Original Article

Upper Incisor Position and Bony Support in Untreated Patients as Seen on CBCT

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ABSTRACT

Objective: To test the null hypothesis that there are no correlations between the morphology of the upper jaw, the position of the upper incisors, and facial type.

Materials and Methods: From a sample of 191 patients, the FMA angle was used to select 20 short face type, 20 norm face type, and 20 long face type patients, aged 12 to 40 years. Using cone-beam computed tomography (CBCT), tomography was carried out on sagittal sections corresponding to the four upper incisors. Some parameters defining the dentoskeletal relationships, the alveolar thickness, the alveolar height, and the dental movement were measured. The measurements were processed using analysis of variance and Tukey's test.

Results: At the upper central incisors, short face type patients presented a greater alveolar bone thickness than long face type patients. In short face type and norm face type subjects the root apex of the upper incisors was farther away from the lingual cortex than in the long face type patients. At the central incisors the alveolar thickness was greater and the lingual cortex was higher with respect to the lateral incisors in all three facial types.

Conclusion: At the upper incisors, facial type is statistically significantly correlated with both alveolar bone thickness and distance between the root apex and lingual cortex. (*Angle Orthod.* 2009;79:692–702.)

KEY WORDS: Upper incisors; Facial type; Upper jaw morphology

INTRODUCTION

Some researchers deem the position of the upper incisors as a fundamental parameter upon which to base an orthodontic treatment plan and define the position to be reached at upon termination of treatment as the "planned incisal position."[1] The correct positioning of the upper incisors is important, especially for esthetic ends, because it conditions the position of the upper lip. The vertical thickness of the upper lip at the vermilion seems to be the most relevant factor for a pleasant smile, and it has a positive correlation with the degree of protrusion of the upper incisors.[2] The inclination of the upper incisor axis with respect to the maxillary occlusal plane should be $64.3 + 3.2°$ in women and $64.0 + 4.0°$ in men. The vertical positioning of the upper incisors should be sufficient to permit the exposure of 3–5 mm of the incisal edge under the upper lip at rest. The horizontal position of the upper incisors takes into account several clinical parameters, including the nasal projection, the upper lip support, and cephalometric parameters such as the thickness and angulation of the upper lip and its projection with respect to the real vertical line.[3]

Tsunori et al[4] analyzed the correlation between the buccal-lingual inclination of the lower first and second molars and facial type in a sample of patients and found that in short face type patients these teeth tend to be more lingually inclined than in norm and long face type patients. A contrasting result was reported in a later article.[5] Janson et al[6] revealed that the upper first molars and second premolars in long face type patients have a far more accentuated buccal inclination than in short face type patients, but he found no difference in inclination of the lower posterior teeth be-

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tween the two facial types. Legović et al[7] also found no significant statistical difference between the position of the third molar and facial type.

Various studies have demonstrated that the characteristics of the alveolar structure of the upper anterior teeth are relevant to dental movement and its consequences in orthodontic treatment. In fact, the height of the lingual cortex is thought to influence the center of resistance of teeth,[8,9] a reduced thickness of the alveolar bone seems to limit the possibility of successful orthodontic treatment, and a short distance from the tooth apex to the lingual cortex appears to be a risk factor for root resorption and loss of periodontal support.[10–12]

As regards the correlation between jaw morphology and facial type, Siciliani et al[13] found that the mandibular symphysis is elongated in long face type patients and thicker in short face type patients. Tsunori et al[4] reported that the cortex is thicker at the lower incisors in short face type patients than it is in norm and long face type patients. He found a greater thickness of the vestibular cortex in the former group, except at the lower first and second molars, where the lingual cortex is thicker. Masumoto et al[5] also evidenced a thicker cortex at the lower first and second molars in short face type patients.

The aim of our research was to use CBCT to determine whether a correlation exists between the morphology of the upper jaw, the position of the upper incisors, and facial type.

MATERIALS AND METHODS

A sample of 191 patients (aged 12 to 40 years) was subdivided into facial type according to their FMA angle. This produced 20 short face type (FMA 15°–21°), 20 norm face type (FMA 22°–28°), and 20 long face type (FMA 29°–35°) patients. Excluded from the study were patients with craniofacial malformations, evidence of previous trauma, and prosthetics, as were those who had undergone endodontic treatment or surgery to the stomatognathic apparatus.

