Mandibular movement capacity in 19-year-olds with and without articulatory speech disorders

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Associations between articulatory speech disorders and mandibular movement capacity, as well as between malocclusions and jaw movements, were examined in two groups of adolescents, i.e. 52 individuals with and 45 without misarticulations of speech. The mean age of the whole sample was 19.2 years. Articulatory speech disorders and functioning of the speech articulators were diagnosed by a phoniatrician. Mandibular movement capacity, malocclusions, occlusal interferences, and signs of temporomandibular dysfunction were recorded by an orthodontist. Multiple regression analyses showed that subjects with articulatory speech disorders were likely to have smaller opening capacity than subjects with a correct speech articulation. Excessive overjet, lateral cross bite, and a tendency to anterior open bite were associated with large movements of the jaw. These results suggest that in young adulthood mandibular movement capacity seems to vary depending on occlusion and is related to misarticulations of speech. □ *Dysfunction; malocclusions: mandibular movement capacity; misarticulations of speech*

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Mouth-opening capacity is regarded as a sensitive parameter reflecting the functional status of the masticatory system (1–4), although it has been criticized for providing information about condylar rotation rather than translation of it (5). While on the one hand hypomobility of the mandible is considered to be a sign of temporomandibular dysfunction (TMD) (3, 4), on the other hand internal derangement of the temporomandibular joint (TMJ) may be regarded as a symptom of general joint hypermobility syndrome (6).

Mouth-opening capacity increases with age, but after cessation of growth only minor changes in maximal jaw opening have been reported (7). The previous results of this longitudinal study (8, 9) showed that in childhood the mandibular movement capacity in children with articulatory speech disorders differed from that of the controls; they also had more problems in oral motor skills than the controls did (10). Since different orofacial dysfunctions seemed to cumulate to the same children during growth (11), we investigated whether articulatory speech disorders could be associated with mandibular movement capacity also in young adulthood. The aim of this study was to test the following hypotheses: 1) In young adulthood there is a relationship between articulatory speech disorders and mandibular movement capacity, and 2) jaw movements are related to occlusion.

Materials and methods

The present investigation is the fourth part of a longitudinal study, started in 1986 by Dr. M. T. Laine, on different orofacial dysfunctions among Finnish schoolchildren. Originally, the study included 287 first-graders divided into two subgroups: 157 children diagnosed by special education teachers as having articulatory speech disorders, and therefore referred to phoniatric consultation at Kuopio University Hospital (Hospital Referral Group, HRG), and 130 first-graders of two elementary schools in Kuopio (Control Group, CG). Since the controls represented one age cohort, some of these children also had articulatory speech disorders, the prevalence of which corresponds to the amount of misarticulation found in the age cohort of Finnish children. The subjects were re-examined at the ages of 10, 15, and 19 years. During the first examination, the mean age of the children was 7.6 years (SD 0.4), in the second 10.6 years (SD 0.4), in the third 15.4 years (SD 0.5), and in the fourth examination 19.2 years (SD 0.5). There were 48 subjects in the original HRG and 49 participants in the CG who attended all four examinations. Since there were no significant differences between the original groups in the prevalence of articulatory speech disorders or in TMD at the age of 19 years, the groups were combined for the present statistical analyses. To investigate the effect of speech misarticulation on mandibular movement capacity in 19-year-olds the sample was redivided into two groups; a group of 26 women and 26 men who had speech misarticulation of some kind, and a group of 28 women and 17 men with correct articulation. The study was approved by the Ethics Committee of the University of Kuopio in 1986.

In this study, articulatory speech disorders were clinically diagnosed by the phoniatrician in accordance with the criteria described by Laine et al. (12). Based on errors in place of articulation, misarticulations were

Table 1. Mandibular movement capacity during growth in 97 Finnish adolescents with and without articulatory speech disorders

	Subjects with articulatory disorder (n = 52)				Subjects without articulatory disorder (*n* = 45)			
Movements of the mandible	At the age of 7 years	At the age of 10 years	At the age of 15 years	At the age of 19 years	At the age of 7 years	At the age of 10 years	At the age of 15 years	At the age of 19 years
Maximal opening								
Mean (mm)	43.7*	48.8*	52.8*	52.2	45.8*	51.6*	55.6*	54.2
SD	3.6	4.6	5.9	6.3	4.8	4.3	5.5	6.0
Maximal laterotrusion to the right								
Mean (mm)	8.5	9.2	10.5	9.8	8.4	9.6	10.6	10.0
SD	2.3	1.5	1.4	2.0	1.7	1.4	1.4	2.0
Maximal laterotrusion to the left								
Mean (mm)	8.3	9.8	11.2	10.5	8.3	10.0	10.9	10.3
SD	2.0	1.3	1.5	2.1	1.7	1.3	1.7	1.7
Maximal protrusion								
Mean (mm)	8.0	9.9	9.9	9.7	8.2	10.0	10.0	9.3
SD	1.8	1.7	1.6	1.8	2.0	1.3	1.6	1.8

