The influence of erupting lateral teeth on maxillary anterior crowding in two Angle Class I maloclussion cases with high and low angles

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Abstract

Two cases of anterior crowding, both Skeletal Class I and Angle Class I maloclussion, one being low angle and the other high angle respectively, respectively, were treated and evaluated to ascertain whether or not there is a relationship among disproportionate mesial axial angulation of the maxillary lateral teeth and the Frankfurt Horizontal-Functional Occlusal plane, therefore generating maxillary anterior crowding. Both cases were Japanese boys, the first one aged 9 years 10 months with chief complaint being anterior crowding and the second case aged 7 years and 8 months complaining of inadequate space for satisfying canine eruption. During and after the second stage of orthodontic treatment on both cases, several radiographic analysis were performed to assess treatment progress and retention; from these radiographs, it was noticed among other findings that in the high-angle case, the axial angulations of the maxillary lateral incisors were markedly smaller than in the low-angle case, thus indicating mesial tipping in the upper dental arch. This decreased mesial axial angulation of the lateral teeth observed at high angles may potentially cause maxillary space deficiency.

Key words: Angle's Class I malocclusion with high canine, axial angulations of the maxillary lateral teeth, functional occlusal plane, high and low angles

INTRODUCTION

Crowding is a form of malocclusion that presents with irregularly positioned teeth as a result of arch length discrepancy (ALD). Clinically, among the various malocclusions, the incidence of crowding is comparatively high.[1-4] van der Linden[1] suggested that the etiology of crowding involves discrepancies between tooth size and jaw size, mainly due to genetics.[4-9] Doris *et al.*,[4] in a biometric study, found that crowded arches caused by an ALD >4 mm consistently had larger teeth than those with less or no crowding. Bernabé *et al.*[10] showed that crowded arches had smaller arch dimensions than noncrowded ones. Moreover, several other factors such as early loss of deciduous molars,[11] mesiodistal tooth and arch dimensions,[12] and oral and perioral musculature[11] are thought to affect the development and severity of crowding.

It has been suggested that the direction of mandibular growth is associated with incisor crowding.[2,3,13-17] Sakuda *et al.*[2] found that increased mandibular incisor crowding was related to a large mandibular plane (MP) angle, a shorter

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mandibular body length, and a larger upper facial height. Similarly, Leighton and Hunter[3] found that patients with severe crowding in the mixed and permanent dentitions had a shorter mandibular body length and concluded that mandibular crowding occurs in patients with a specific mandibular morphology characterized by downward growth of the mandible. Based on these studies, various explanations for the development of mandibular incisor crowding have been proposed. However, even if the discrepancy between tooth size and jaw size is the cause of crowding in both arches, the maxillary and mandibular dentitions show different patterns of crowding.[18] For instance, the maxilla often shows anterior crowding with high canines and the mandible often shows malposition of the incisors.

In general, the maxillary lateral teeth are angulated more mesially than the mandibular ones.[19] Therefore, maxillary anterior crowding with high canines may result from a completely different mechanism than the one that causes slight mandibular incisor crowding. The factors that lead to maxillary anterior crowding have not been fully elucidated. One potential cause may be the prominent mesial axial angulation of the maxillary lateral teeth relative to the functional occlusal plane (FOP).[20] This study was performed to examine the influence of the axial angulations of the erupting maxillary lateral teeth relative to the FOP on maxillary anterior crowding in Angle's Class I malocclusion with high and low angles.

CASE REPORTS

Case 1

History and diagnosis

A Japanese boy aged 9 years and 10 months presented with the chief complaint of anterior crowding. He had a short, symmetric face with a straight brachyfacial profile [Figure 1a]. The molar relationship was Angle Class I bilaterally. The overjet and overbite were +4.0 and +2.8 mm, respectively [Figure 2a]. His upper dental arch was slightly narrow, but both dental arches were approximately symmetrical [Figure 3a].

In Phase I orthodontic treatment, we began with a lingual holding arch to maintain space until the permanent lateral teeth erupted. Before the completion of the permanent dentitions, four panoramic radiographs were taken, confirming the erupting permanent lateral teeth [Figure 4a-d].