Cone-beam computed tomography (CBCT) was performed using a NewTom 3G Volume Scanner (QR srl, Verona, Italy). A secondary reconstruction of each digital volumetric tomography was acquired using Newtom 3G software in order to obtain axial sections that permitted clear observation of the root canals of the upper central and lateral incisors (Figures 1, 2). A line passing through the center of each root canal was traced, and the software was used to obtain several sagittal sections of the upper jaw perpendicular to the aforementioned line. The sagittal sections analyzed were those corresponding to the central axis of the four upper incisors (Figures 3 through 5). Several parameters were calculated for each section.

Figure 1. Lateral scout view.

The parameters defining the dentoskeletal relationships were the following (Figure 6):

- Angle between the incisor axis and the SN plane[14];
- Angle between the incisor axis and the bispinal plane[15];
- Angle between the incisor axis and the line NA[16];
- Distance between the incisor crown and the line NA[16]; and
- Angle between the incisor axis and the axis of the buccal and lingual cortex.[11]

The measurements defining the alveolar thickness were the following (Figure 7):

- Distance from the buccal cortex to the internal and external lingual cortex at 15 mm from the incisal edge[17];
- Distance from the buccal cortex to the internal and external lingual cortex at 20 mm from the incisal edge[17];

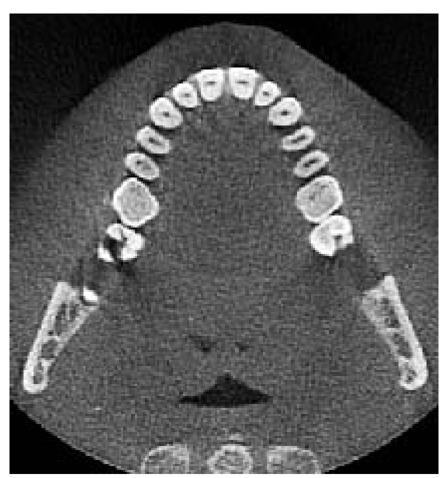

Figure 2. Axial section of an upper arch.

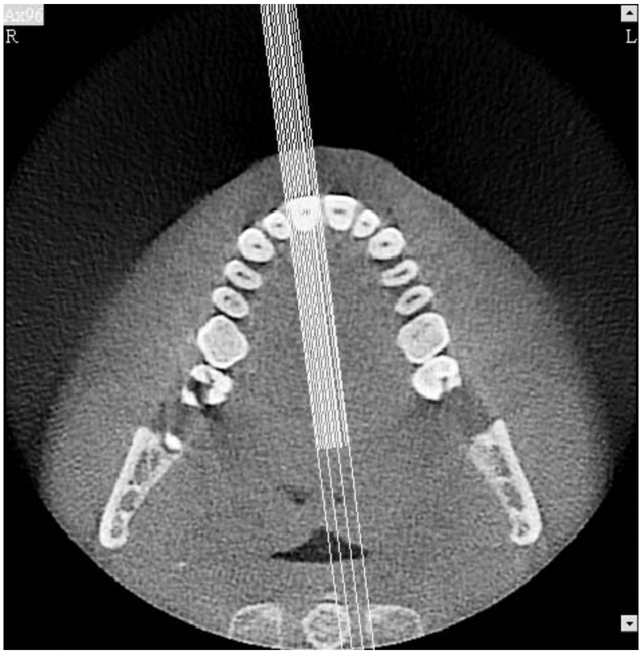

Figure 3. Section perpendicular to the line traced through the center of the root canal of an upper right central incisor.

- Distance from the buccal cortex to the internal and external lingual cortex at point A[17]; and
- Distance between the tooth apex and the buccal and lingual cortex.[10]

The measurements of alveolar height were the following (Figure 8):

- Dentoalveolar height[18];
- Height of the buccal and lingual alveolar bone[8];
- Distance between the plane passing through the apex and center of resistance of the tooth,[8] which is found halfway between the apex of the root and the crest of the alveolar bone[19]; and
- Distance between the apex and the bispinal plane.[10]