* Statistically significant difference between subjects with and without articulatory disorders.

categorized into too anteriorly, too posteriorly, and laterally produced sounds. All remaining misarticulations were categorized as unclassified variants. Functioning of the longitudinal and other than longitudinal muscles of the tongue, that of the lips and the circumoral muscles, during 19 different tasks was judged to be accurate, inaccurate, or failed. Coordination of the repeated movements was assessed to be accurate if the subject was able to repeat the movement more than 5 times in 10 seconds. The detailed description of the methods has been published (10, 13)

Occlusion was registered clinically in the intercuspal position in accordance with the criteria described by Björk et al. (14), but with slight modifications (15). In summary, distal or mesial molar occlusion was recorded when there was a deviation of at least one-half cusp width bilaterally. Overjet and overbite were measured in millimeters. Lateral open bite, determined as a visible space between one or more antagonistic buccal teeth in the intercuspal position, lateral cross bite, and scissors bite were registered for the premolars and molars.

With the patient in a supine position, clinical signs of TMD (jaw deviation on maximal opening, palpatory tenderness of the masticatory muscles and that of the TMJ, TMJ sounds such as clicking and crepitation, and palpable asynchrony in condylar movements during mouth opening), mandibular mobility (maximal inter-incisal distance, maximal laterotrusion to the right and left and maximal protrusion), mediotrusion contacts, retrusion and protrusion interferences, and a slide between the retruded contact position (RCP) and intercuspal position (ICP) were registered. For the maximal opening inter-incisal distance, both with and without overbite were measured in millimeters, for the maximal protrusion overjet was added in the measurement. Maximal opening with overbite was used in multiple regression analyses while maximal opening without overbite was used in *t* tests, since overbite was not measurable in most of the 7-year-olds because of the early mixed dentition. These methods have been described in detail previously (8, 16). In addition, subjects were asked about previous traumas of the orofacial area.

In the present longitudinal study, clinical recordings of TMD and mandibular movement capacity at the age of 7 were performed by a different dentist from the one who did the recordings at the later stages. With the present method, correlation coefficient for maximal opening across the examiners has proved to be good, varying from 0.96 to 0.99 (17).

Statistical methods

The differences in mandibular mobility between the groups were analyzed by *t* tests. Multiple regression analyses were used to estimate the associations between mandibular movement capacity at the age of 19 years (maximal opening, maximal laterotrusion as the mean of the movements to the left and right, and maximal protrusion) and articulatory speech disorders, functioning of the speech articulators, malocclusions, TMD, occlusal interferences and trauma of the orofacial area. The effect of gender was also considered. Variables for which the prevalence was $<5\%$ (palpatory tenderness of TMJ, crepitation of TMJ, RCP-ICP slide, lateral open bite, scissors bite) were excluded from the models. Regression coefficient represents the relationship between dependent and independent variables, e.g. how much and to what direction (sign $+/-$) the independent variable changes when the dependent variable increases. For all comparisons, P values ≤ 0.05 were considered to be statistically significant.

Results

In both groups with and without misarticulations of speech the adult level in maximal opening and in lateral movements had been reached by the age of 15 years, in protrusion capacity even before, by the age of 10 years

Table 2. Relationship between maximal opening capacity (mm) and independent variables* in 97 Finnish adolescents estimated by multiple regression model

Independent variable	Regression coefficient	P
Articulatory speech disorder	−2.6	0.03
Lateral crossbite	5.0	0.02
Deviation on opening	−3.1	0.03
Asynchrony of condylar movement	3.3	0.02
Gender	2.5	0.04

$R^2 = 0.170$
* Articulatory speech disorder (0 = no, 1 = yes), problems in movements or in coordination of speech articulators (0 = no, 1 = yes), molar occlusion (1 = distal, 2 = normal, 3 = mesial), overjet (mm), overbite (mm), lateral crossbite, palpatory tenderness of muscles, clicking, deviation on opening, asynchrony of condylar movement, protrusion interference, mediotrusion contact, trauma (0 = no, 1 = yes), gender (0 = girls, 1 = boys). Only statistically significant variables are listed.

(Table 1). Furthermore, there seemed to have been some decrease in movement capacity between the ages of 15 and 19 years. Subjects with articulatory speech disorders at the age of 19 had had a statistically significantly smaller opening capacity of the jaw at the ages of 7, 10, and 15 years compared to the subjects with a correct articulation in young adulthood.

Multiple regression analyses showed that, regarding malocclusions, lateral cross bite had a positive relationship with maximal opening and lateral movement capacities (Tables 2 and 3), and excessive overjet with laterotrusion and protrusion movements (Tables 3 and 4). An association between overbite and maximal protrusion was negative, as well as between mediotrusion contacts and laterotrusion capacity.

Furthermore, subjects with an articulatory speech disorder had a smaller opening capacity than those with correct articulation, and the maximal openings in males were larger than those in females. Jaw deviation on maximal opening was negatively related to opening capacity, while asynchrony of condylar movement was positively related. In addition, large lateral movements of the jaw increased the risk for palpatory tenderness of the masticatory muscles.

