Original Paper

Characteristics of condylar movement during lateral excursion in children with early mixed dentition

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Abstract: Evaluation of the function of the temporomandibular joint in healthy children is important. The purpose of this study was to investigate characteristics of condylar movement during lateral excursion in children in consideration of the differences of jaw length and jaw width between children and adults. Eighteen healthy subjects (thirty-six joints total) with normal occlusion were divided into two age groups: early mixed dentition group (4 boys, 5 girls, 8-10 years old, mean 8 years 11 months) and permanent dentition group (2 men, 7 women, 23-28 years old, mean 25 years 9 months). Jaw movements were measured with 6 degrees of freedom jaw tracking device. Characteristics of condylar movement in children were investigated by three-dimensional condylar path distance during lateral excursion. The lateral excursion was done from the intercuspal position. The distance of condylar path was calculated at 1.0 mm interval from 1.0 to 5.0 mm of incisal path (D100%). Furthermore, the distance of condylar path was calculated at 0.9 mm interval from 0.9 to 4.5 mm of incisal path (in children only, D90%) in consideration of the differences of jaw length and jaw width between children and adults. The distance between incisal point and anatomical center point of condyle (IP-CP) and the distance between left side anatomical center point of condyle and right side anatomical center point of condyle (LCP-RCP) were significantly smaller in children than in adults. IP-CP and LCP-RCP in children were about 90% of those in adults. The distance of working condylar path was significantly larger in children than in adults when the distance of incisal path was at D100% and D90%. The distance of working condylar path did not show significant correlation with both the jaw length and the jaw width in children. These results suggest that the working condylar movement during lateral excursion in children has higher mobility than that of adults without it is influenced by difference of jaw size between children and adults.

I. Introduction

Evaluation of the function of the temporomandibular joint in healthy children is important to understand the development of the function of the temporomandibular joint with growth correctly. However, there are a few studies on condylar movement in 6 degrees of freedom in children¹⁻³⁾.

We reported in previous studies⁴⁻⁶⁾ that the distance of working condylar path during lateral excursion was significantly larger in children than in adults.

However, the difference of the distance of condylar path may be caused by the difference of jaw size between children and adults. The jaw size of children is smaller than that of adults, generally. The distance of working condylar path may be significantly larger in children than those in adults, because the working condylar movement at same distance of incisal path was required bigger load for children than that for adults.

The purpose of this study was to investigate characteristics of condylar movement during lateral excursion in children in consideration of the differences of jaw length and jaw width between children and adults.

II. Subjects and Methods

1. Subjects

Eighteen healthy subjects (thirty-six joints total) with normal occlusion were divided into two age groups: early mixed dentition group (4 boys, 5 girls, 8-10 years old, mean 8 years 11 months) and permanent dentition group (2 men, 7 women, 23-28 years old, mean 25 years 9 months).

These subjects in children had either no dental caries or slightly restored teeth. These children whom all permanent first molars, permanent central incisors and permanent lateral incisors of both the upper jaw and the lower jaw had erupted and all primary canines, primary first molars and primary second molars remained were chosen as a subject.

Informed consent was obtained before the measurements.

2. Methods

Border jaw movements, protrusive and lateral excursions and maximum jaw opening were measured with jaw tracking device (SHOFU, MM-JI-E)⁷⁾. This device can record the full range of jaw movement with 6 degrees of freedom and is accurate to a level of 150 μ m at any jaw position. Each movement was measured three times after each subject had practiced each movement. The movement was measured several times in addition, if each movement is difficult for subject.

The reference points were incisal point and working and nonworking kinematic condylar point. The kinematic condylar point as a reference point for condylar movements has been suggested by Suzuki⁸⁾. At this point, every mandibular movement pathways converge into the narrowest range in three-dimensional.

The jaw movements of each group were examined using work station (DEC, VAX STATION 4000) and graphic terminal (EVANS & SUTHERLAND, PS390).

The standard coordinates of the analysis system was the right-handed coordinates system and defined on the occlusal plane. The occlusal plane was defined on the upper incisal point, central fossa of left and right upper permanent first molars.

The jaw length of each group was compared using the distance between incisal point and anatomical center point of condyle (both left and right, IP-CP). The jaw width of each group was compared using the distance between left side anatomical center point of condyle and right side anatomical center point of condyle (LCP-RCP). Anatomical center point of condyle determined using frontal and lateral cephalograms⁹⁾. IP-CP was measured using lateral cephalogram and LCP-RCP was measured using frontal cephalograms. These values of IP-CP and LCP-RCP were corrected by the scale of enlargement in X-ray taking

Characteristics of condylar movement in children were investigated by three-dimensional condylar path distance during lateral excursion. The lateral excursion was done from the intercuspal position. The distance of incisal path was calculated for the distance in a straight line between intercuspal position and each jaw position. Each jaw position at 1.0 mm interval from 1.0 to 5.0 mm of incisal path was used in calculation of the distance of condylar path (D100%). The distance of condylar path was calculated for the distance in a straight line between condylar position at intercuspal position and condylar position at each jaw position. Furthermore, the distance of condylar path was calculated at 0.9 mm interval from 0.9 to 4.5 mm of incisal path (in children only, D90%). The same data was used in calculation of the distance of condylar path of D100% and D90%.

Statistical differences between each group were tested by Student's t-test or Welch's t-test. Pearson's correlation coefficient was used to test the influence of jaw size on the distance of condylar path.

