Original Article

Growth-Related Differences in Maximum Laterotrusion and Retrusion between Children and Adults

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ABSTRACT

Objective: To test the null hypothesis that there are no differences between children and adults in maximum laterotrusion and maximum retrusion on the right and left sides.

Materials and Methods: This population-based study included 81 randomly selected children between the ages of 6 and 10 years and 67 adults. Kinematic variables were measured with the ultrasonic JMA-System for registration.

Results: The mean maximum laterotrusion of the children's group (10.6 $\pm$ 1.5 mm on the left, 11.0 $\pm$ 1.7 mm on the right) was significantly smaller than that of the adult group (11.7 $\pm$ 2.0 mm on the left, 12.2 $\pm$ 1.7 mm on the right). The maximum laterotrusion of the children's group corresponded to about 90% on the left and right sides of that of the adult group. The mean maximum retrusion of the children's group was significantly bigger than that of the adult group. There, the adult values corresponded to 66.7% on the left and 50% on the right side of the children's values. No significant difference in maximum laterotrusion and retrusion was noted on the right and left sides, and no significant differences according to gender specificities were observed in either group.

Conclusions: The hypothesis is rejected. In development of the temporomandibular joint, maximum laterotrusion on the right and left sides increases significantly with age, and maximum retrusion decreases significantly with age. (*Angle Orthod.* 2009;79:265–270.)

KEY WORDS: Laterotrusion; Retrusion; Temporomandibular joint; JMA-System; Growth-related differences

INTRODUCTION

The range of movement of the mandible is a valuable measure in the examination of patients with suspected functional disorders of the masticatory apparatus.[1–3] Study of the normal function and development of mandibular movements with age is an essential part of any physiologic study of the stomatognathic system and contributes to determination of differences in suspected functional disorders. Also, during treatment, it may be important to measure the range of mandibular movement to assess effects of therapy and to evaluate treatment progress.[4]

With the development of electronic registration systems, several studies,[5–7] most of which consisted of adults, were conducted to record condylar movement. Depending on the choice of condylar reference points, the shape and distance of the condylar curvilinear pathways may be greatly affected during lateral movement by the presence of rotatory components.[8]

Many authors have discussed the physiologic play or tolerance area within the joint in which the condyles can move freely under the control of the neuromuscular system.[9–12] Although several studies about maximum laterotrusion and retrusion in adults have been published,[10,13–15] studies on the functional development of the temporomandibular joint during childhood and changes in joint shape during the growth period are lacking. Wright and Moffett[16] and Carlson[17] described

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Table 1. Demographic Parameters of the Children's Group and the Adult Group Examined in the Present Study[a]

Age Group	N	Age, y				
		Mean	SD	Median	Min	Max
Children	81	8.7	1.3	8.6	6.3	10.6
Adults	67	29.2	6.1	28.5	18.0	44.6

[a] Max indicates maximum; Min, minimum; and SD, standard deviation.

in detail the histomorphology and form of the temporomandibular joint from birth through young adulthood. However, only few studies with different registration methods that described changes in temporomandibular joint kinematics in children during the growth period have been published.[7,18–20]

The purpose of the present investigation was to test the null hypothesis that there is no difference between children and adults in maximum laterotrusion and retrusion on the right and left sides. Maximum laterotrusion and retrusion were quantified in a children's group and in an adult group with the use of an electronic registration system, and changes were evaluated according to growth. The aims of this study were first to report and second to compare the mean values of maximum laterotrusion and retrusion on the right and left sides of a group of children versus those of an adult group and to evaluate changes according to growth.

MATERIALS AND METHODS

Patients

The examined group was composed of two major groups (Table 1). In this population-based study, the first group comprised 81 randomly selected children with age ranging between 6.3 and 10.6 years and an average age of 8.7 years. The examination was conducted in an elementary school in Germany.

The second group was composed of 67 randomly selected adults who ranged in age from 18 to 44 years, with an average age of 29.2 years. All adults had complete permanent dentitions with no missing teeth. The gender distribution of children and adults was equal.

All experiments were conducted by one examiner with the understanding and written consent of each subject. Before the instrumental functional analysis test was performed, the temporomandibular joints of all patients were examined according to the Modified Hamburg CMD-Screening craniomandibular dysfunction (CMD) Test.[21] None of the children or adults had any symptoms of functional disorders. No pain was noted upon palpation, and no muscular pain was reported by any examinees. All subjects showed a neutral class I position with no orthodontic treatment history.

