6 years (SD 0.4). By the third examination, about 5 years later, there were 41 girls and 53 boys in HRG and 50 girls and 43 boys in the control group who had participated in all three stages of the study. The mean age of those adolescents in this third examination was 15.4 years (SD 0.5). With the patient in a supine position, clinical signs of the TMDs were examined by the same dentist, as follows:

### *Palpation of muscles*

Tenderness of the muscles was recorded as "yes" if pain was reported by the patient during palpation. The following muscles were palpated: the anterior and posterior parts and the insertion area of the temporal, the superficial and deep parts of the masseter, the lateral and medial ptrerygoids, the sternocleidomastoid and the posterior digastric (0 = no, 1 = yes for each).

### *Clicking/crepitation of temporomandibular joint (TMJ) and TMJ tenderness on movement*

Irregularities in the movement of the TMJ were reported as "TMJ sounds" if clicking or crepitation sounds could be heard or irregularities over the TMJ area could be palpated during active opening and closing of the mouth (0 = no, 1 = yes). A stethoscope was not used. TMJ tenderness was examined on opening and closing and was recorded as "yes" if pain was noted during palpation. The structures were palpated from the lateral direction (0 = no, 1 = yes).

### *Deviation of the mandible*

Deviation of the mandible on opening and closing (0 = no, 1 = yes) was recorded by the naked eye if it was more than 2 mm from the midline during movement.

### *Mandibular movement capacity*

Recordings were made for maximal interincisal distance on opening, maximal lateral movements to the right and left and maximal protrusion. The distance was measured in millimetres. The changes in movement capacity between the two examinations were also recorded in millimetres. Hypo- and hypermobile movements of the mandible were determined as 2 SD from the mean values of different movements at each of the age groups 7, 10, and 15 years.

### *Occlusal contacts/interference and slide*

Different types of occlusal contacts/interference (0 = no, 1 = yes for each) were recorded with GHM occlusal test foil. Unilateral contact in RCP was recorded if there was a single lateral contact on guided hinge closure. Mediotrusive contact was recorded if there was/were any mediotrusive contact(s) when the laterotrusion ended with contact just between the canines. Protrusive interference was recorded if there were any post-canine contacts preventing symmetric, interincisal contact under protrusive movement. The sagittal and lateral slide between retruded cuspal position (RCP) and intercuspal position (ICP) was recorded in millimetres. Only long ($\geq$2 mm) sagittal RCP-ICP slide (0 = no, 1 = yes) and visible (>0.5 mm) lateral slide (0 = no, 1 = yes) were included in the analyses of the results.

### *Prevalence of articulatory speech disorders*

Prevalence of articulatory speech disorders were recorded clinically by the phoniatrician. Articulatory disorders were recorded during spontaneous speech and test words using Remes Articulation Test (16) for the

Table 1. Prevalence (%) of articulatory speech disorders in 187 Finnish children at the ages of 7, 10 and 15 years

| | Hospital referral group (HRG) ($n = 94$) | | | Control group ($n = 93$) | | |
|---|---|---|---|---|---|---|
| Articulatory speech disorder | 7 years | 10 years | 15 years | 7 years | 10 years | 15 years |
| Sounds produced too far anteriorly | 55 | 56 | 57 | 29 | 44 | 38 |
| Sounds produced too far posteriorly | 19 | 15 | 9 | 2 | 5 | 2 |
| Sounds produced laterally | 5 | 1 | 1 | 2 | 0 | 0 |
| Unclassified variants | 19 | 15 | 10 | 7 | 3 | 3 |

Table 2. Prevalence (%) of signs of temporomandibular disorders in 187 Finnish children at ages 7, 10, and 15 years

| | Hospital referral group (HRG) ($n = 94$) | | | Control group ($n = 93$) | | |
|---|---|---|---|---|---|---|
| Sign of TM disorder | 7 years | 10 years | 15 years | 7 years | 10 years | 15 years |
| Deviation on opening | 11 | 32 | 31 | 14* | 31* | 31* |
| Palpatory tenderness of muscles | 16 | 28 | 18 | 13 | 22* | 12* |
| Palpatory tenderness of TMJ | 2 | 9 | 3 | 2 | 9 | 0 |
| Clicking | 10 | 17 | 7 | 7 | 14 | 7* |

* Statistically significant difference ($p \leq 0.05$) between genders by chi-squared statistics.

Finnish language. Based on errors in place of articulation, misarticulations were categorized into too far anteriorly, too far posteriorly, and laterally produced variants (0 = no, 1 = yes). All misarticulations that did not fit into these categories were classified into the category of unclassified variants. Table 1 gives the prevalences of misarticulations at the ages of 7, 10, and 15 years in the subjects studied. A detailed description of the method has been published (17).