When we began edgewise appliance treatment (Phase II, Figure 1b), cephalometric analysis indicated the following angles: SNA, 80.1°; SNB, 79.2°; and ANB, 0.9°. The FMA was 15.5°. The maxillary and mandibular incisors were proclined by 127.7° and 94.4° relative to the Frankfurt Horizontal (FH) and MPs, respectively. For the soft-tissue measurements, the distance from the upper lip to the E line was larger than the distance from the lower lip to the E line [Table 1]. The ALDs were −2.0 and −3.5 mm in the upper and lower dental arches, respectively [Figures 2b and 3b]. The diagnosis was determined to be skeletal Class I malocclusion with low-angle case.

Treatment and progress

The treatment objectives were to correct anterior crowding and to achieve suitable functional occlusion in the absence of premolar extraction. Standard edgewise appliances (0.018 inch × 0.025 inch) were placed on both dental arches. Leveling was performed by using a series of nickel-titanium (Ni-Ti) wires, including 0.014

Table 1: Summary of cephalometric analysis Case 1 (°)

Case 1	T1 (9 years 11 months)	T2 (10 years 9 months)	T3 (11 years 5 months)	T4 (13 years 8 months)	T5 (15 years 4 months)
SNA	80.0	80.0	80.0	80.0	81.0
SNB	78.0	78.0	78.0	78.0	79.0
ANB	2.0	2.0	2.0	2.0	2.0
Facial angle	87.0	87.0	87.0	87.0	88.0
Y-axis	60.0	58.0	61.0	61.0	62.0
Occlusal plane	10.0	10.0	10.0	7.0	7.0
FMA	16.0	18.3	17.8	17.2	18.0
Gonial angles	119	120	121	115	112
SN−MP	28.0	28.0	28.0	27.0	27.0
U1 to FH	122	117	118	120	114
FMIA	62.0	66.0	63.0	60.0	62.0
IMPA	98.0	96.0	95.0	100	100
Upper lip to E line	3.0	3.0	2.0	2.0	1.0
Lower lip to E line	0	1.0	2.0	1.0	1.0

MP – Mandibular plane; IMPA – Incisor mandibular plane angle; FMIA – Frankfort Mandibular incisor angle; SN – Sella-nasion; FMA – Frankfort-Mandibular plane angle; FH – Frankfurt horizontal

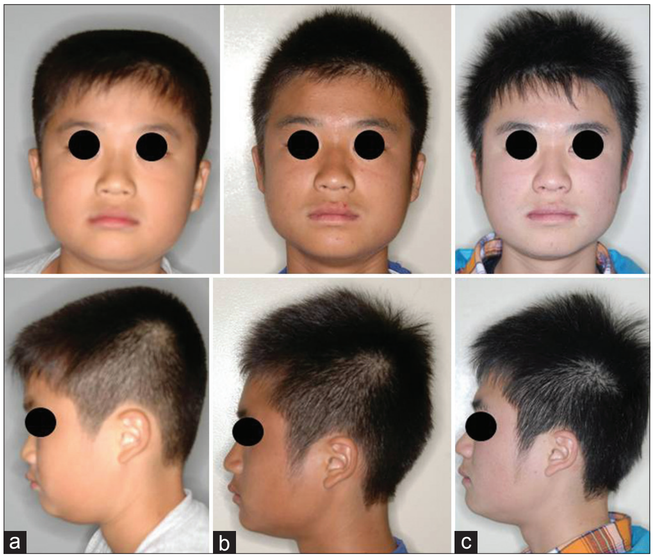

Figure 1: Facial photographs of patient 1: (a) Initial; (b) pre-Phase II treatment; and (c) posttreatment