Figure 1. The JMA-System mounted on the head of a patient. 1: Lower frame with three built-in ultrasonic transmitters, fixed with a functional occlusion metal clutch to the lower anterior teeth. 2: Upper frame with four built-in receiving sensors (reproduced with the kind permission of Zebris Medical GmbH, Isny, Germany).

Instrumental Function Analysis

Condylar and mandibular movements were recorded with the JMA-System (Jaw Motion Analyzer, Zebris Medical GmbH, Isny, Germany), which is a contactless and remote from the joint ultrasonic registration system. Information on the accuracy and performance of this method has been introduced in previous publications.[5,7,22] Sequential ultrasonic pulses are transmitted at a frequency of 40 Hz[23] between a sending device mounted on the lower anterior teeth with CronMix K Plus (Merz Dental GmbH, Lütjenburg, Germany) and a receiver mounted on the forehead (Figure 1).

Before the registration process was started, the delineation of a reference plane for the WinJaw software program (Zebris Medical GmbH, Isny, Germany) was carried out. The kinematic center as described by Yatabe et al[24] was chosen as a condylar reference because of the translatory and rotatory nature of mandibular movements.

In the functional analysis test, all subjects performed three maximum left and right lateral jaw movements that were not manipulated and tooth guided. Each movement was repeated more than once to allow for more accurate readings. Three-dimensional movements were calculated with WinJaw, version 10.05.03.

Statistical Analysis

Documentation and statistical analysis of recorded data were carried out with the Statistical Package for the Social Sciences (SPSS), version 15.0 for Windows

Table 2. Descriptive Statistics for Right and Left Maximum Laterotrusion and Right and Left Maximum Retrusion (all measurements in mm) for the Children's Group and the Adult Group[a,b]

Variable	Age Group	N	Distance, mm					*P* (Mann-Whitney)
			Mean	SD	Median	Min	Max	
Right laterotrusion	Children	81	11.0	1.7	11.0	5.3	15.1	< 001*
	Adults	67	12.2	1.7	12.5	7.7	15.4	
Left laterotrusion	Children	81	10.6	1.5	10.6	7.0	14.9	.001*
	Adults	67	11.7	2.0	11.6	8.4	15.7	
Right retrusion	Children	81	0.6	0.6	0.4	0	2.7	.008*
	Adults	67	0.3	0.3	0.2	0	1.1	
Left retrusion	Children	81	0.6	0.6	0.4	0	3.0	.013*
	Adults	67	0.4	0.3	0.3	0	2.0	

[a] Differences between the adult and children's groups were tested for significance with the Mann-Whitney *U*-test.
[b] Modified table from the Statistical Package for the Social Sciences (SPSS; SPSS Inc, Chicago, Ill).
* Significant difference compared with the adult age group ($P \leq .05$).

(SPSS Inc, Chicago, Ill). Data were presented graphically by box and whisker-plots with the use of SigmaPlot 10.0 (Systat Software GmbH, Erkrath, Germany). Results were considered significant at $P \leq .05$.

RESULTS

Maximum Laterotrusion

The maximum laterotrusion of the right and left sides in the group of children and in the adult group is shown in Table 2. The mean maximum laterotrusion in the children's group was 11.0 mm on the right side and 10.6 mm on the left side. As can be seen on the box-plots (Figure 2), the maximum laterotrusion in the adult group exceeded that in the group of children.

The mean maximum laterotrusion of the group of children on the right side was 90.2% of the mean maximum laterotrusion on this side in the adult group. On the left side, the mean of the group of children corresponded to 90.6% of the adult value. The Kolmogorov-Smirnov test showed a normal distribution of the data, and Levene's test showed no homogeneity of variances. Therefore, significance was tested with the Mann-Whitney *U*-test. A significant difference between the children's group and the adult group was found in maximum laterotrusion on the right ($P < .001$) and left ($P = .001$) sides.

Even though the maximum lateral movement was numerically bigger to the right side than to the left side, no statistically significant differences were identified between the right and left sides in children (*U*-test; $P = .170$) or in adults (*U*-test; $P = .097$) (Table 3).

Testing for gender specificities with the Mann-Whitney *U*-test revealed no significant differences in maximum laterotrusion between males and females independent of age group.