With the present methods, intraexaminer reproducibility for the occlusal recordings and TMD variables was good (18). In the present study, TMD examinations at the ages of 7 and 10 were performed by different observers, interexaminer consistency between those two dentists varying from satisfactory to good; the kappa values were from 0.15 to 0.78, with an agreement of 65–90%. For mandibular movement capacity, the correlation coefficients between examiners varied from 0.61 to 0.85. Since those consistencies were calculated for a small sample (20 children), even a few cases of disagreement between the examiners lowered kappa values markedly. In such cases the percentage agreement characterizes the validity of the method better.

## Statistical methods

Chi-squared statistics or Fisher's exact tests and t-tests were used to analyze the differences in prevalences of single signs of TMD, and in those of occlusal recordings between the HRG and control group, and between girls and boys. In addition, the Wilcoxon matched-pairs signed-ranks test was used for analysis of differences between the two examinations of TM disorders and occlusal recordings within each group. Paired $t$ test was used to estimate differences in mandibular movement capacity between the second and third examinations. For all comparisons, $p$ values $\leq 0.05$ were considered to be statistically significant.

## Results

Throughout the study, children of the HRG tended more often to have signs of TMD, occlusal precontacts, and RCP-ICP slide than the controls (Tables 2 and 3). The differences between the groups were statistically significant for unilateral contact in RCP, RCP-ICP slide, and for lateral slide among 7-year-olds. Long ($\geq$2 mm) sagittal RCP-ICP slide was quite common among 7-year-olds, but it almost totally disappeared with age. Further, unilateral contact in RCP became more prevalent with age; 90% of the adolescents had those precontacts.

In the HRG, the only statistically significant difference between genders was in unilateral contact in RCP at the age of 15 years. Those precontacts were more common in girls than in boys. In the control group, girls significantly more often than boys had deviation on opening in every examination, palpatory tenderness of the masticatory muscles at ages 10 and 15, and clicking at age 15 (Tables 2 and 3).

Table 4 gives the changes in TMD signs from 10 to 15 years in both groups. Wilcoxon matched-pairs signed-ranks tests within each group showed that in palpatory tenderness of the masticatory muscles and of TMJ, and in clicking among the controls, the signs fluctuated signifi-

Table 3. Prevalence (%) of occlusal recordings in 187 Finnish children at ages of 7, 10, and 15 years

| | Hospital referral group (HRG) ($n = 94$) | | | Control group ($n = 93$) | | |
|---|---|---|---|---|---|---|
| | 7 years | 10 years | 15 years | 7 years | 10 years | 15 years |
| Unilateral contact in RCP | 73** | 77 | 94* | 50 | 72 | 91 |
| Protrusive interference | 63 | 29 | 39 | 53 | 20 | 27 |
| Mediotrusive contacts | 51 | 29 | 37 | 53 | 27 | 28 |
| RCP-ICP slide ($\geq$2 mm) | 38** | 2 | 2 | 24 | 0 | 1 |
| Slide with lateral deviation (>0.5 mm) | 36** | 14 | 18 | 22 | 13 | 11 |

* Statistically significant difference ($p \leq 0.05$) between genders by chi-squared statistics.
** Statistically significant difference ($p \leq 0.05$) between HRG and control group by chi-squared statistics.

Table 4. Changes (%) in signs of TM disorders from 10 to 15 years of age among 187 Finnish children

| | Hospital referral group (HRG) ($n = 94$) | | Control group ($n = 93$) | |
|---|---|---|---|---|
| Sign of TM disorder | % | $p$* | % | $p$* |
| Deviation on opening | | 0.86 | | 1.00 |
| Sign disappeared | 18 | | 15 | |
| New sign | 17 | | 15 | |
| Consistent sign | 14 | | 16 | |
| Palpatory tenderness of muscles | | 0.06 | | 0.05 |
| Sign disappeared | 17 | | 16 | |
| New sign | 7 | | 7 | |
| Consistent sign | 11 | | 5 | |
| Palpatory tenderness of TMJ | | 0.10 | | 0.01 |
| Sign disappeared | 7 | | 9 | |
| New sign | 2 | | 0 | |
| Consistent sign | 1 | | 0 | |
| Clicking | | 0.06 | | 0.04 |
| Sign disappeared | 17 | | 10 | |
| New sign | 7 | | 2 | |
| Consistent sign | 0 | | 4 | |

* Significance of the change by Wilcoxon matched-pairs signed-ranks test.

cantly. In the HRG the changes in TMD signs were not statistically significant.

