Original Article

Change in the mesiodistal axial inclination of the maxillary lateral teeth during the mixed dentition stage: Morphometric analysis of panoramic radiographs from two cases of mild crowding with a high canine

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Abstract

Objective: The aim of this study was to investigate the changes of the mesiodistal axial inclination of the maxillary lateral teeth relative to the functional occlusal plane (FOP) on panoramic radiographs in patients with Angle Class I maxillary anterior crowding with high canines during the mixed dentition stage. **Materials and Methods:** Panoramic radiographs were used to measure the mesiodistal axial inclination of the teeth before orthodontic treatment in Cases 1 and 2. The long axes of the teeth were determined according to the previous study by Ursi *et al*. Finally, the angles between the long axes of teeth and the FOP were measured. **Results:** The first premolar and canine showed mesial tipping in the alveolar bone during eruption. The crown of the second premolar was located close to the apex of the first molar and showed excessive mesial inclination relative to the long axis of the second deciduous molar. Before orthodontic treatment, considerable autonomous changes in the mesiodistal inclination were found in the canine and the second premolar in the maxillary alveolar bone during eruption. With respect to the first molar, the mesiodistal inclination was invariable, or the angle was almost 90° without any significant change during the observation period. **Conclusions:** Based on the results of this study, two new findings are described. Autonomous changes in the inclination of the mesiodistal maxillary teeth were observed during exfoliation, particularly in the canine and second premolars. In addition, the eruption of the maxillary lateral teeth influenced the neighboring teeth, whereas the first molar maintained an environmentally defined position.

Key words: Arch length discrepancy, crowding, maxillofacial panoramic radiography, mixed dentition

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INTRODUCTION

Crowding is a type of malocclusion characterized by irregularly positioned teeth caused by an arch length discrepancy (ALD). According to an etiologic survey, the incidence of crowding is high compared with other types of malocclusion.[1-4] Tooth size is an important determinant of crowding.[4-9] In a biometric study, Doris *et al*.,[4] found that patients with crowded dentition due to an ALD >4 mm consistently had larger teeth than those with less or no crowding. By contrast, Howe *et al*.[10] found no significant differences in tooth size between dentitions with and without crowding. The relationship between crowding and arch dimensions has also been studied.[11-13] Bernabé *et al*.[11] showed that crowding was associated with smaller arch dimensions. Moreover, several other factors, such as the early loss of deciduous molars,[14] oral and perioral musculature,[14] and direction of mandibular growth,[15,16] are assumed to affect the development and severity of crowding.

A maxillofacial panoramic radiography analysis was carried out in this study. Panoramic radiography has been used extensively for orthodontic diagnosis and treatment planning because of the simplicity of the procedure, the low radiation dosage, and the ability to widely project the structures with reduced overlap with the intervening tissues.[15,16] However, panoramic radiography always includes a certain amount of image distortion due to the discrepancy between the horizontal and vertical magnification.[17] Although horizontal measurements, in particular, are not accurate enough for absolute determination, the angular distortion is less in these images, and they can be used to compare angular measurements taken from similar regions on different films.[18] Thus, angular measurements are used to determine the axial inclination of the teeth and to accurately confirm the tooth position to ensure that the roots are parallel after orthodontic treatment.[19]

In a previous study based on the analysis of models, the crowns of the maxillary lateral teeth erupted mesially in relation to the functional occlusal plane (FOP) in patients with Angle Class I malocclusion and high canines, and these teeth were uprighted by nonextraction orthodontic treatment.[20]

The aim of this study was to investigate the changes of the mesiodistal axial inclination of the maxillary lateral teeth relative to the FOP on panoramic radiographs in patients with Angle Class I maxillary anterior crowding with high canines during the mixed dentition stage.

MATERIALS AND METHODS

Subjects

This study included two mixed dentition cases diagnosed as Angle Class I malocclusion with a unilateral high canine after exfoliating the permanent dentition. The Institutional Ethics Committee approved the study design, which adhered to the tenets of the amended Declaration of Helsinki.