Table 3. Relationship between maximal laterotrusion capacity (mm) and independent variables* in 97 Finnish adolescents estimated by multiple regression model

Independent variable	Regression coefficient	P
Lateral crossbite	1.7	<0.01
Overjet	0.2	0.04
Mediotrusion contact	−0.8	0.02
Palpatory tenderness of muscles	1.0	0.02

$R^2 = 0.322$
* See Table 2.

Table 4. Relationship between maximal protrusion capacity (mm) and independent variables* in 97 Finnish adolescents estimated by multiple regression model

Independent variable	Regression coefficient	P
Overjet	0.5	<0.01
Overbite	−0.4	<0.01

$R^2 = 0.221$
* See Table 2.

Discussion

About half of the subjects of the present sample were diagnosed at the age of 7 years as having a considerable disorder of speech articulation and were therefore referred to phoniatric consultation; the other half served as controls. None of the participants had any additional organic or neurologic disorder. With age, the differences in the prevalence of misarticulation between the groups leveled off; certain misarticulations tended to turn milder or improve, but there was also an increase, especially in /s/ sounds among the controls, probably reflecting the manner of speaking in this age group (18). In addition, there were 24 subjects who had a history of (minor) trauma in the orofacial area by the age of 19 years, but traumas did not seem to have an effect on mandibular movement capacity.

The present study showed that in protrusion movement the adult level was reached earlier, by the age of 10 years, than that in maximal opening and in laterotrusion movements. In addition, mandibular movements seemed to have been largest at about the age of 15 years, a finding in parallel with the other studies (1, 3). A previous part of this longitudinal study showed some reduction on protrusion capacity already between the ages of 10 and 15 years (16). Functionally, it has been realized that the masticatory pattern changes by the age of 10–12 years, showing less lateral excursion on opening than in childhood (19, 20). These findings most likely reflect the neurophysiological maturation of orofacial functions in concomitance with morphological growth changes.

In retrospect, it seemed that subjects with articulatory speech disorders at the age of 19 years had had significantly smaller jaw openings at the ages of 7, 10, and 15 years than those without misarticulation. Also multiple regression analyses in 19-year-olds showed that subjects with a deviant speech sound production are likely to have a smaller maximal opening than subjects with correct articulation. As reported previously (8), the maximal opening capacity in children referred to speech therapy was less at the age of 7 years, while the lateral and protrusion movements of these children were larger than those of the controls. Also the fluctuation pattern of those movements during growth was unlike in the groups (9, 16). These findings indicate that there is similarity in neuromuscular programming strategy in different functional jaw movements. It is suggested that deviations in this otherwise healthy population reflect an inadequate compensation mechanism or poor fine motor control of the neuromuscular system. Although control of the speech articulators has been reported to increase markedly in normally developed children by the age of 10 to 11 years (21, 22), it is suggested that some improvement in oral motor skills may still occur in the late teens (23).

Furthermore, the results showed that subjects with an excessive overjet or lateral crossbite seemed to have large mandibular movements. Those two malocclusal traits are often combined in persons with a long and narrow maxillary arch, e.g. A II division 1 malocclusion, which thus seems to favor wide paths/courses of the jaw for different function, speech articulation and mastication. This finding is parallel to an axiographic study by Zimmer et al. (24), who found that Class II patients were able to move their jaws further forward and sideways than patients with a Class III or even Class I sagittal molar relationship.

In addition, an anterior open bite tendency seemed to predispose to large protrusion capacity, a finding that agrees with the study of Ingervall (2), who stated that at least in children the range of lateral and protrusive movements of the jaw is large in persons with a triangular shape of the face with the TMJs situated far posteriorly, e.g. persons who are likely to have a skeletal open bite. On the contrary, Anders et al. (25) found in their axiographic evaluation that Class II/2 (deep overbite) patients have increased mobility in mandibular protrusion compared to controls.

Furthermore, mediotrusion contacts seemed to increase the risk for reduced lateral mobility of the jaw. Mediotrusion contacts are usually found in subjects with an anterior open bite or mesial molar occlusion. It has previously been found that even mild Class III occlusions are considered to predispose to some difficulties in orofacial functional movements, e.g. during speech articulation (26). To conclude, it seems that physiologically mandibular mobility is related to occlusion and most likely to skeletodental morphology. However, it may be overly optimistic to aim to change that pattern with orthodontic treatment.

Interestingly, asynchrony of condylar movements was positively related to jaw hypermobility, but deviation on opening was negatively related to it, indicating that the etiology of those ‘signs’ is different. Jaw deviation on opening during growth has been reported to partly reflect immaturity/inaccuracy in oral motor skills (11), while condylar asynchrony is likely to be caused by internal derangement of the TMJ (27).

In conclusion, it seems that in young adulthood how large the mandibular movements are depends on the occlusion. On the other hand, mandibular movement capacity is still somehow related to misarticulations of speech.

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