Changes in occlusal recordings were similar in both groups (Table 5). The changes in unilateral contact in RCP in both groups and in protrusive interference in the HRG were statistically significant.

Mandibular movement capacity mainly increased between the age of 10 and 15 years (Table 6). In maximal opening, the increase was discernible in almost 90% of the adolescents, but in protrusive movement in only 33% of the participants. The increase in laterotrusive movements was larger in HRG than in the control group. This increase was found in about 70% and 60% of cases, respectively. Regarding the decrease in movements, it was remarkable that in about 40% of the adolescents the protrusive capacity decreased during the 5-year period. Changes in all mandibular movements except in protrusive capacity were statistically significant in both groups.

## Discussion

Dropout of subjects, which cannot be avoided in longitudinal studies, was mainly due to relocation away from

Table 5. Changes (%) in occlusal recordings from 10 to 15 years of age among 187 Finnish children

| | Hospital referral group (HRG) ($n = 94$) | | Control group ($n = 93$) | |
|---|---|---|---|---|
| | % | $p$* | % | $p$* |
| Unilateral contact in RCP | | 0.00 | | 0.00 |
| Disappeared | 4 | | 3 | |
| New | 21 | | 23 | |
| Consistent | 72 | | 69 | |
| Protrusive interferences | | 0.04 | | 0.20 |
| Disappeared | 7 | | 9 | |
| New | 18 | | 15 | |
| Consistent | 21 | | 12 | |
| Mediotrusive contacts | | 0.13 | | 0.84 |
| Disappeared | 11 | | 12 | |
| New | 19 | | 13 | |
| Consistent | 18 | | 15 | |
| RCP-ICP slide | | 1.00 | | 0.32 |
| Disappeared | 2 | | 0 | |
| New | 2 | | 1 | |
| Consistent | 0 | | 0 | |
| Slide with lateral deviation (>0.5 mm) | | | | |
| Disappeared | 9 | 0.37 | 5 | 0.48 |
| New | 13 | | 3 | |
| Consistent | 5 | | 8 | |

* Significance of the change by Wilcoxon matched-pairs signed-ranks test.

Table 6. Changes (%) in mandibular movement capacity from 10 to 15 years of age among 187 Finnish children

| | Hospital referral group (HRG) ($n = 94$) | | Control group ($n = 93$) | |
|---|---|---|---|---|
| Movements of the mandible (mm) | % | $p$* | % | $p$* |
| Maximal opening | | | | 0.00 |
| Increase | 84 | | 89 | |
| Unchanged | 5 | | 7 | |
| Decrease | 11 | | 4 | |
| Maximal laterotrusion to the right | | 0.00 | | 0.00 |
| Increase | 75 | | 65 | |
| Unchanged | 17 | | 24 | |
| Decrease | 9 | | 12 | |
| Maximal laterotrusion to the left | | 0.00 | | 0.00 |
| Increase | 67 | | 59 | |
| Unchanged | 21 | | 24 | |
| Decrease | 12 | | 17 | |
| Maximal protrusion | | 0.00 | | |
| Increase | 35 | 0.36 | 31 | 0.45 |
| Unchanged | 26 | | 24 | |
| Decrease | 39 | | 45 | |

* Significance of the change by paired $t$-test.

the district and partly to unwillingness to come to the examinations. Between the first and second examinations, the dropout rate in the HRG was twice as high as among the controls, which might partly have been due to overexposure to care. The distribution of articulatory errors and TMD signs in the remaining sample did not differ from the whole sample during the first examination. The number of dropouts did not therefore significantly affect the results.

More important than just reporting the prevalences of single signs and symptoms of TMD in different age groups is finding out if a certain sign is important clinically, e.g., whether it reflects pathofunction or is predictive of later TM problems. On the other hand, often it is difficult to separate mild signs/symptoms of dysfunction from a normal condition, since growth itself in some cases has been suggested to manifest in signs/symptoms that are similar to TM disorders (13, 15). For example, young children often lack the ability to make a normal, straight opening and closing movements of the jaw upon request (19), which may reflect poor control of the orofacial movements due to muscle immaturity (20). It has also been shown that different orofacial dysfunctions cumulate to the same children (12, 13, 21). In order to identify individuals at high risk of development of TMD, each of the possible etiologic factors and their interactions should be evaluated thoroughly.