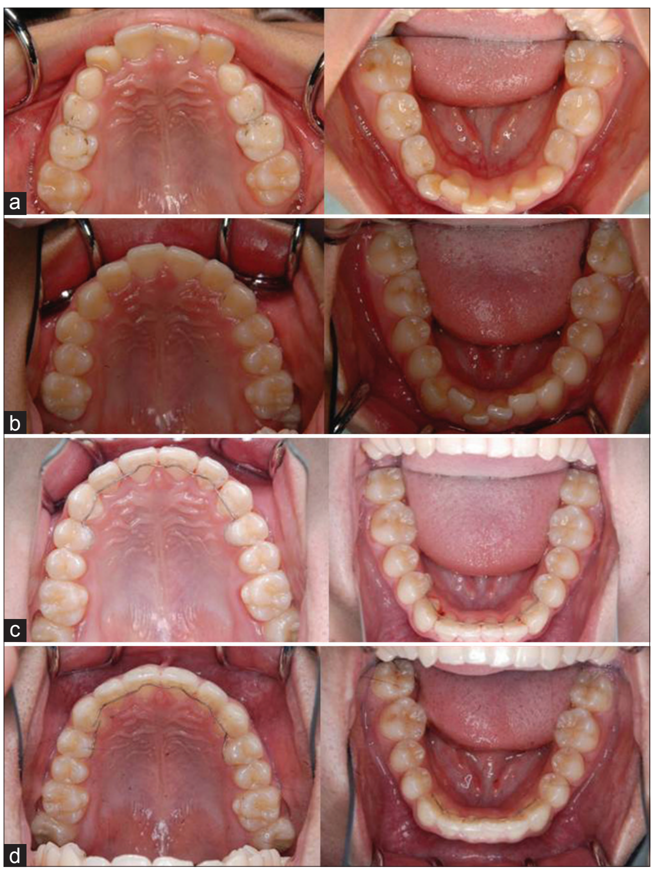

Figure 3: Occlusal view of patient 1 (centric occlusion): (a) Initial; (b) pre-Phase II treatment; (c) posttreatment; and (d) postretention

inch, 0.016 inch, and 0.018 inch round wires. As a final step, the ideal-sized 0.016 inch × 0.022 inch archwires were applied to both dental arches. The total active treatment time was 16 months (T5: After edgewise appliance treatment; Figures 1c, 2c, 3c, and 4e). After

Figure 2: Intraoral frontal and lateral view of patient 1 (centric occlusion): (a) Initial; (b) pre-Phase II treatment; (c) posttreatment; and (d) postretention

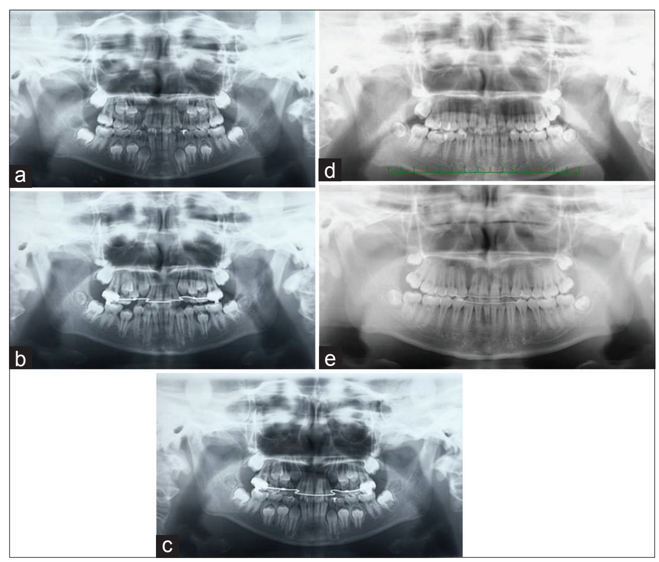

Figure 4: Panoramic radiographs of patient 1 (centric occlusion): (a) T1, initial; (b) T2, 1 year after T1; (c) T3, 2 years after T2; (d) T3, pre-Phase II treatment; and (e) T4, posttreatment

removal of the edgewise appliances, a Hawley-type retainer was used on the maxilla, and a canine-to-canine spring retainer was used on the mandible. After 25 months of retention, occlusal relation was nearly achieved [Figures 2d and 3d].