Maximum Retrusion

As is shown in Table 2 for the children's group, the mean maximum retrusion on the right and left sides was found to be 0.6 mm, with standard deviations of 0.6 mm on the right and left sides. As is evident on the box-plots (Figure 2), the mean maximum retrusion of the adult group was somewhat smaller than that of the children's group.

Because higher values for the mean maximum retrusion on the right and left sides were found in the children's group, the mean of the adult group corresponded to only 50% on the right side and 66.7% on the left side of the children's group.

The Kolmogorov-Smirnov test showed normal distribution of the data, and Levene's test showed no homogeneity of variances. Therefore, differences in maximum retrusion between the children's group and the adult group were tested for significance with the Mann-Whitney *U*-test. A significant difference between the children's group and the adult group was found in maximum retrusion on the right ($P = 0.008$) and left ($P = .013$) sides (Table 2).

Normal data distribution (Kolmogorov-Smirnov test) and homogeneity of variances (Levene's test) were found for comparison of the right and left sides. Therefore, Student's *t*-test was applied.

Student's *t*-test (Table 3) revealed no significant differences in maximum retrusion between the right and left sides for children ($P = .654$) or for adults ($P = .084$). The maximum retrusion to the left (0.4 mm) was slightly larger than that to the right side (0.3 mm) in the adult group.

Testing for gender specificities with the Mann-Whitney *U*-test revealed no significant differences in maximum retrusion between males and females.

DISCUSSION

Maximum Laterotrusion

In the adult group, the mean maximum laterotrusion to the right was found to be 12.2 ± 1.7 mm and to the left 11.7 ± 2.0 mm, which compares well with values