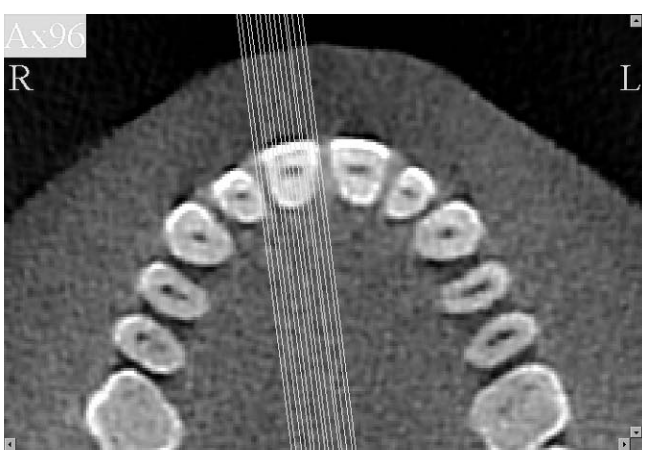

Figure 4. Detail of Figure 3.

Figure 5. Sagittal section of an upper right central incisor.

Each sagittal section was saved in JPEG format (Figure 9) and imported into the program AutoCAD 2007, (Autodesk Inc, San Rafael, CA, USA) with which the vestibular and lingual movements were simulated at their maximum measurement, mimicking a radicular rotation of the upper incisors around their center of resistance.

The following parameters were then calculated (Figure 10):

- Angle of vestibularization in which one of the two sides corresponded to the distance between the center of resistance and the point at which the apex came into contact with the internal buccal cortex;
- Angle of lingualization, (movement in palatal direction) in which one of the two sides corresponded to the distance between the center of resistance and the point at which the apex came into contact with the internal lingual cortex;
- Arc of vestibularization, defined as the distance traveled by the apex until its contact with the internal buccal cortex during the vestibularization, which indicated the maximum possible inclination in the buccal direction of the apex without provoking resorption;

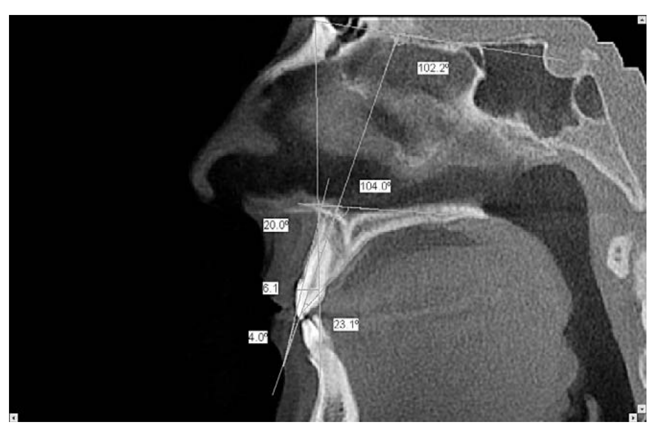

Figure 6. Dentoskeletal relationships.

Table 1. Means and Standard Deviations (SDs) of the Values Measured at the Right Central Incisor, Compared Among Facial Types

