Labiolingual and mesiodistal positioning of maxillary permanent incisors during the eruption process

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This study aimed to establish radiographical parameters concerning the tipping, the labiolingual positioning and the angulation of the maxillary permanent incisors in the mixed dentition. Three groups of 20 cephalograms and 20 orthopantomographic radiographs taken from children aging from 7 to 12 years old, with normal occlusion were compared. The Group I presented only the eruption of the central permanent incisors, the Group II presented both the central and lateral permanent incisors and the Group III presented central, lateral incisors and permanent canine teeth. The tipping and the labiolingual positioning were measured, respectively, using U1/PP and U1↔A^{VERT}. Mesiodistally, the angles between the teeth axis and the line that touched the lower border of the orbit in the orthopantomographic radiographs were measured. The mean values of tipping, labiolingual positioning and angulation of the central and lateral incisors obtained from Groups I, II and III were respectively 112˚, 1.2mm, 90.4˚ and 91.7˚; 112˚, 2.6mm, 89.5˚ and 96.8˚ and. 114˚, 2.7mm, 87.4˚ and 92.6˚. The tipping levels were similar for all groups, the mean values of the labiolingual positioning were significantly different at 5% when Group I was compared to both Groups II and III. And the mean values of the angulation were significantly different 5% for the central incisors between Groups I and III, and at 1% for the lateral incisors between Groups I and II, and, II and III.
J Clin Pediatr Dent 25(1): 13-21, 2000

INTRODUCTION

The labiolingual and mesiodistal positioning of maxillary permanent incisors is considered as one of the most important aspects to be analyzed for the elaboration of orthodontic diagnosis.[12,36] Sagitally, the anterior teeth positioning is established by means of a variety of cephalometric analysis.[7-10,22,25-28]

Furthermore, the mesiodistal angulation of permanent teeth also should be considered in an occlusion analysis, once Andrews[1] determined the mean values of tooth crown angulation and chose this condition as one of the six keys to be evaluated in a normal occlusion.

Posteriorly, Ursi *et al*.[39] determined, through orthopantomographical radiographs, the angulation of all permanent teeth axis in young individuals aging from 12 to 17 years old.

Finally, the axis tipping also should be analyzed in orthodontically treated cases, principally when the evaluation of root parallelism is desired. These concerns were emphasized by Capezolla Filho *et al*.[8] when compared post-treatment teeth angulation between Straight-wire and Edgewise Standard techniques.

The transition dynamic between primary and permanent dentition is widely considered as a clinical condition, which awakens preoccupation to both the patient parents and the clinician, with regard the esthetical and functional positioning of maxillary permanent incisors.

During the physiological eruption process, permanent incisors acquire generally an esthetically compromised position due to the presence of space and, to the discrepancy between the tooth size and maxillofacial dimension. According to Bonnar,[5] maxillary permanent incisors initiate eruption vertically and, then, labially. Additionally, the incisor crowns divergencies associated with the

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Research partly supported by CNPq, Brazil.

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spaces establish a period routinely known as "ugly duckling stage", which chronologically occurs from 7 to 11 years old of age.[6,25] The interdental spacing may reduce partly or even totally with the eruption of permanent canines. And in this dynamic period, the incisors may change position labiolingually and mesiodistally.[25]

On the other hand, during the mixed dentition, some other factors, such as habits of lingual interposition, tongue and pacifier sucking as well as labial incompetency, may determine undesirable teeth positioning. With these clinical circumstances, it is possible to notice that the incisors, after the eruption, may change the position physiologically or even through habitual interferences. Despite the recognition of these clinical changes, there are few reports in the literature with respect of the position that the permanent maxillary incisors acquire during the phase of transition between primary and permanent dentition, that is, the mixed dentition period.

Thus, clinicians seek a more reliable parameters to differentiate the sagittal tooth positioning considered as normal from the abnormal condition, which demands orthodontic treatment.

Considering the importance of maxillary permanent incisors in the dentofacial complex, the present transversal study aims to evaluate the positioning of these teeth mesiodistally, as well as the protrusion level and labiolingual tipping in three different periods during the mixed dentition.

