Longitudinal observation of basic mandibular movements: report of a case

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Sound development of mandibular function during childhood is indispensable to establishing healthy function in adults. To examine this developmental process, longitudinal recordings of basic mandibular movements were done using an optoelectronic analysis. Mandibular movements were recorded on five separate occasions in one boy, from an age of six years and five months to 14 years and five months. The incisor pathways during protrusion and lateral excursion were initially shallow, with more anterior than inferior movement, but as he grew the amount of inferior movement and the amount of rotation both increased. Similarly, at his first recording there was very little hinge-like rotation during mouth closing, but rotation increased markedly after eruption of his permanent second molars. These findings suggest that mandibular movements change from being relatively simple with more translation in younger children to more complex movements with more rotation once the permanent dentition is established.

J Clin Pediatr Dent 27(4): 333-338, 2003

INTRODUCTION

Functional changes during growth of the stomatognathic region depend upon changes in dental development as well as changes in the craniofacial skeleton and muscles. Although morphological changes during the growth of the occlusion have often been reported,[1-3] the functional changes during development from child to adult are still largely unknown. Both the skeletal and neuromuscular systems continue to develop as the dentition changes from primary to mixed and finally to permanent dentition. Mandibular movements may need to adapt to the changing dental conditions. A better understanding of normal growth-related changes in mandibular function may form a basis for assessing the causes and effects of mandibular dysfunction.

Several cross-sectional studies of mandibular function in children have been reported.[4-6] These reports established that mandibular movements in children differ from those of adults.[4,7,8] However, to our knowledge, there have been no longitudinal observations of mandibular movement during childhood development. The aim of this case report was to show how mandibular movements change during growth and development.

CASE REPORT

The subject was a boy with sound dentition, 6 years and 5 months of age when the first measurement was done. He had no history of orthodontic therapy, symptoms indicative of temporomandibular disorders or other serious dental problems during the eight years he was followed. He received caries treatment with metal inlays, which did not cover the functional cusps, on the right upper first and second molars. Informed consent was obtained from his parents. Three types of mandibular movements were recorded on five separate occasions until the boy was 14 years and 5 months years of age (Table 1). He was instructed to slowly move the mandible: 1) anteriorly with sliding occlusal contacts (protrusion), 2) to the right and left side with sliding occlusal contacts (lateral excursions), and 3) in an open-close movement. All movements were started from the maximum intercuspal position (MICP).

The mandibular movement measuring system used in this study has been described in detail elsewhere,[9,10] however a brief description follows. Mandibular move-

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Table 1. Age and dental stage at each measuring occasion.

Measurement	Age	Dental Stage
1	6y 5m	Early Mixed Dentition
2	8y 4m	Early Mixed Dentition
3	9y 10m	Mixed Dentition
4	12y 5m	Permanent Dentition
5	14y 5m	Permanent Dentition

Figure 1. Intra-oral photographs (frontal views): **(A)** 6y 5m, **(B)** 9y 10m, and (**C)** 14y 5m.

ment was recorded using an optoelectronic analysis system with six degrees-of-freedom (Selspot system, NAC Inc., Tokyo, Japan; TRI-MET, Tokyo-shizaisha, Tokyo, Japan). In setting up this reference frame, the origin of the coordinate axes was defined as the medial tip of the lower left primary or permanent central incisor. The x-y plane (horizontal plane) extended from the origin to the left and right tips of the distal cusp of the lower primary second molars. A right-handed coordinate system was then defined using the horizontal (occlusal) plane so that the x-axis was anterior to posterior, the y-axis was left to right and the z-axis was superior to inferior. For simplicity of presentation, the figures of mandibular movements include only the tracings that demonstrate significant differences between ages.

CHANGES OF MANDIBULAR MOVEMENTS

Protrusive excursions

Superimpositions of sagittal projected pathways of the lower incisal point during protrusive excursion and outlines of the upper primary or permanent central incisor are presented at four different ages (Figure 2). Because all pathways of the lower incisal point were along the palatal surface of the upper central incisor, the shape was directly dependent upon the amount of overbite and overjet at each age. The pathways became steeper with more inferior excursion as the boy grew.

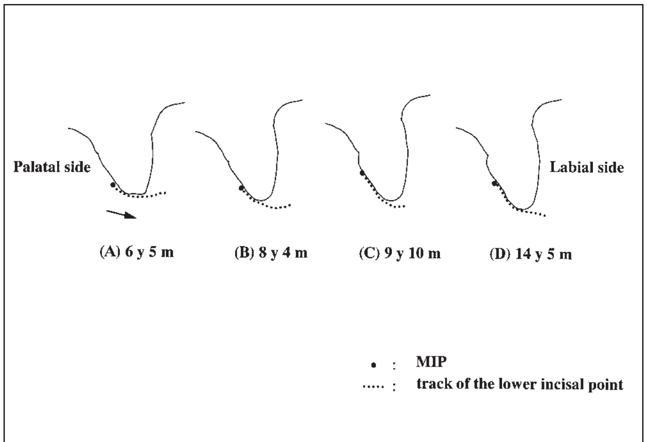

Figure 2. Superimpositions of primary or permanent central incisor and track of lower incisal point during protrusive excursion with occlusal contacts (sagittal views): **(A)** 6y 5m, **(B)** 8y 4m, **(C)** 9y 10m, and **(D)** 14y 5m.