	Short Face Type Mean ± SD	Norm Face Type Mean ± SD	Long Face Type Mean ± SD	*P*
Dentoskeletal relationships				
Inc ax/SN (°)	103.00 ± 7.43	102.70 ± 8.51	100.60 ± 8.80	ns
Inc ax/bispin (°)	109.10 ± 6.51	108.50 ± 9.36	106.60 ± 8.59	ns
Inc ax/NA (°)	21.06 ± 8.95	20.71 ± 7.40	18.62 ± 7.03	ns
Inc crown-NA (mm)	7.09 ± 2.44	6.58 ± 2.29	6.75 ± 1.95	ns
Inc ax/bucc cort (°)	6.82 ± 3.82	6.10 ± 2.15	6.21 ± 2.59	ns
Inc ax/ling cort (°)	25.09 ± 7.68	24.23 ± 7.96	21.06 ± 7.85	ns
Alveolar thickness				
Bucc cort-int ling at 15 mm (mm)	8.08 ± 1.44	7.71 ± 1.18	7.38 ± 1.16	ns
Bucc cort-ext ling at 15 mm (mm)	9.79 ± 1.59	9.18 ± 1.28	8.71 ± 1.35	ns
Bucc cort-int ling at 20 mm (mm)	9.32 ± 2.02*	9.23 ± 1.92	7.86 ± 0.09	.028
Bucc cort-ext ling at 20 mm (mm)	11.23 ± 2.19*	10.89 ± 2.01	9.53 ± 2.12	.032
Bucc cort-int ling at point A (mm)	11.57 ± 2.81	10.54 ± 2.32	9.56 ± 3.18	ns
Bucc cort-ext ling at point A (mm)	14.08 ± 3.75	12.46 ± 2.52	11.58 ± 3.27	ns
Apex-bucc cort (mm)	3.75 ± 1.39	3.80 ± 1.22	3.60 ± 0.97	ns
Apex-ling cort (mm)	11.21 ± 3.47*	11.14 ± 3.87*	8.26 ± 2.76	.011
Alveolar height				
Dentoalv height (mm)	28.41 ± 2.59	28.05 ± 2.92	29.52 ± 3.73	ns
Bucc cort height (mm)	8.90 ± 2.13	8.42 ± 2.16	8.02 ± 1.24	ns
Ling cort height (mm)	11.32 ± 1.92	11.08 ± 2.21	10.36 ± 1.24	ns
Resist center-apex (mm)	5.10 ± 0.85	4.79 ± 0.95	4.64 ± 0.59	ns
Apex-bispin (mm)	7.19 ± 3.09	7.21 ± 3.30	8.72 ± 3.46	ns
Dental movement				
Ang vestibul (°)	20.85 ± 11.5	20.30 ± 9.46	18.60 ± 8.92	ns
Ang lingual (°)	57.40 ± 15.38*	49.50 ± 16.67	42.15 ± 17.46	.019
Arc vestibul (mm)	2.08 ± 1.01	2.03 ± 1.20	1.73 ± 0.75	ns
Arc lingual (mm)	5.99 ± 1.91**	4.81 ± 2.01	4.02 ± 1.57	.005
Max poss movem (mm)	8.07 ± 1.90**	6.84 ± 2.67	6.74 ± 1.91	.006

* $P < .05$ vs long face type; ** $P < .01$ vs long face type; *** $P < .001$ vs long face type; ns indicates not significant.

- Arc of lingualization, defined as the distance traveled by the apex until its contact with the internal lingual cortex during the lingualization, which indicated the maximum possible inclination in the lingual direction of the apex without provoking resorption; and
- Maximum possible movement, given by the sum of the arcs of vestibularization and lingualization.

Statistical Analysis

The means and standard deviations of all the measurements were calculated. The one-way analysis of variance (ANOVA) test was used for variance analysis, in which the facial types were initially compared with each other, and then the four incisors belonging

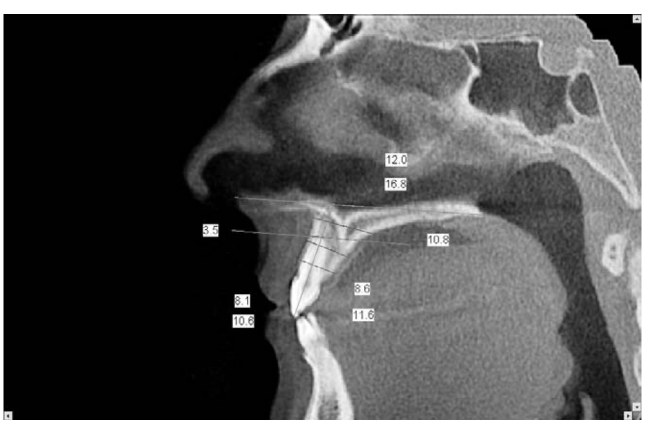

Figure 7. Measurements of alveolar thickness.

Figure 8. Measurements of alveolar height.

Table 2. Means and Standard Deviations (SDs) of the Values Measured at the Right Lateral Incisor, Compared Among Facial Types