Case 2

History and diagnosis

A Japanese boy aged 7 years and 8 months presented with the chief complaint of deficient space for satisfactory eruption for the canines. He had a dolichofacial, symmetric face and a convex profile [Figure 5a]. The molar relationship was bilateral Angle Class I. The overjet and overbite were +4.8 mm and +2.5 mm, respectively [Figure 6a]. The intraoral view showed a slightly narrow maxillary arch [Figure 7a].

We began treatment by applying a functional orthodontic appliance to enhance occlusal force and to eliminate any adverse oral habits during the early stages of orthodontic treatment (Phase I treatment). During Phase I treatment, panoramic radiographs were taken, confirming the presence of erupting permanent lateral teeth [Figure 8a-c].

After completion of the permanent dentition, cephalometric analysis indicated the following angles: SNA, 81.2°; SNB, 75.9°; and ANB, 5.4°. FMA was 34.1°. The maxillary and mandibular incisors were proclined by 120.2° and 110.5° relative to the FH and MPs, respectively. With regard to the soft tissue, the distance from the lower lip to the E line was greater than the distance from the upper lip to the E line [Table 2].

The ALDs were estimated to be −15.0 and −4.0 mm in the upper and lower dental arches, respectively [Figures 6b and 7b]. The diagnosis was determined to be Angle Class I malocclusion with high-angle case.

Treatment and progress

The treatment objectives were to correct anterior crowding with upper and lower premolar extraction and to achieve a functionally optimal occlusion. A 0.018 inch × 0.025 inch standard edgewise appliance was placed on both dental arches. A series of Ni-Ti wires, including 0.014 inch, 0.016 inch, and 0.018 inch round wires, were used for leveling. Finally, the ideal-sized 0.016 inch × 0.022 inch archwires were used for both dental arches. The active treatment period lasted for 28 months (T5: After edgewise appliance treatment; Figures 5c, 6c, 7c, and 8d). After removal of the edgewise appliances, a Hawley-type retainer was placed on the upper dental arch, and a canine-to-canine spring retainer was placed on the lower dental arch. After 21 months of retention, acceptable occlusion was achieved [Figures 6d and 7d].

Measurements of mesiodistal angulation

Cephalometric measurements

During the orthodontic treatment, cephalometric analysis was conducted to evaluate the mesiodistal angulation in reference to the posterior angle between the FOP and the long axis of the canines, premolars, and first molars. Lateral cephalograms were obtained during Phases I and II of the orthodontic treatment, with the patients seated upright and the FH plane parallel to the floor. A natural head posture was ensured using visual feedback in a mirror. Each subject was instructed to swallow, to lightly contact the molars to bring the mandible into the natural intercuspal position, and to breathe naturally during the radiography. The cephalograms were traced on acetate paper and the axes of the lateral teeth were digitized. All of the measurements were taken by a single examiner. The FOP, drawn through the cuspal overlap of the first molars and first premolars, was used as a reference plane for measuring the changes in the axial angulations [Figure 9].

RESULTS

Treatment results

Case 1

The edgewise appliances were used for 1 year and 5 months. The facial profile was well maintained to the end of treatment [Figure 5b]. The crowding was

Table 2: Summary of cephalometric analysis Case 2 (°)

Case 2	T1 (7 years 9 months)	T2 (8 years 6 months)	T3 (9 years 3 months)	T4 (11 years 6 months)	T5 (14 years 1 month)
SNA	81.0	81.0	81.0	82.0	82.0
SNB	75.0	76.0	76.0	77.0	77.0
ANB	6.0	5.0	5.0	5.0	5.0
Facial angle	86.0	86.0	86.0	87.0	88.0
Y-axis	64.0	66.0	66.0	66.0	65.0
Occlusal plane	17.0	20.0	20.0	18.0	17.0
FMA	30.0	33.0	35.0	34.1	33.0
Gonial angle	124	125	127	124	125
SN−MP	43.0	44.0	46.0	44.0	43.0
U1 to FH	111	105	105	125	112
FMIA	59.0	55.0	57.0	52.0	53.0
IMPA	92.0	93.0	90.0	96.0	96.0
Upper lip to E line	4.0	4.0	4.0	3.0	0
Lower lip to E line	5.5	6.0	6.0	6.0	1.0