MATERIAL AND METHODS

This study needed analyses of 60 lateral norm cephalograms and 60 orthopantomographical radiographs taken from 60 young individuals, regardless sex, aging from 6 to 12 years old. All the individuals presented normal occlusion, without tooth loss and showed overjet and overbite up to 3mm.

After obtaining these prospective samples, they were divided into three groups characterized as following:

Group I: 20 cephalograms and 20 orthopantomographical radiographs taken from 20 young individuals with average age of 7 years and 3 months, presenting only maxillary permanent central incisors (CI) erupted.

Group II: 20 cephalograms and 20 orthopantomographical radiographs taken from 20 young individuals with average age of 8 years and 9 months, presenting CI and LI erupted.

Group III: 20 cephalograms and 20 orthopantomographical radiographs taken from 20 young individuals with average age of 10 years and 8 months, presenting CI, LI and C erupted.

Cephalometric tracing

The cephalograms were obtained in lateral norm in habitual occlusion. The tracing was made by one orthodontist and checked by another one. The paper used was a transparent acetate paper "StraightLine™ GCH Wire Company," dimensioned 17.5cm x 17.5cm with 0.003inch of thickness.

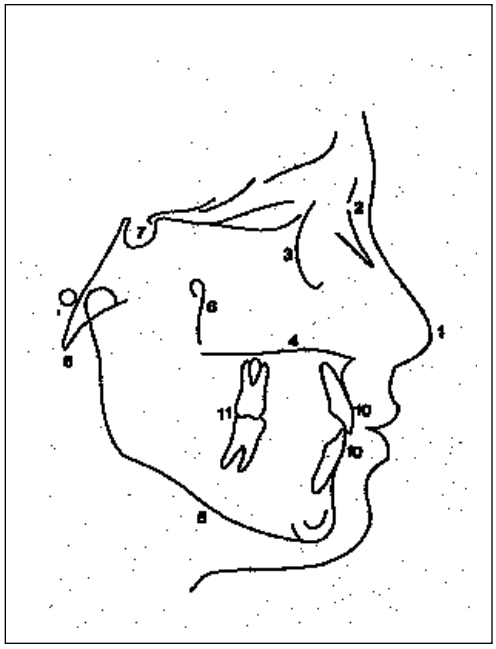

Figure 1. Cephalometric tracing of anatomic structures.

Anatomic tracing

The anatomic tracing consisted of the following details according to Krogman; Sassouni[19] (Figure 1) with esthetic and landmark determination finality.

1. Soft tissue profile, starting at the frontal region and following the mandible including the complete contouring of the chin;
2. Profile of frontal and nasal bones
3. Averaged lower border of the orbital cavity;
4. Maxilla, consists of the portion that goes from anterior nasal spine to the cervical portion of alveolar process (prosthion, PR), and the floor of nasal fossa, that is, from anterior nasal spine (ANS) to posterior nasal spine (PNS) and hard palate;
5. Mandible, labial and lingual outline of the chin, passing through the averaged lower border of the body and ramus of the jaw and mandibular condyle;
6. Pterygomaxillary fissure;
7. Sella turcica, including the anterior, posterior and lower border;
8. Lower border of the anterior margin of foramen magnum, in the middle sagittal plane;
9. Delimitation of external auditory meatus;
10. Upper and lower central incisors;
11. Upper and lower first molars in occlusion.

Definition of cephalometric landmarks

The landmarks established according to Krogman, Sassouni[19] and McNamara Jr.[23] were the following (Figure 2):