Table 1 Comparison with jaw size

	Jaw length : IP-CP (mean $\pm$ SD)	Jaw width : LCP-RCP (mean $\pm$ SD)
children	95.27 $\pm$ 3.46mm	92.46 $\pm$ 4.11mm
adults	105.55 $\pm$ 3.50mm	101.38 $\pm$ 5.42mm
children $\div$ adults	0.90	0.91

IP: incisal point

CP: anatomical center point of condyle

LCP: left side anatomical center point of condyle

RCP: right side anatomical center point of condyle

***: $P < 0.001$

Fig. 1 The distance of working condylar path at kinematic condylar point

III. Results

The distance between incisal point and anatomical center point of condyle (IP-CP) and the distance between left side anatomical center point of condyle and right side anatomical center point of condyle (LCP-RCP) are shown in Table 1. IP-CP and LCP-RCP were significantly smaller in children than in adults. IP-CP and LCP-RCP in children were about 90% of those in adults.

The distance of working condylar path at kinematic condylar point during lateral excursion is shown in Figure 1. The distance of working condylar path was significantly larger in children than in adults when the distance of incisal path was at D100% and D90%.

The distance of nonworking condylar path at kinematic condylar point during lateral excursion is shown in Figure 2. The distance of nonworking condylar path did not show significant difference between children and adults.

The correlation between the distance of working and

Table 2 Correlation between the distance of condylar path and jaw size

	Jaw length IP-CP		Jaw width LCP-RCP	
distance of condylar path	r	p	r	p
working side	-0.095	0.731	0.385	0.144
nonworking side	0.567	0.021*	0.503	0.046*

IP: incisal point

CP: anatomical center point of condyle

LCP: left side anatomical center point of condyle

RCP: right side anatomical center point of condyle

r: Pearson's correlation coefficient

*: $P < 0.05$

Fig. 2 The distance of nonworking condylar path at kinematic condylar point

nonworking condylar path (D100%) at kinematic condylar point during lateral excursion and the jaw length (IP-CP), and the correlation between the distance of working and nonworking condylar path (D100%) and the jaw width (LCP-RCP) are shown in Table 2. The distance of working condylar path did not show significant correlation with both the jaw length and the jaw width. The distance of nonworking condylar path showed significant correlation with both the jaw length and the jaw width.

IV. Discussion

It is well known in healthy adults generally that the rotation center of mandible during lateral excursion exists near working condyle, and the distance of working condylar path during lateral excursion is very small in many cases. It has been reported in previous studies⁴⁻⁶⁾ that in children a fixed rotation center during lateral excursion does not exist near working condyle in many cases, and the distance of working

condylar path during lateral excursion is significantly larger in children than those in adults. However, the difference of the distance of condylar path may be caused by the difference of jaw size between children and adults. The jaw size of children is smaller than that of adults, generally. The distance of working condylar path may be significantly larger in children than those in adults because the working condylar movement at same distance of incisal path was required bigger load for children than that for adults. It need to confirm whether the distance of working condylar path is larger in children than those in adults when the load of condylar movement was similar for children and adults.

The difference of jaw size between children and adults was compared with IP-CP and LCP-RCP in this study. IP-CP and LCP-RCP were significantly smaller in children than those in adults. IP-CP and LCP-RCP in children were about 90% of those in adults. Therefore, the jaw size in children showed about 90% of that in adults. Then, the distance of incisal path in children was specified as 90% of the adults in order to make the similar load of condylar movement as adults. It can decrease the difference of the load of condylar movement between children and adults that the value of D90% in children was used to compare the distance of condylar path between children and adults.

The distance of working condylar path was significantly larger in children than in adults when the distance of incisal path was at D100% and D90%. The distance of nonworking condylar path did not show significant difference between children (D100%, D90%) and adults.

The distance of condylar path during lateral excursion in adult of this study was mostly in agreement with the past report¹⁰⁻¹²⁾.

In children the anatomical growth and functional development are not yet enough. Children with early mixed dentition are in the transition stage which has not adult's condition yet^{13, 14)}, but has developed condition from children with primary dentition in an anatomical temporomandibular joint form^{15, 16)} and a muscular function¹⁷⁾. Temporomandibular joint of children with early mixed dentition are almost grown-up though a slight place is remained for growth. These are the reason why the distance of nonworking condylar path did not show significant difference between children (D100%, D90%) and adults.

In children with early mixed dentition the guide by lateral teeth is scarcer than children with primary dentition because

the lateral teeth are still primary teeth and attrition of those teeth is advanced. In children with early mixed dentition there is a slight space in mandibular fossa for lateral condylar movement because a slight growth of outside of mandibular condyle and mandibular fossa are still continuing^{18, 19)}. These are the reason why the distance of working condylar path during lateral excursion shows larger in children (D100%, D90%) than in adults.

The distance of working condylar path (D100%) did not show significant correlation with both the jaw length and the jaw width. The distance of nonworking condylar path (D100%) showed significant correlation with both the jaw length and the jaw width.

The distance of condylar path during lateral excursion is larger at nonworking condylar point than at working condylar point. It may suggest that the difference of jaw size is easy to be reflected in the distance of nonworking condylar path with large quantity of movement.

If the growth of jaw size showed correlation with development of stomatognathic function or growth of anatomical temporomandibular joint form, the distance of working condylar path may show correlation with jaw size. However, the result did not show correlation between the distance of working condylar path (D100%) and jaw size.

These results suggest that the working condylar movement during lateral excursion in children has higher mobility than that of adults without it is influenced by difference of jaw size between children and adults.

The high mobility of condylar movement in children is considered to be advantageous to correspondence to the change of occlusion such as eruption of tooth and exchange of tooth.

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