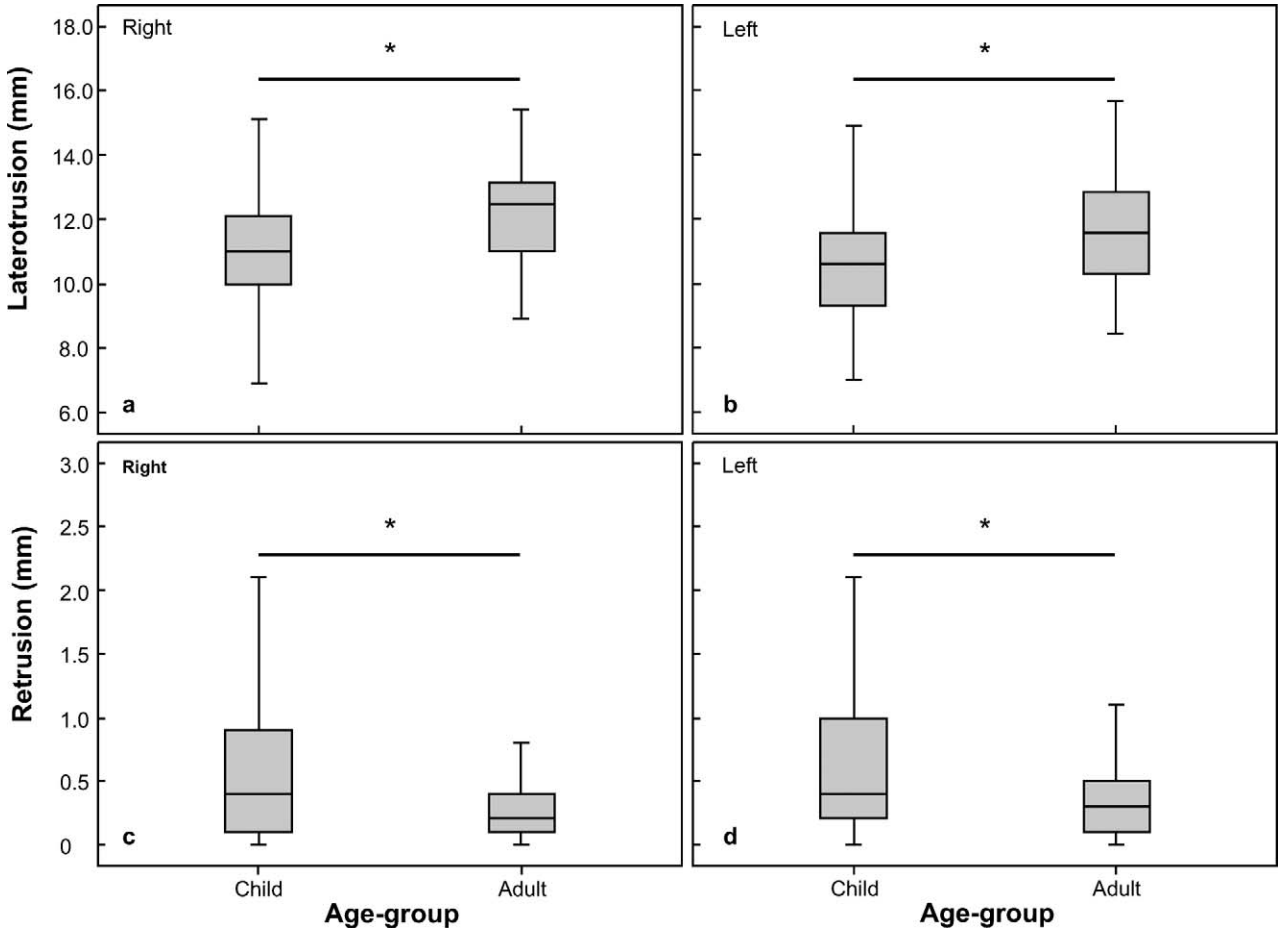

Figure 2. Box-plots showing maximum laterotrusion (a, b) and maximum retrusion (c, d) on the right (a, c) and left sides (b, d) of the children's group compared with the adult group. * $P \leq .05$ (Mann-Whitney *U*-test).

previously published for adults. The readings were somewhat larger than those found by Buschang et al[14] Ingervall,[18] and Agerberg,[13] but they fall within the ranges of values reported previously.

Ingervall[18] found the maximal lateral movement of the mandible in adult females to be larger to the right (10.48 mm) than to the left side (9.82 mm). Buschang et al[14] found in a study of 27 adult females with normal occlusion that during right laterotrusion, the incisors consistently moved a greater linear distance (11.45 mm) than they did during left laterotrusion (10.89 mm). Similar functional differences have been reported by other authors.[6] In the present study, the maximum laterotrusion to the right was somewhat larger than to the left, but the difference was not significant. Intraindividual variation on both sides in this study varied between 7.7 mm and 15.7 mm and was thus slightly smaller than that reported by Ingervall[18] (with a range of 5.5 mm to 14.8 mm in 20-year-old women) and those reported by Agerberg[13] (5–6 mm).

The mean maximum laterotrusion of the children's group in the present study was found to be 11.0 $\pm$ 1.7 mm on the right side and 10.6 $\pm$ 1.5 mm on the left side and was significantly smaller than in the adult group. The values measured in the children's group corresponded to 90.6% on the left side and 90.2% on the right side of the adult group.

Very few studies were conducted for the purpose of examining the kinematic variables in children. The values in the present investigation are very similar to those found in 1970 by Ingervall,[18] who studied the ranges of mandibular movement in boys and girls at the age of 10 years and compared them with those of women aged 20 years. As for maximum lateral movement, Ingervall[18] found that the mandible in 10-year-old boys moved on average about 10.81 mm to the right and 10.41 mm to the left. The 10-year-old girls showed somewhat smaller values.

In accordance with the findings of Ingervall,[18] lateral movement in our study was numerically larger to the right than to the left side in the children's group, although no significant difference was noted. Additionally, Ingervall[18] found no differences in maximum laterotrusion between 10-year-old girls and women aged

Table 3. Descriptive Statistics for Right and Left Maximum Laterotrusion and Maximum Retrusion (all measurements in mm) for the Children's Group and the Adult Group[a,b]

				Distance, mm					
Variable	Age Group	Side	N	Mean	SD	Median	Min	Max	*P* (*t*-test)
Laterotrusion	Children	Right	81	11.0	1.8	11.0	5.3	15.1	.170
		Left	81	10.6	1.5	10.6	7.0	14.9	
	Adults	Right	67	12.2	1.7	12.5	7.7	15.4	.097
		Left	67	11.7	2.0	11.6	8.4	15.7	
Retrusion	Children	Right	81	0.6	0.6	0.4	0	2.7	.654
		Left	81	0.6	0.6	0.4	0	2.8	
	Adults	Right	67	0.3	0.3	0.2	0	1.1	.084
		Left	67	0.4	0.3	0.3	0	1.7	

[a] Differences between the right and left sides in the adult and children's groups were tested for significance with Student's *t*-test.
[b] Modified table from the Statistical Package for the Social Sciences (SPSS; SPSS Inc, Chicago, Ill).