Case 1

A Japanese girl aged 9 years 3 months presented with a chief complaint of an insufficient maxillary canine space on the left side. She had a symmetric face and a slightly convex lateral soft tissue profile [Figure 1]. The molar relationship was Angle Class II bilaterally in the mixed dentition stage. The overjet and overbite were +1.0 mm [Figure 2]. Using Moyers' prediction tables, the ALDs were estimated to be −4.0 and +6.0 mm in the upper and lower dentitions, respectively [Figure 3]. Before the completion of permanent dentition, the periodic observation was carefully continued to monitor the exfoliation on both dentitions.

Case 2

A Japanese girl aged 9 years 8 months presented with a chief complaint of a maxillary ALD and a high canine on the right side. She had a symmetric face and a straight lateral soft tissue profile [Figure 4]. The molar relationship was Angle Class I on both sides. The overjet and overbite were +1.5 mm [Figure 5]. Both dental arches were nearly symmetrical, and the maxillary dental arch was somewhat narrow. Using Moyers' prediction tables, the ALDs were estimated to be −3.5 and +6.0 mm in the upper and lower dentitions, respectively [Figure 6]. The Periodic observation was carefully continued for 2 years to monitor the exfoliation on both dentitions.

Methods

Panoramic radiographs were used to measure the mesiodistal axial inclination of the teeth before orthodontic

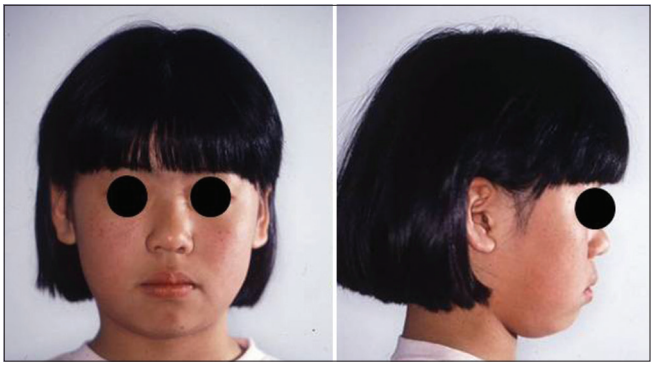

Figure 1: Facial photographs of patient 1

Figure 2: Intraoral photographs of patient 1 (centric occlusion)

Figure 3: Occlusal view of patient 1

Figure 4: Facial photographs of patient 2

treatment in Cases 1 and 2 [Figures 7a and b, 8a and b]. The constructed reference line was the FOP on each side on the panoramic radiographs. The outlines of the maxillary lateral teeth and first molars and their long axes were traced and drawn on acetate paper. In the mixed dentition, the long axes of the maxillary lateral teeth buds were drawn using a line that bisected the line connecting the mesial and distal outlines of the cervical areas. The long axes of the teeth were determined according to the previous study by Ursi *et al*.[21] Briefly, the single-rooted teeth were measured using the image of the root canal showing its longest extent; the upper bicuspids were measured using the average image of the buccal and palatal root canals; the upper molars were measured using the image of the palatal root canal; the lower molars were measured using average image of the mesial and distal root canals. Finally, the angles between the long axes of teeth and the FOP were measured, as shown in Figure 9.

RESULTS

Panoramic radiograph of the mixed dentition in Case 1 is shown in Figure 7a. The mesial inclination of the maxillary lateral permanent teeth can be seen in the alveolar bone. Specifically, the maxillary first premolar on the left side already presented and angle of 64.0°, demonstrating the excessive mesial inclination that caused the disturbance in the canine eruption. The second premolars on the left and right sides also presented angles of 76.0° and 69.0°, indicating mesial inclination. With respect to the anterior teeth, the permanent canines on the both sides presented angles of 70.5° and 73.5°, or mesial tipping in the alveolar bone, and the "ugly duckling stage" phenomenon was observed in the incisor area. By contrast, no anterior crowding was detected on the lower dentition, and the second premolars undergoing the exchange from deciduous to permanent were upright relative to the FOP.