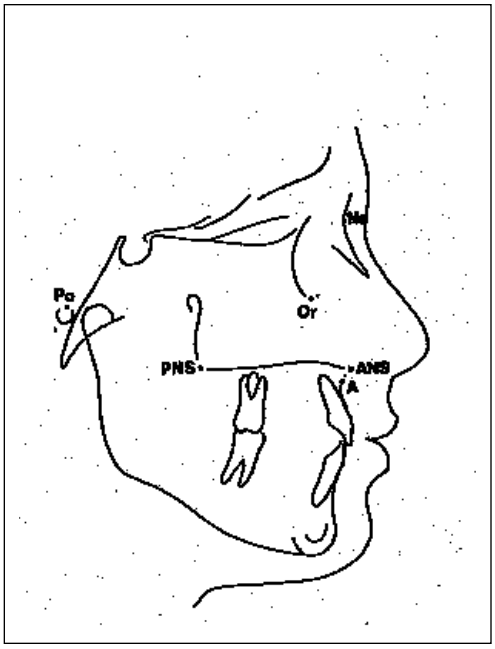

Figure 2. Cephalometric landmarks.

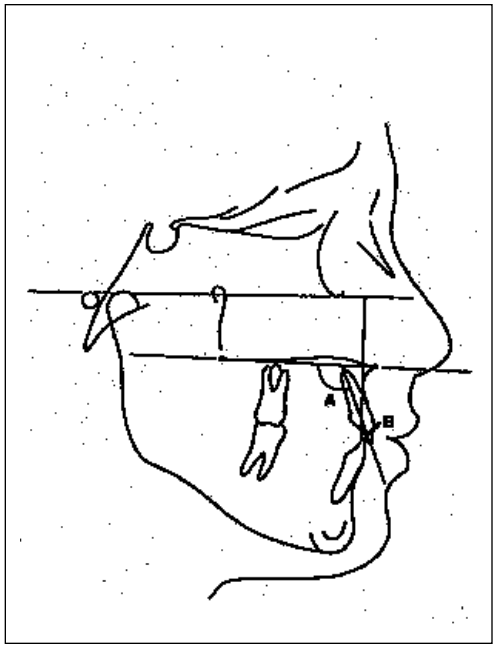

Figure 3. Cephalometric measures U1/PP (A) and U1 <--> A^{VERT} (B).

- Na (Nasion): the most anterior point on the nasofrontal suture;
- ANS (Anterior nasal spine): the tip of the bony anterior nasal spine;
- PNS (Posterior nasal spine): the most posterior point on the hard palate in the sagittal plane;
- "A" point (Subspinale): the deepest point in the curved bony outline from the base to the alveolar process of the maxilla; Or (Orbitale): the lowest point on the outline of the orbit contour; Po (Porion): the most superior point on the outline of the external auditory meatus.

After landmarks delimitation, the tracings were done on a digitizing tablet ACCUGRID XNT of Numonics Corp., which was connected to a computer. Then the cephalometric measures were obtained by means of the Software Dentofacial Planner 7.0 from Dentofacial Software Inc. Toronto, Canada.

Cephalometric measures

The cephalometric measures used for the present study were the following (Figure 3):

A- U1/PP: the angle between the upper incisors axis and the palatal plane (ANS-ANP); Burstone,[7]

B- UI↔ ^{VERT}: the horizontal distance between the facial surface of the upper incisor and a perpendicular erected from point A to the Frankfort horizontal plane, McNamara Jr.[24]

Maxillary incisors mesiodistal angulation measurements

For the evaluation of upper incisors mesiodistal angulation, orthopantomographic radiographs were used. A sheet of acetate paper Straight-Line™ of GCH Wire Company was placed over the radiographic film in the same proportion in size. By means of 0.5mm pencil, the lower outline of both the right and left orbit were traced.[4]

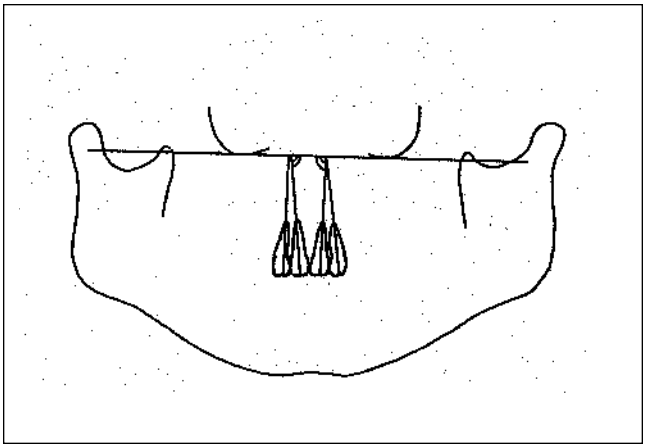

Figure 4. Anatomic tracing, reference line and angulation measurements from othopantomagraphic radiographs.