20 years, suggesting that in girls, the range of movement of the mandible reaches adult level by 10 years of age. In this study, we found a significant difference in laterotrusion between the children's group and the adult group. This might be due to the age difference of the children's group between the two studies.

In the present investigation, intraindividual variation in the children's group ranged between 5.3 and 15.1 mm for the right laterotrusion; variation in the left laterotrusion was somewhat smaller at 8.4 to 15.7 mm. These values are similar to those reported by Ingervall,[18] who found a range of 7.0 to 14.3 mm on the right side and 5.8 to 14.8 mm on the left side for 10-year-old children.

Even though Ingervall[18] reported significantly larger lateral movement in 10-year-old boys than in girls, in the present study, maximal laterotrusion did not vary significantly according to gender specificity. Hirsch et al[19] reported in a study of children aged 10 to 17 years a similar mean (right side, 10.2 mm; left side, 10.6 mm) for maximum laterotrusion.

Cortese et al[20] examined a group of children with average age of 6.9 years and found somewhat smaller values of maximum laterotrusion (right side, 6.05 mm; left side, 6.13 mm). These smaller values might be due to the lower average age of the group of examined children.

Maximum Retrusion

In the present study, dorsal movement of the condyle was measured indirectly from ipsilateral laterotrusion. The mean registered value in the adult group was 0.3 mm on the right side and 0.4 mm on the left side with a standard deviation of 0.3 mm on the right and left sides. The current findings are close to the values reported by Gernet.[25] He measured the distance from maximum intercuspation into maximum retrusion and reported values from 0.4 mm to 0.6 mm in more than 80% of adults. The values obtained in this investigation are smaller than those reported by Ricketts,[10] who in a study of 50 patients found that the space between the posterior surface of the condylar head and the glenoid fossa in occlusion is about 2.56 $\pm$ 0.7 mm. This difference could be due to differences in the measuring technique and reference point used. The range of movement on the right side (0.0–1.1 mm) was smaller than that on the left side (0.0–2.0 mm) in the adult group.

To the best of our knowledge, no investigation has used kinematic measurements to assess the development of maximum retrusion in children. Ingervall[26] recorded the retruded positions of the mandible in children with the aid of wax records and dental casts. The mean values of the present study are somewhat smaller but fall within the ranges reported by Ingervall.[26]

The mean maximum retrusion in children measured in this study was significantly larger than that of the adult group, with a value of 0.6 mm on the right and left sides.

Ricketts[10] reported that the size of the fossa is maximum before the condyle reaches full size. This would indicate a provision for play in the condyle–fossa relationship during the growth period. In adulthood, the condyle continues to grow until it fills the fossa space, which consequently limits condylar mobility. Therefore, larger retrusive movement of the condyles may be expected in children compared with adults. This means that posterior border movement of the mandible is not established by early stages of childhood—between 6 and 10 years—but is developing further. In adults, when the size of the condyle is fully developed, less space is available for condylar retrusive movements, and smaller maximum retrusive values are noted.

The range of movement of both condyles was also greater in the children's group than in the adult group. This supports Ricketts' notion[10] that condylar mobility in retrusive movement is larger in children and decreases during adulthood.

The mean maximum retrusion in the children's group was found to be equal at the right and left sides (0.6 mm). In the adult group, the maximum retrusion of the right side (0.3 mm) was slightly smaller than that of the left side (0.4 mm), but no significant difference was found.

In the present study, no significant differences in maximum retrusion were found according to gender specificities either. This is in accordance with the findings of Ingervall,[26] who found the retruded contact position and the intercuspal position to be of the same magnitude in boys and in girls.

CONCLUSIONS

- The tested null hypothesis that there is no difference between children and adults in maximum laterotrusion and retrusion on the right and left sides is rejected.
- The mean maximum laterotrusion was significantly larger in the adult group than in the children's group, showing that maximum laterotrusion increases with age.
- However, despite the fact that the maximum laterotrusion to the right was numerically greater than that to the left side in both groups, no significant difference was noted.
- The mean maximum retrusion was significantly smaller in the adult group than in the children's group, showing that maximum retrusion decreases with age.

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