A panoramic radiograph before orthodontic treatment in Case 1 is shown in Figure 7b. Exfoliation can be seen on the maxillary lateral teeth on both sides. These lateral teeth, which were oriented mesially in the alveolar bone, were autonomously upright upon eruption [Table 1]. In particular, the second premolars presented the most autonomously upright orientation on both sides (left: 10.0°, right: 9.5°). Moreover, the mesiodistal tooth axes of the canine and the first premolar appeared upright relative to the FOP as well. On the other hand, the axial inclination of the first premolar was smaller on the crowded side than on the noncrowded side. With respect to the anterior teeth, the so-called "ugly duckling stage" was improved due to the autonomous uprighting of the canine during eruption.

With respect to the first molar, the mesiodistal inclination was invariable, or the angle was almost 90° without any significant change during the observation period.

A panoramic radiograph of the mixed dentition in Case 2 is shown in Figure 8a. The lateral permanent teeth of the

Figure 5: Intraoral photographs of patient 2 (centric occlusion)

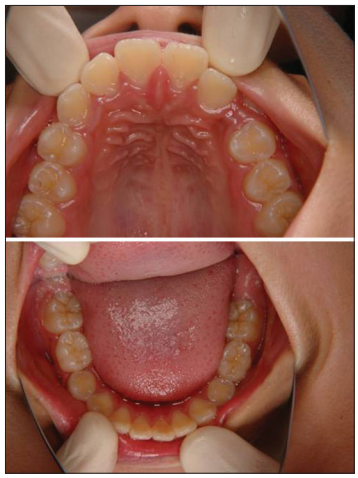

Figure 6: Occlusal view of patient 2

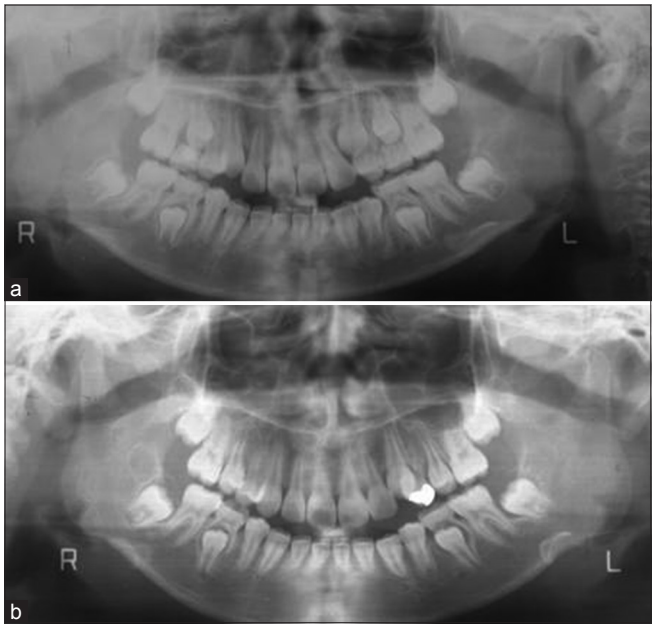

Figure 7: Panoramic radiographs of patient 1: (a) Mixed dentition, (b) pretreatment

maxillary and mandibular dentitions had not yet erupted or were undergoing eruption, and they presented synchronous mesial tipping on both sides of the maxillary alveolar bone. The crown of the second premolar was located close to the apex of the first molar and showed excessive mesial inclination relative to the long axis of the second deciduous molar. The angles of inclination of the teeth were 69.0° and 78.5° on the left and right sides, respectively [Table 2]. Moreover, the first premolar and canine showed mesial tipping in the alveolar bone during eruption. With respect to the anterior teeth, the permanent incisors on both sides presented distal tipping in the alveolar bone, which is regarded as the "ugly duckling stage."