Later, upper central and lateral incisors were traced as well as the axis, having as references the respective longest extension of the root canal.

In each radiograph, the values of the angles between the upper incisor axis and the reference line which touches the lowest point on the orbit outline were obtained.

Statistical Analysis

All the numerical findings were submitted to the test of analysis of variance and tukey test when the differences were significant.

Table I. Analysis of variance of maxillary permanent central incisors mesiodistal angulation obtained from Groups I, II and III.

Source of variation	Sum of Squares	Freedom degree	Mean Square	F	Probability (HO)
Among Groups	185.4125	2	92.7063		1.175%*
Residues	2351.8999	117	20.1017	4.61	
Total variation	2537.3125	119			

*Statistically significant at 5%

Table II. Tukey test for the comparison of mean values of maxillary permanent central incisors mesiodistal angulation obtained from Groups I, II and III.

Group	N	Mean	Standard deviation	Statistical decision *
I	40	90.4	5.8	A
II	40	89.5	4.1	AB
III	40	87.4	3.0	B

* Different letters determine statistically significant differences.
q value = 3,362
Critical value = 2,4

Table III. Analysis of variance of maxillary permanent lateral incisors mesiodistal angulation obtained from Groups I, II and III.

Source of variation	Sum of Squares	Freedom degree	Mean Square	F	Probability (HO)
Among Groups	597.8750	2	298.9375	6.61	0.230%*
Residues	5294.5000	117	45.2521		
Total variation	5892.3750	119			

*Statistically significant at 1% and 5%

Table IV. Tukey test for the comparison of average values of maxillary permanent lateral incisors mesiodistal angulation obtained from Groups I, II and III.

Group	N	Mean	Standard deviation	Statistical decision *
I	40	91.7	8.6	A
II	40	96.8	6.9	B
III	40	92.6	3.4	A

* Different letters determine statistically significant differences
q value = 3,362
Critical value = 3,4

RESULTS

Results from orthopantomographic radiographs

The mean values of mesiodistal angulation of upper permanent central incisors before and after the eruption of lateral incisors were 90.4˚ (Group I) and 89.5˚ (Group II), respectively. After the eruption of permanent canines, the mean value of mesiodistal angulation of upper permanent central incisors was 87.4˚ (Group III). The values evidenced in Group I and III were statistically different at 5% (Tables I and II).

The mean values of mesiodistal angulation presented by the permanent lateral inciors before and after eruption were 91.7˚ (Group I) and 96.8˚ (Group II), respectively. After the eruption of permanent canines, the value of mesiodistal angulation presented was 92.6˚ (Group III). The value presented by Group II was statistically different at 1% when compared with

Table V. Analysis of variance of cephalometric measure values U1↔A^{VERT} obtained in Groups I, II and III.

Source of variation	Sum of Squares	Freedom degree	Mean Square	F	Probability (HO)
Among Groups	28.3544	2	14.1772	3.88	2.556%*
Residues	208.1951	57	3.6525		
Total variation	236.5494	59			

*Statistically significant at 5%

Table VI. Tukey test for the comparison of mean values of U1↔A^{VERT} among Groups I, II and III.

Group	N	Mean	Standard deviation	Statistical decision *
I	20	1.2	1.9	A
II	20	2.6	2.0	B
III	20	2.7	1.7	B

* Different letters determine statistically significant differences
q value = 3,41
Critical value = 1,4

Table VII. Analysis of variance of cephalometric measure values U1/PP obtained in Groups I, II and III.

Source of variation	Sum of Squares	Freedom degree	Mean Square	F	Probability (HO)
Among Groups	70.0375	2	35.0187	1.22	30.232%*
Residues	1634.7125	57	28.6792		
Total variation	1704.7500	59			

Group I and Group III. (Tables III and IV).