MP – Mandibular plane; IMPA – Incisor mandibular plane angle; FMIA – Frankfort mandibular incisor angle; SN – Sella-nasion; FMA – Frankfort mandibular-plane angle; FH – Frankfurt horizontal

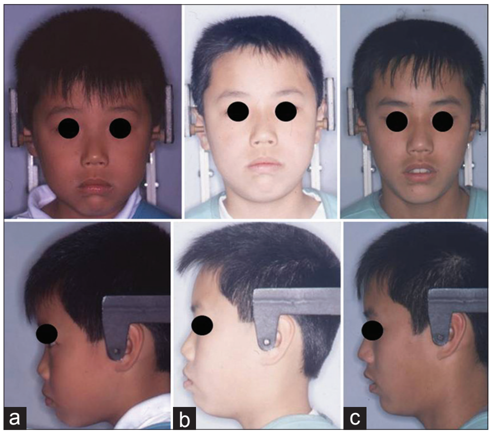

Figure 5: Facial photographs of patient 2: (a) Initial; (b) pre-Phase II treatment; and (c) posttreatment

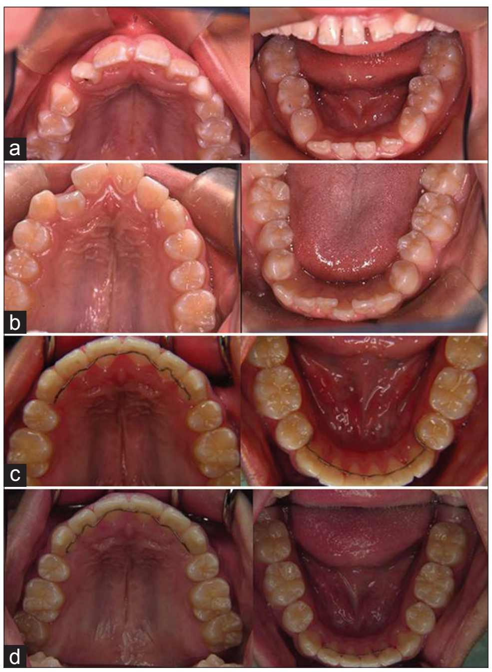

Figure 7: Occlusal view of patient 2 (centric occlusion): (a) Initial; (b) pre-Phase II treatment; (c) posttreatment; and (d) postretention

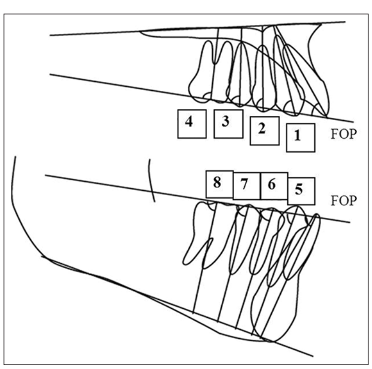

Figure 9: Measurement of the axial angulations of the lateral teeth relative to the functional occlusal plane. 1 – Maxillary canine; 2 – Maxillary first premolar; 3 – Maxillary second premolar; 4 – Maxillary first molar; 5 – Mandibular canine; 6 – Mandibular first premolar; 7 – Mandibular second premolar; 8 – Mandibular first molar

Figure 6: Intraoral frontal and lateral view of patient 2 (centric occlusion): (a) Initial; (b) pre-Phase II treatment; (c) posttreatment; and (d) postretention

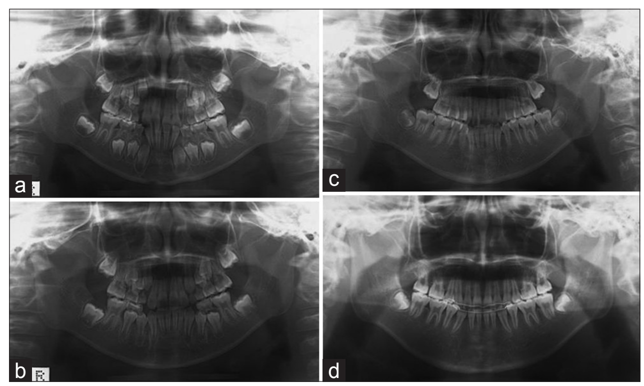

Figure 8: Panoramic radiographs of patient 2 (centric occlusion): (a) T1, initial; (b) T3, 2 years after T1; (c) T4, pre-Phase II treatment; and (d) T5, posttreatment