A panoramic radiograph taken before orthodontic treatment in Case 2 is shown in Figure 8b. The maxillary and mandibular permanent dentitions were complete on both sides. Considerable autonomous changes in the mesiodistal inclination were found in the canine (left: 12.0°, right: 10.5°), and the second premolar (left: 15.5°, right: 15.0°) in the maxillary alveolar bone during eruption [Table 2]. Moreover, the distal inclination of the incisors was improved according to the eruption of the canines in the anterior region. On the other hand, the axial inclination of the right first premolar was 71.5°, which was smaller than that on the noncrowded side and demonstrated the mesial tipping on the crowded side. By contrast, the lower second premolars were uprighted to the FOP behind the second deciduous molars, and there was no ALD [Table 2].

DISCUSSION

It remains unclear how the mesiodistal inclination of the lateral teeth changes during the transition from mixed dentition to permanent dentition. In a previous study, we performed a model analysis and reported that the crowns of the lateral teeth exhibited mesial inclination in Class I malocclusion with a high canine.[20] We demonstrated that the upper lateral teeth exhibited a prominent mesial inclination relative to the FOP and were uprighted distally by nonextraction orthodontic treatment in the crowding cases.

In this study, a morphometric analysis was conducted using panoramic radiographs to determine the mesiodistal axial inclination of the maxillary lateral teeth on crowding associated with a high canine and tooth crown inclination. Panoramic radiography is commonly used in orthodontic practice for the assessment of tooth root parallelism prior to, during, and after orthodontic treatment.[22,23] However, disadvantages of panoramic images, such as

image magnification and distortion, reduce the accuracy of the measurements.[17] On the other hand, panoramic radiography has many prominent advantages; namely, the images present no overlap,[15,16] and the skeletal and dental pathology, as well as the angles of the teeth, can be evaluated relative to other structures on each side.[16] In addition, it has been reported that the analysis of dental angulations using panoramic radiographs can be performed with reasonable reliability.[24,25] Graber also suggested the use of panoramic radiographs to evaluate the axial inclination of the teeth.[24] Thus, the angular changes of the teeth relative to the reference plane have been measured on panoramic radiographs in many previous studies.[26-28]

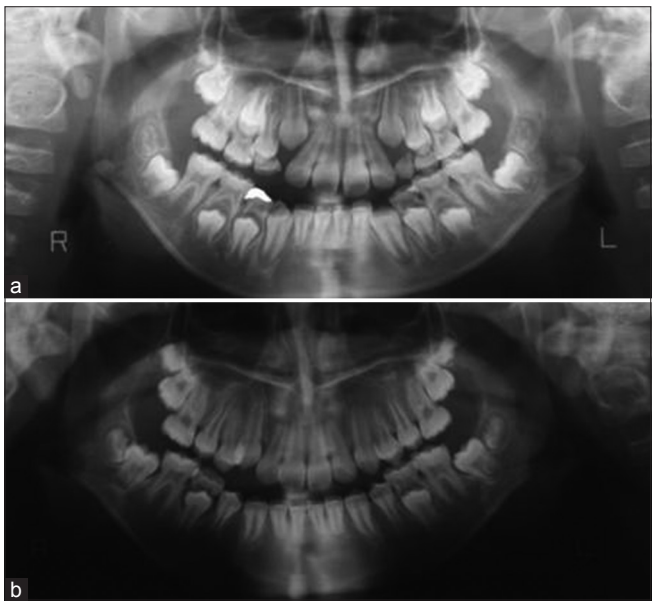

Figure 8: Panoramic radiographs of patient 2: (a) Mixed dentition, (b) pretreatment

In this study, the FOP was used as a reference plane on each side to evaluate the angular measurements. This approach is very useful for evaluating the mesiodistal inclination of the teeth in the dentition because the angulation of the mesiodistal crown is particularly important for the clinical evaluation of the crowding in the dentition.