Results from cephalometric measures

The mean values of cephalometric measure, which evaluate the level of protrusion of upper permanent incisors, U1↔A^{VERT}, were 1.2, 2.6 and 2.7 millimeters in Groups I, II and III, respectively. Group I was statistically different from Groups II and III at 5% (Tables V and VI).

The mean values of labiolingual tipping of upper permanent incisors established by cephalometric measure U1/PP were 112°, 112° and 114° in Groups I, II and III, respectively. These values were not statistically different (Table VIII).

DISCUSSION

The determination of parameters for anteroposterior and mesiodistal incisor positioning aims to help the clinicians in the orthodontic diagnosis and, consequently, the treatment planning.

Although the numerical values may vary individually, the knowledge about the mean values of the tooth positioning provides a better orientation to the clinician during the clinical approach.

In this present transversal study, three groups of orthopantomographical radiographs and cephalograms were analyzed. These groups belong to the three different central, lateral incisors and canines eruption periods. These conditions were analyzed due to the wide clinical variation with regard the incisors positioning during mixed dentition. The most mentioned phase by researchers and clinicians is the "ugly duckling stage", in which spacing and maxillary incisors protrusion can be evidenced.[6,25] These clinical characteristics of esthetic and funtional differences between the primary and permanent dentitions, may establish doubts for both the parents and the clinicians. Although these characteristics constitute normal condition in the transition phase, they may transmit some difficulty during the occlusal analysis, with respect of the necessity of orthodontic treatment.

Another important factor is the fact that the preventive and interceptive orthodontic interventions are increasing. Thus, the clinician should have in mind parameters to differentiate the abnormal tooth position from tooth with physiological developmental normal positions.

Among the auxiliary methods used for orthodontic

diagnosis during the phase of dento-skeletal development, orthopantomographic radiographs and cephalograms can be mentioned.

Besides presenting a general view of the teeth development, orthopantomographic radiograph allows the establishment of the axial positioning of crown and root individually as well as in a group of teeth.

Andrews[1] demonstrated that in a normal occlusion the crowns should present some level of angulation to reach the occlusion balance. This was one of the six most important keys evidenced in normal occlusion and, posteriorly, this principle was applied to idealize brackets for "Straight Wire" technique. This fact demonstrates the importance of the determination and evaluation of the teeth mesiodistal positoning during the diagnosis as well as for the cases treated orthodontically with fixed appliances.[8,37]

The sagittal positioning of the incisors evaluated by the labiolingual tipping and by the protrusion or retrusion level are factors that should not be neglected in any kind of orthodontic evaluation. For this purpose, the cephalometric measures U↔A^{VERT} and U1/PP to evaluate the protrusion and the tipping levels, respectively, was used. Ellis and McNamara Jr.[13] considered these measures as the most reliable for the positioning determination of the upper permanent incisors.

Mesiodistal positioning of maxillary permanent central incisors

The mean value of the angulation of the maxillary central permanent incisors (CI), before the eruption of the lateral permanent incisors (LI) and upper permanent canine (C) in Group I was of 90.4˚, that is, practically in right angle with the reference line that passes through the lowest border on the orbits.

After the eruption of LI (Group II), CI acquired a smaller angulation value (89.5˚), therefore, the long axis increased tipping level, establishing a crown mesialization and root distalization, however, this mean value was not statistically different in comparison to the Group I.

When the canine erupted, Cl presented an angulation of 87.4˚, and, therefore, more reduced than the previous phases, that is, in this period, thelong axis of CI were tipped more distally. The value found in this phase (Group III) was statistically different ($p < 0.05$) from that observed in the first phase (Group I), where LI and C were not erupted yet.

With these results, it was evident that after the eruption of CI, they were almost verticalized, probably due to the influence of the crown of LI in the root positioning of CI. In this period, the procedure of spacing reduction is not recommended, any movement that can move the root of central incisors distally should be avoided.

The mean value of the angulation found in the last phase (Group III), when almost all the upper teeth were erupted, was similar to that found by URSI,[39] who determined the angulation average of permanent dentition in normal occlusion.