improved, showing an optimal overjet and overbite and bilateral Class I molar relation [Figure 6b]. The panoramic radiograph taken after treatment showed proper parallel alignment of the roots without signs of resorption or periodontal bone loss. There were no significant changes in the skeletal cephalometric measurements or in the facial appearance. The maxillary incisors were inclined lingually, as indicated by the change in the U1 to FH from 120° to 114°, and approached the Japanese standard of normal. The mandibular incisor angulation was not significantly changed [Table 2]. The occlusal condition was well-maintained during the 14-month retention period [Figures 5c, 6c, and 7].

Case 2

After the active extraction treatment, an acceptable occlusion and facial profile were achieved [Figures 1c, 2c, and 3c].

The posttreatment panoramic radiograph showed that the roots were parallel, without resorption or periodontal bone loss [Figure 4e]. The skeletal measurements did not show any significant changes. On the contrary, the maxillary incisors were inclined lingually to the FH plane, as was noted by the change from 125° to 112°, and approached the Japanese standard of normal. There were no significant changes in the mandibular incisor angulation or the soft-tissue measurements [Table 2]. The intercuspation remained stable and was maintained during the 2-year retention period [Figure 2c].

Changes in the mesiodistal tooth axis

In Case 1, during T1–T4, the axial angulation of the maxillary canines and premolars measured as the angle formed between the long axis and the occlusal plane changed from 62.0° to 74.0° and from 70.0° to 85.0°, respectively. These measurements indicated that the teeth showed distal tipping. However, the upper first molars showed an approximately 90°–95° angle relative to the occlusal plane. Similarly, in the lower dental arch, the first molars had an approximate angulation of 90° to the occlusal plane. Furthermore, the angulations of canines and premolars in the lower dental arch were generally larger than those in the upper dental arch [Table 3].

In Case 2, during T1–T5, the axial angulations of the upper canine and first premolar (canines: 50°–70°, first premolars: 63°–68°) were considerably smaller than those in Case 1, indicating that the teeth showed mesial tipping. However, the upper second premolars were similar (Case 1: 83°–92°, Case 2: 82°–88°). The canine angulations tipped most mesially, particularly in Case 2, following the second smallest angulation of the first premolar. In addition, the angulations of the lower canines and premolars largely showed greater angulation than those of the upper dental arch [Table 4].

Table 3: The mesiodistal tooth axis to the occlusal plane Case 1 (°)

Case 1	Canine	First premolar	Second premolar	First molar
Upper				
T1	62.0	72.0	90.0	91.0
T2	68.0	70.0	83.0	95.0
T3	67.0	82.0	88.0	96.0
T4	74.0	85.0	92.0	95.0
T5	74.0	85.0	87.0	96.0
Lower				
T1	90.0	88.0	103.0	89.0
T2	85.0	85.0	100.0	82.0
T3	82.0	87.0	88.0	88.0
T4	80.0	82.0	81.0	89.0
T5	70.0	79.0	80.0	85.0

Table 4: The mesiodistal tooth axis to the occlusal plane Case 2 (°)

Case 2	Canine	First premolar	Second premolar	First molar
Upper				
T1	50.0	65.0	88.0	92.0
T2	54.0	68.0	88.0	95.0
T3	63.0	63.0	82.0	95.0
T4	60.0	65.0	85.0	94.0
T5	70.0	-	83.0	88.0
Lower				
T1	75.0	81.0	91.0	83.0
T2	83.0	88.0	92.0	86.0
T3	80.0	86.0	88.0	85.0
T4	70.0	77.0	78.0	84.0
T5	72.0	-	85.0	90.0