In both cases, panoramic radiographs of the mixed dentition showed that the crown of the second premolar inclined mesially and was located close to the apex of the first molar in the maxillary alveolar bone. In the anterior teeth, the crowns of the canines were located close to the apex of the lateral incisors, and the phenomenon of the "ugly duckling stage" was observed. During exfoliation of the lateral teeth, the maxillary canine, and the second premolar exhibited the greatest extent of autonomous

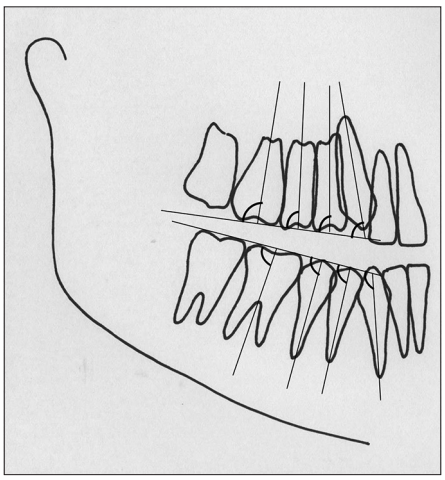

Figure 9: The method used to quantify the positions of the lateral teeth and buds relative to the functional occlusal plane. The posterior angle between the long axis of the lateral teeth and the functional occlusal plane was measured

Table 1: Comparison of the axial angulations of the lateral teeth in Case 1

	Mean angulation±SD, degrees							
	Right side				Left side			
	First molar	Second premolar	First premolar	Canine	Canine	First premolar	Second premolar	First molar
Mixed dentition	96.0	69.0	72.5	73.5	70.5	64.0	76.0	91.0
Pretreatment	96.5	78.5	79.0	77.0	79.0	71.5	86.0	93.0
Difference	0.5	9.5	6.5	3.5	8.5	7.5	10.0	2.0

Table 2: Comparison of the axial angulations of the lateral teeth in Case 2

	Mean angulation±SD, degrees							
	Right side				Left side			
	First molar	Second premolar	First premolar	Canine	Canine	First premolar	Second premolar	First molar
Mixed dentition	95.5	78.5	73.5	68.0	58.5	72.0	69.0	93.5
Pretreatment	93.5	93.5	71.5	78.5	70.5	78.5	84.5	92.5
Difference	−2.0	15.0	−2.0	10.5	12.0	6.5	15.5	−1.0

change in the angle of the mesiodistal tooth angle. In the anterior segment, the angulation of the teeth was found to have changed autonomously according to the canine eruption. During the eruption of these lateral teeth, autonomous uprighting was induced on both the crowded and noncrowded sides. However, excessive mesial tipping of the first premolar resulted in insufficient space for the canine eruption.

In the cases of skeletal Class I malocclusion described here, little crowding was found in the lower dentition. The mandibular deciduous teeth were exfoliated successfully, and the tooth alignment and dental arch became harmonized in the permanent dentition before orthodontic treatment was performed. Basically, normal exfoliation during the transition from deciduous to permanent teeth resulted in uprighting of the permanent teeth relative to the FOP.

Dempster *et al*. reported that the long axes of the roots of the upper teeth extend beyond the crowns and are visible in an orthographic projection.[29] The long axes of the upper teeth tend to converge in the maxilla, whereas those of the lower teeth tend to diverge in the mandible. Based on these findings, the underlying mechanism can be described as follows. As the maxillary teeth from the canine to the second premolar are located closer to each other in the mixed dentition than the mandibular teeth, the maxillary teeth interacted easily in the alveolar bone, resulting in progressive mesial tipping of the lateral teeth. This might be explained in part by the fact that the canine and the first and second premolars are located close to the first molar root, where root formation and calcification are completed in the mixed dentition.

In addition, the first molar was oriented perpendicular to the FOP during the observation period. The reason may be that the first molar has the greatest impact on occlusion and must support the bite force. It is mechanically beneficial for the upper first molar, which is connected to the large area of the "key ridge," to face the mandible through the FOP.

CONCLUSIONS

Based on the results of this study, two new findings are described. Autonomous changes in the inclination of the mesiodistal maxillary teeth were observed during exfoliation, particularly in the canine and second premolars. In addition, the eruption of the maxillary lateral teeth influenced the neighboring teeth, whereas the first molar maintained an environmentally defined position.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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