Also, the mean values of the angulation of the maxillary permanent central incisors found in those cases treated orthodontically with fixed appliance by Edgewise Standard and Straight Wire technique[8] were very similar to those found in Group III of this study, in normal occlusion.

As the value found in Group III was different statistically from Group I, it should be emphasized once again that the angulation positioning of the standard brackets and the angulation included in the Straight Wire brackets of approximately 5˚ are not necessary for CI before the eruption of the permanent lateral incisors and canines.

Andrews[3] reported that when the crown of the upper permanent central incisor was tipped approximately 5˚ mesiodistally, its diameter would increase 0.15mm. During the treatment with Standard and Straight Wire brackets, it would provide a 5˚ of crown angulation for the central incisors and that, at the end of the treatment, they acquired a long axis angulation of 87˚. Thus, with these angulations, the permanent central incisors may occupy 0.3mm approximately in the dental arch.[8]

As the mean value of the angulation, from the permanent central incisors in the Group III, was also approximately 87˚, it suggests that each upper permanent central incisors used 0.15mm more in the dental arch.

Mesiodistal positioning of upper permanent lateral incisors

The mesiodistal angulation of the lateral incisors before their eruption (Group I) was 91.7˚ in average. After eruption (Group II) the angle increased to 96.8˚, because, the crown became more tipped distally, establishing a statistically significant difference in relation to the previous phase (Group I).

After the eruption of the permanent canine (Group III) the lateral incisors presented an angle of 92.6˚ and this value was statistically different from the value of the previous phase (Group II). However the angle found in this phase (Group III) was similar to that obtained before eruption (Group I).

From these results, it was noticed that the lateral permanent incisors altered the level of axial tipping after the eruption. The crown trended to be positioned distally and, with the eruption of the permanent canine, they became more verticalized.

During the radiographic observation it was noticed that the close influence of the permanent canine on the lateral incisors axial tipping. In some studies, there were mentioned possibilities of resorptions of the lateral incisors related with the positioning of the permanent canine tooth. By this point view Ericson and Kurol,[14] reported cases of resorption even in well-positioned lateral incisors. They recommended clinical supervisions before 10 years old of age or, by means of an radiographic evaluation, and these supervisions should not pass the 11 year-old age.

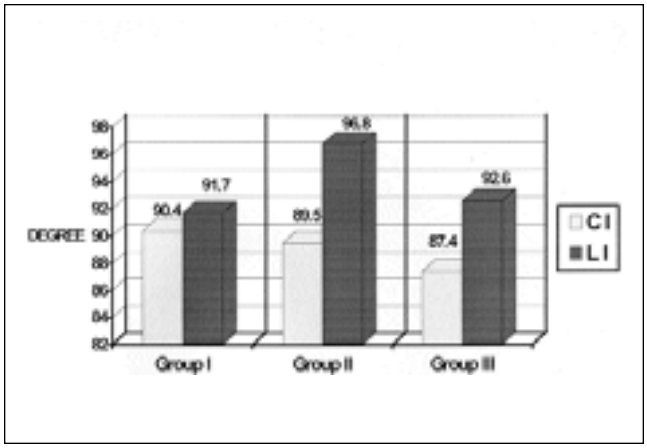

Figure 5. Mean values of the angulation of upper permanent central and lateral incisors in Groups I, II and III.

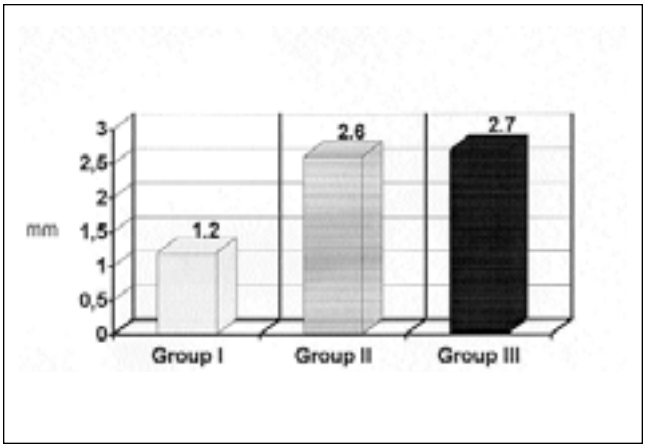

Figure 6. Mean values of cephalometric measure U↔A^{VERT} in Groups I, II and III.