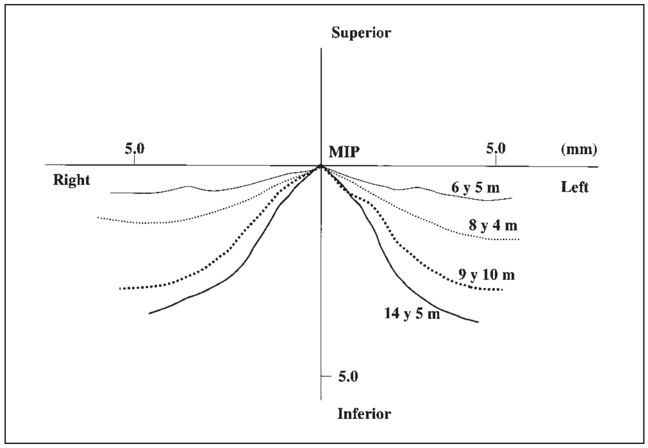

Figure 3. Frontal views of right and left lateral excursions from the maximum intercuspal position at four ages.

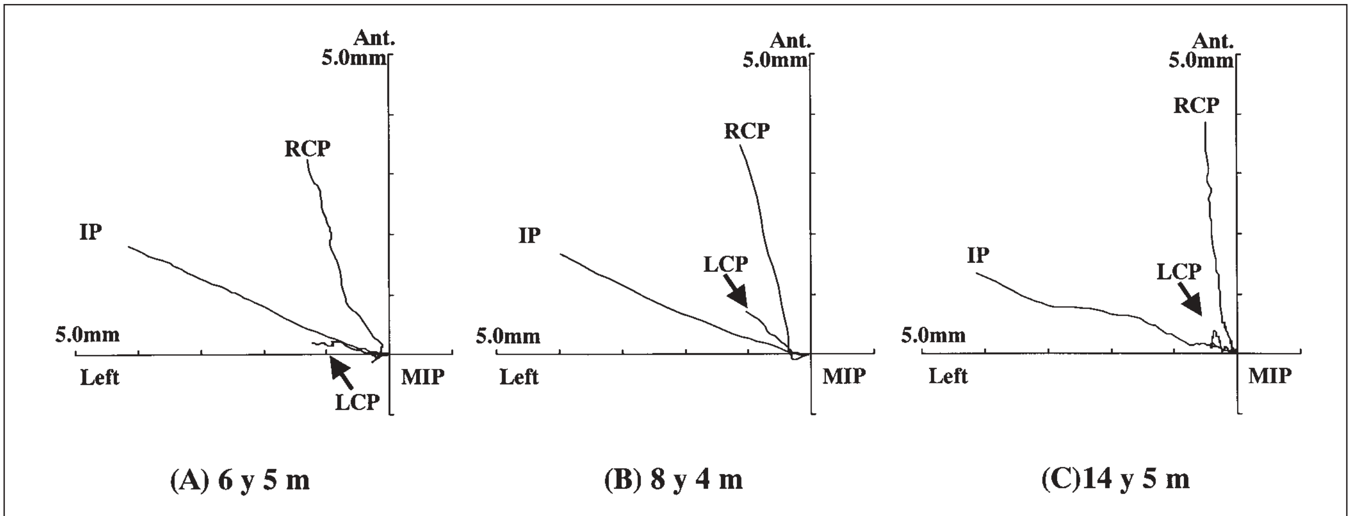

Figure 4. Horizontal views of pathways on lower incisal point (IP), the left (working) side condylar point (LCP) and the right (non-working) side condylar point (RCP) during the left lateral excursion at three ages. The pathways for each reference point were superimposed by transforming the data so that the starting position of each point was zero at the maximum intercuspal position (MIP). Each movement was tracked from MIP to the point where the lower incisal point had moved a 3-D straight-line distance of 5.0 mm.

Lateral excursions

Superimpositions of frontal projected pathways at the lower incisal point during right and left lateral excursions at four different ages are shown in Figure 3. As the boy grew, the pathway of the lateral excursion tended to become steeper in both right and left lateral excursions. The lower incisal pathway and the right and left condylar pathways during left lateral excursion are shown at three different ages in Figure 4. The pathway of each point during lateral excursion was plotted from its position at maximum intercuspation to the position when the incisor had traveled a 3-D straight-line distance of 5.0 mm. There was relatively little change in the incisor pathway with growth, but both condylar pathways showed progressive reduction in the amount of lateral shift as he grew.