DISCUSSION

In the present study, two cases, both Skeletal I and Angle class I malocclusion, with the difference of one being High angle and the second Low angle and analyzed to determine whether an association between excessive mesial axial angulation of the maxillary lateral teeth and the FH-FOP angle could be a cause of maxillary anterior crowding. Results showed that the axial angulations in the high-angle case were considerably smaller than those in the low-angle case, indicating mesial tipping in the upper dental arch. In particular, progressive mesial tipping of the maxillary lateral teeth was noted. This tipping was more prominent in the canines than in the first premolar. The mechanics underlying the mesial tipping of the maxillary lateral teeth can be explained as follows: The first molar erupts toward the end of the primary dentition. During root formation and calcification, when the patient is between the ages of 6 and 9 years, its roots lie adjacent to and at the same level as the first and second premolar germs.[21] The tooth germs straighten labiolingually from the canine to the second molar, and the second premolar germ descends to the level of the first premolar germ. However, the canine germ remains at its highest position, in the upper half of the maxillary process, in the mixed dentition.[22] Several panoramic X-ray films in this study showed that in the high-angle case, the mesial angulation of the erupting maxillary canine and premolars increased with steep FOP angle.

In addition, a difference between the upper and lower dentitions in the mesiodistal tooth axis was demonstrated in both cases. In a previous study, the axes of the maxillary teeth tended to converge in the maxilla, whereas the opposite was true in the mandible.[23] These findings may explain why crowded maxillary lateral tooth germs are encountered frequently during radiographic analysis.

Another important result of this study was that in both cases, the first molar was located almost perpendicular to the FOP. A possible reason for this is that the first molar is the principal tooth supporting the bite force. For mechanically beneficial occlusion, the maxillary first molar must be perpendicular to the FOP.

In the present study, Cases 1 and 2 showed considerable differences in the main vertical dentofacial variables of Down's analysis. In particular, the FH-FOP angles in the low- and high-angle cases were 7°–10° and 17°–20°, respectively. Interestingly, a wide FH-FOP angle was found to be related to the mesial axial angulation of the maxillary lateral teeth. Based upon these data, the FOP seems to rotate downward and backward in the same direction as mandibular growth. The resulting change in the FH-FOP angle causes the first molar roots to move forward and closer to the unerupted or erupting second and first premolars. The axial angulations of the maxillary lateral teeth then progressively increase in the mesial direction during premolar eruption. Therefore, high canines might occur easily in high-angle cases because the canines normally erupt among the lateral teeth, even though the space for eruption is insufficient. Conversely, the low-angle case demonstrated distal tipping of the canine and the first premolar crowns because the upright movement of these teeth decreased the anterior crowding [Figure 10].

Finally, it should be noted that this analysis is based upon a very small sample size. Further investigation focusing on mesiodistal tooth axis and the basal arch length in a larger number of cases is warranted to determine the influence of the axial angulations of the maxillary lateral teeth relative to the FOP on maxillary anterior crowding.

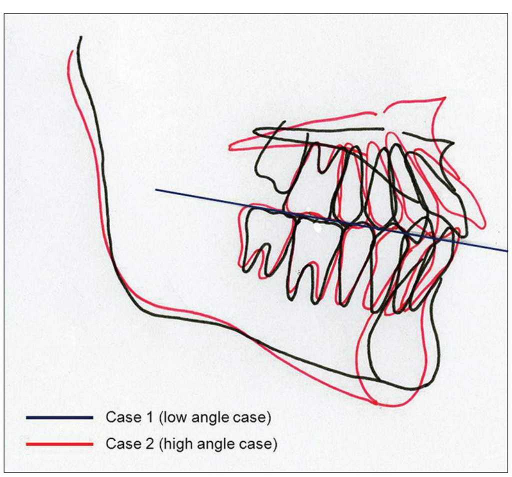

Figure 10: Superimposition of the cephalometric tracings on the functional occlusal plane at Mo in Cases 1 and 2 (Mo is defined as midpoint of upper and lower first molar occlusal surfaces)

CONCLUSIONS

The decreased mesial axial angulation of the maxillary lateral teeth observed in the Class I high-angle case potentially causes space deficiency in the permanent dentition, resulting in maxillary anterior crowding with high canines.

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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Nil.

Conflicts of interest

There are no conflicts of interest.

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