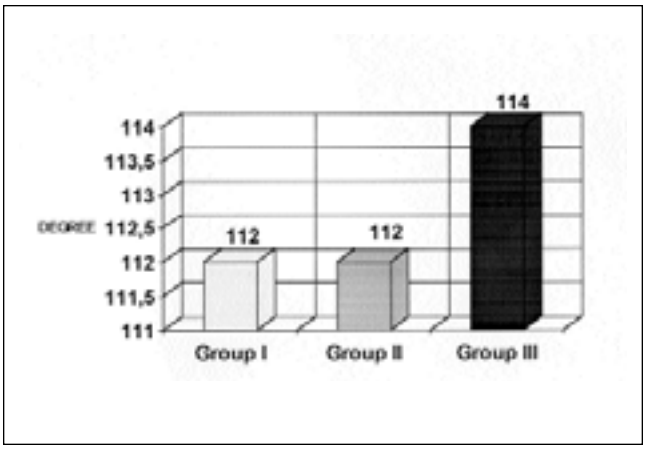

Figure 7. Mean values of cephalometric measure U1/PP in Groups I, II and III.

The mean value of the angulation of LI 92.6° after the eruption of the permanent canine (Group III), was within the range of the values reported by Ursi.[39] According to Capelozza Filho,[8] the permanent lateral incisors treated orthodontically with Straight Wire brackets, prescribed by Andrews,[3] presented at the end of the treatment, long axis angulation similar to that found in this study.

According to Andrews[3] by Straight Wire technique, the brackets of the lateral incisors presents an angulation of 9° mesiodistally. After the establishment of this crown angulation, that is, at the end of the leveling, the mesiodistal distance of LI occupies approximately 0.25mm more, when compared with verticalized teeth.

Correlating the results obtained by Andrews[3] and by Capelozza Filho[8] with the results obtained in this study, it suggests that LI occupies, approximately, 0.5mm (0.25mm on each side) only after the eruption of the permanent canine, once the angulation of LI in Group III was similar to those found in the cases treated by Straight Wire technique.[6]

Anteriorposterior positioning of the upper permanent incisors

The values observed, during the dynamics of eruption of upper anterior teeth, for the cephalometric measure U1↔A^{VERT} were 1.2; 2.6; 2.7 millimeters in Groups I, II and III, respectively. In the cases where only the upper permanent central incisors were erupted (Group I), the mean value of 1.2mm was statistically different from the mean values observed in the Group II and III.

On the other hand, the mean value found in Group II (2.6mm) was similar to that found in Group III (2.7mm), showing no significant difference.

These results demonstrated that the upper incisors, when analyzed sagittally, were more retruded before the eruption of LI and C.

After the eruption of LI, the protrusion level, analyzed cephalometrically, increased significantly when compared with the Group I, in which only CI were erupted and, the incisors trended to keep the protrusion level immediately after the eruption of the canine.

The values found in the last phase (Group III) did not reach the values of 4 to 6mm established in the normal mixed dentition by McNamara Jr.[24] However, the values presented by Martins *et a1*.[23] corroborate with the results found in this study, when compared between the same age group.

As a parameter, the values ranging from 1.2mm to 2.6mm can be established for cephalometric measure U1↔A^{VERT} value, in the anteroposterior positioning of the upper permanent incisors superiors, before the eruption of LI and, after the eruption of the upper permanent canine, respectively.

Labiolingual tipping of the upper permanent incisors

The labiolingual tipping of the upper incisors was evaluated by the angle between the axis and palate plane (UI/PP).