Mouth closing movement

Figure 5 shows the pathway of the lower incisal point in the sagittal plane during mouth closing. Mouth closing is relatively passive compared with mouth opening, and the final phase is thought to be a hinge-like movement. The closing pathway moved more anteriorly than the MICP at 6y 5m and 12y 5m, but remained posterior to MIP at 14y 5m. The overall shape of the pathway at 6y 5m differed from the pathways at the other two ages. Hinge-like movement was observed at both 12y 5m and 14y 5m, but not at 6y 5m. The reason for this difference can be demonstrated by plotting the percent of mandibular rotation against the percent of anteroposterior condylar translation (Figure 6). The angle of mandibular rotation decreased at nearly the same rate as the decrease in anteroposterior condylar translation

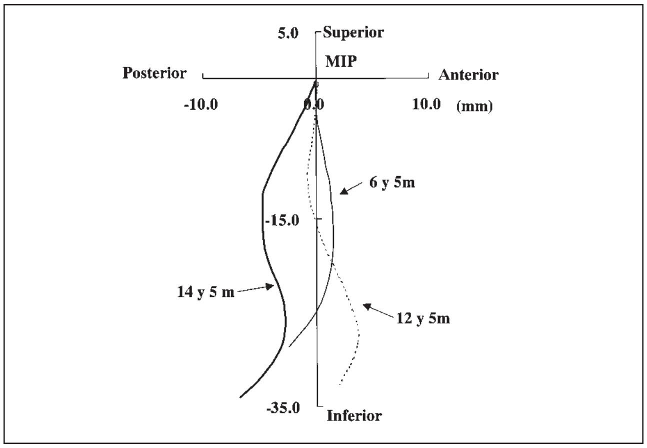

Figure 5a. Sagittal projections of pathways of the lower incisal point during mouth closing at three ages.

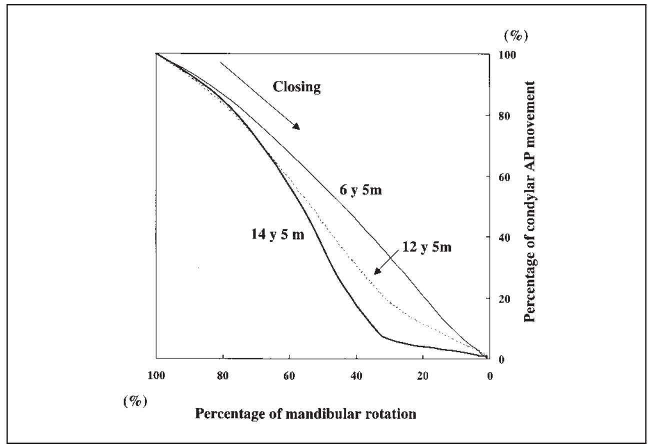

Figure 5b. Relationship between the percentage of mandibular rotation and percentage of anteroposterior (AP) movement of the condyle during closing at three ages.

at 6y 5m, but at 12y 5m and 14y 5m mandibular rotation occurred faster than condylar translation during the final phase of closing. Specifically, more than 30% of mandibular rotation occurred during the final 7% of condylar anteroposterior translation at 14y 5m.

DISCUSSION

Development of mandibular movements in normal, growing individuals has received little attention in the literature. Understanding these changes during normal growth may give insight into naturally occurring interrelationships between dental morphology and neuromuscular function, and may also be helpful in assessing the effects of malocclusion in children and adults. The deciduous occlusion is in a continuous state of rapid change as it adapts to skeletal growth and to developing mandibular movements. Basic mandibular movement patterns are well established prior to eruption of the permanent teeth, making the first stages of occlusal development extremely important. It has been reported that by 12 to 14 years of age, the adult chewing pattern has become established,[11] suggesting that each pattern of mandibular function will be established by the end of full eruption of the permanent second molars. Our findings support this because the observation period in this study started at the age of initial permanent teeth eruption and ended after the permanent second molars had erupted.

The findings in this study confirm results reported in cross-sectional studies.[7] Excursive movements become steeper with growth and development. Sagittal pathways during protrusive excursion are directly affected by the morphology of the palatal surface of the upper incisor, resulting in shallower movement at younger ages. Frontal pathways during lateral excursions also have steeper pathways. Although occlusal views of the incisor pathways during lateral excursions were similar at different stages, the condylar pathway changed, indicating that lateral shifting of the entire mandible, *i.e.* Bennett movement decreases with growth.[12]

Differences in the pathways during mouth closing are mainly due to changes in the amount of mandibular rotation. Initially the mandibular movements of the boy were shallow and relatively straight and horizontal, but as he grew the movements became more complex, with less translation and more rotation at different parts of the movement. At his final recording, his movements were essentially the same as those reported for adults.[7,9,13]

In order to understand the reasons for the changes in mandibular movements, it is necessary to consider the morphological changes. These include increasing steepness of the articular eminence,[14] development of anterior tooth guidance,[15] and the change from primary to permanent teeth. Other physiological maturation and functional adjustments due to changes in dentition and skeletal growth may also play a role. Additional longitudinal observations should be done to confirm and enhance our results.

ACKNOWLEDGEMENT

This study was supported in part by Asahi Breweries Foundation (Tokyo, Japan) and Grant-in Aid for Scientific Research (No. 12672004) from the Japanese Society for the Promotion of Science.

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