In some studies, 11–15 years of age has been reported to be a “calm” period with no increase in the prevalence of subjective symptoms (5, 9). In the present study, however, during the mixed dentition (10-year-olds) there were more manifestations of TMD than there were some years before (10) or after, as reported in this paper, which parallels the previous results in Finnish children (22). In agreement with the studies on Swedish children and adolescents (23), the prevalence of mediotrusive contacts and protrusive interference in the present sample was higher among 7-year-olds than that in 10-year-olds, but increased again by the age of 15 years. This fluctuation in interference most likely reflects occlusal changes during dental development. A high prevalence of unilateral contacts in RCP, which were rarely related to long sagittal RCP-ICP slide, especially among 15-year-olds, raises the question of the pathology of those precontacts as predisposing factors for TMD.

In agreement with the results reported from earlier stages of this longitudinal study (11, 12), occlusal interference in the permanent dentition was more prevalent in adolescents with misarticulations of speech than in the controls. Since the interference among 7-year-olds, but not among 10-year-olds, was associated with certain misarticulations (12, 13), we previously speculated that interference might have disturbed the development of peripheral mechanism of speech motor control, but as fine motor control of the orofacial muscles matured with age, the adaptation to peripheral factors had probably increased (24). The high prevalence of precontacts in subjects with problems producing speech in the correct place of the mouth (the HRG) might indicate that a deviant pattern of jaw functioning results in subsequent reduction of functional wear of the teeth. On the other hand, certain malocclusions, which are often related to occlusal interference, are likely to increase the risk of deviant speech (25). In the previous part of the present study, dental malocclusions were not related to any speech disorders among 7-year-olds, but they became more obvious explanations for articulatory speech disorders with age (13).

The results of this study concur with previous reports (9, 26) that towards adolescence girls are more likely to suffer from TMD than boys. Unlike the 15-year-old controls, however, no clear difference in TM disorders between genders was found in the HRG. Regarding changes in single signs of TMD with age, it was found that these fluctuated significantly more among the controls than in HRG. These results suggest that different orofacial dysfunctions are related to each other also in adolescence, supporting authors' previous conclusions concerning children (12, 13).

Clinically, it has been observed that most of the treated cases of TMD are women, and the age of experienced pain onset due to TMD is almost always after puberty (27). It has been demonstrated that there are some gender differences in the jaw musculature's fiber composition (28), as well as in EMG output (29). These findings might partly explain earlier exhaustion and pain in the musculature of females than in that of males (30). Hanson (31) has suggested that TM joints in women are more stable morphologically, whereas in men they are more adaptive even before condylar growth has ceased. On the other hand, in some studies (32, 33) the gender difference on TMD is suggested to be mainly due to psychosocial factors. In the present report we did not evaluate those factors, but since girls in this non-patient population were more prone to having TMDs during *clinical* examination compared to boys, especially among the controls, we consider the gender difference to be mainly due to organic/hormonal factors.

The opening capacity of the mandible has been noted to increase until 12 to 15 years of age (5, 34, 35). On the other hand, there are findings that, during growth, certain movements of the jaw are larger than they will be later when growth has ceased (34, 36). The present results parallel those studies, since mandibular movement capacity mainly increased between the ages of 10 and 15 years, but protrusion movements, in particular, decreased in almost half of the cases. The previous findings of this longitudinal study (10, 11) showed that at the age of 7 years the maximal opening capacity in children referred to speech therapy was smaller, while their lateral and protrusive movements were larger than those of the controls. By the age of 10 years, these differences between the groups levelled off, since lateral movements decreased more often in HRG than in the controls, especially in boys. In the last stage of present study, following the same children up to 15 years of age, lateral movements increased again more often in the HRG than in controls. This fluctuation in mandibular movements probably reflects the normal changes in growth pattern suggested above, but the developmental "timetable/timing" in children with and without speech disorders might be different. As reported previously, children with misarticulations seem to have poorer oral motor skills (3, 21) than children without speech problems.

In summary, single signs and symptoms of TMD fluctuated between the ages of 10 and 15 years, especially among the controls. With age, girls were more prone to have certain signs of TMD compared to boys. Gender difference in TMD was evident among the controls but not in the HRG. These findings signify that even in adolescence different orofacial dysfunctions are related to each other. The results strengthen the hypothesis of this study that TMDs in growing individuals are for the most part inconsistent in nature, and different orofacial dysfunctions are positively related. These findings should be borne in mind when the decision is made for the need for clinical treatment on TMD signs in growing individuals. In future research trying to differentiate developmental variation from pathological changes, the predictive value of the early signs of different orofacial dysfunctions, malocclusions, and occlusal interferences for the development of signs of TMD in adolescense will be evaluated.

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