The mean value found when CI have just erupted (Group I) was 112˚**.** After the eruption of LI (Group II) the value did not alter and, with the eruption of the permanent canine, (Group III) the tipping of the incisors increased smoothly to 114˚. There were not statistically significant differences among three phases of study.

The results of this study demonstrated that the upper permanent incisors tipping maintained stable during all the studied phases, which was in agreement with the results of Smith, Rap,[32] who observed the same behavior of the incisors in youths of the age group between 3 and 9 years of age.

It is important to emphasize that the values found in this study were similar to those found by Martins *et al*.[23] in the same age group (period of occlusion development).

The results also were similar to those found by Ellis and McNamara Jr.[13] when they evaluated people above 16 years of age.

Correlating the results of these studies, it is possible to point out that the incisors tipping are almost established at the moment of the eruption of the central incisors and it maintains until the eruption of the permanent canine. It should be emphasized that in the first transition period of normal occlusion development, the incisors have similar tipping level when compared with those observed after the establishment of the occlusion in the permanent dentition.

Based on the results obtained in three analyzed phases it is possible to stipulate the value of 112˚ as the parameter for the values of U1/PP, since the eruption of CI until the eruption of permanent canine.

GENERAL CONSIDERATIONS

The results obtained in this study established that central and lateral incisors altered positioning mesiodistally at the moment of the eruption CI until the complete eruption of the canine.

The upper permanent central incisors (CI) erupted almost vertically in relation to the reference line which touch, the border of the orbit, the crowns trended to tip mesially and the root, distally, with the eruption of LI, establishing a smaller angle. The tipping became significantly different after the eruption of permanent canine (C).

The upper permanent lateral incisors (LI), before the eruption, had the crowns positioned mesially (angle of 91.7˚). After the eruption, these teeth presented, in mean value, the crowns more distally and the root more mesially, establishing a significantly larger angle (96.8˚) when compared with that observed before their eruption. After the eruption of C, the crowns of LI were less tipped distally and the angulation (92.6˚) was statistically different from the value found in the previous phase (96.8˚). On the other hand, the axial tipping of LI in this phase (92.6˚) was similar to that found before their eruption (91.7˚).

The results evidenced by Andrews[3] and Capelozza Filho[8] and with the results obtained in this study, allowed the establishment of the upper inter-incisor spacing of approximately 0.8mm, before the eruption of the canine teeth, trends to reduce totally only through the mesiodistal alteration, of the upper permanent incisors axial angulation.

The anteroposterior positioning of the upper permanent incisors, when measured by ($U1 \leftrightarrow A^{VERT}$) presented mean value of 1.2mm, which became more protruded after the eruption of LI (2.6mm) and did not increase with the eruption of the permanent canine (2.7mm).

During the evaluation of the labiolingual tipping level, which was established by the cephalometric measure U1/PP, the results found in the three phases were not different statistically demonstrating that the tipping of the upper permanent incisors do not alter at the moment of the eruption of CI until the complete eruption of the upper permanent canine.

The results of the protrusion and tipping levels established that the incisors were retruded ($U1 \leftrightarrow A^{VERT}$) before eruption of the lateral incisors, however, in this period, the tipping (U1/PP) in relation to the palate plane was within the normal range. After the permanent lateral incisors and canine eruption, the incisors positioned more anteriorly, although the axial mean tipping does not alter significantly.

These modifications suggest a bodily displacement of the maxillary incisors with the eruption of the permanent lateral incisors and canine, probably associated with the anteroposterior growth.

CONCLUSIONS

Based on the methodology and considering the inherent limitations, the results obtained in this study were as follows:

1. Upper central permanent incisors modify their axial tipping (mesiodistal position) moving the crown mesially, from eruption until the complete eruption of the permanent canines. Upper lateral permanent incisors acquire an axial position in moving the crown distally, at the moment of eruption and, then, they become verticalized when permanent canines are erupted.
2. Upper permanent incisors are more protruded (anteroposterior position) after the eruption of lateral incisors and do not change significantly with the eruption of upper permanent canines.
3. The upper permanent incisors maintain the same level of labiolingual tipping, from the eruption of central incisors until the eruption of upper permanent canines.

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