	Short Face Type Mean ± SD	Norm Face Type Mean ± SD	Long Face Type Mean ± SD	*P*
Dentoskeletal relationships				
Inc ax/SN (°)	106.80 ± 9.58	107.30 ± 8.63	103.40 ± 8.09	ns
Inc ax/bispin (°)	111.20 ± 7.21	111.30 ± 8.36	107.40 ± 7.56	ns
Inc ax/NA (°)	20.88 ± 8.03	23.98 ± 6.36	18.49 ± 7.01	ns
Inc crown-NA (mm)	6.87 ± 1.96	7.06 ± 2.65	6.64 ± 2.26	ns
Inc ax/bucc cort (°)	6.07 ± 3.19	5.73 ± 2.43	6.60 ± 4.23	ns
Inc ax/ling cort (°)	21.32 ± 8.84	19.71 ± 6.95	19.30 ± 8.50	ns
Alveolar thickness				
Bucc cort-int ling at 15 mm (mm)	7.72 ± 1.62	6.95 ± 0.99	7.01 ± 1.22	ns
Bucc cort-ext ling at 15 mm (mm)	9.36 ± 1.52	8.63 ± 1.29	8.28 ± 1.33	ns
Bucc cort-int ling at 20 mm (mm)	7.85 ± 1.78	7.53 ± 2.16	7.16 ± 2.07	ns
Bucc cort-ext ling at 20 mm (mm)	9.96 ± 1.88	9.47 ± 2.25	8.89 ± 2.17	ns
Bucc cort-int ling at point A (mm)	8.95 ± 1.96	8.28 ± 1.94	8.54 ± 3.20	ns
Bucc cort-ext ling at point A (mm)	11.16 ± 2.56	10.42 ± 2.05	10.85 ± 3.34	ns
Apex-bucc cort (mm)	3.79 ± 1.11	3.70 ± 1.21	4.19 ± 1.14	ns
Apex-ling cort (mm)	8.57 ± 2.59	8.71 ± 3.56	7.22 ± 2.59	ns
Alveolar height				
Dentoalv height (mm)	27.49 ± 2.59	27.50 ± 3.08	29.04 ± 3.83	ns
Bucc cort height (mm)	8.45 ± 1.69	8.38 ± 1.73	8.48 ± 1.41	ns
Ling cort height (mm)	10.61 ± 1.44	10.58 ± 1.57	9.92 ± 1.06	ns
Resist center-apex (mm)	4.84 ± 0.85	4.74 ± 0.78	4.54 ± 0.64	ns
Apex-bispin (mm)	8.00 ± 2.73	8.09 ± 3.33	9.35 ± 4.11	ns
Dental movement				
Ang vestibul (°)	17.55 ± 7.71	19.90 ± 11.27	20.50 ± 11.08	ns
Ang lingual (°)	47.45 ± 12.25	42.05 ± 14.99	38.30 ± 15.98	ns
Arc vestibul (mm)	1.71 ± 0.77	2.00 ± 1.24	1.88 ± 1.06	ns
Arc lingual (mm)	4.57 ± 1.04	4.19 ± 1.73	3.59 ± 1.55	ns
Max poss movem (mm)	6.28 ± 1.35	6.20 ± 2.52	5.46 ± 2.11	ns

* $P < .05$ vs long face type; ** $P < .01$ vs long face type; *** $P < .001$ vs long face type; ns indicates not significant.

to each group were compared. Where the ANOVA test produced results of 95% significance, Tukey's test for multiple comparisons was applied to verify where the statistically significant differences could be collocated.

RESULTS

Tables 1 through 4 show the means and standard deviations of the measurements carried out on each of the four incisors in the three facial types. The results of the statistical analysis are reported in the last column, and the results were found to be statistically significant using Tukey's test are shown in symbolic form.

Figure 9. Center of resistance of an upper right central incisor.

Regarding the upper right central incisor (Table 1), the ANOVA yielded significant results for the following parameters:

- Distance from the buccal cortex to the internal and external lingual cortex at 20 mm from the incisal edge;
- Distance from the apex to the lingual cortex;
- Angle and arc of lingualization; and
- Maximum possible movement.

The mean values for these parameters were significantly greater in short face type patients than in long face type subjects.

As regards the upper right lateral incisor (Table 2), the ANOVA test failed to reveal statistically significant differences between the three groups.

The ANOVA yielded significant results in the following parameters pertaining to the upper left central incisor (Table 3):

Table 3. Means and Standard Deviations (SDs) of the Values Measured at the Left Central Incisor, Compared Among Facial Types

	Short Face Type Mean ± SD	Norm Face Type Mean ± SD	Long Face Type Mean ± SD	*P*
Dentoskeletal relationships				
Inc ax/SN (°)	101.70 ± 7.59	103.80 ± 8.01	99.83 ± 8.83	ns
Inc ax/bispin (°)	108.50 ± 6.58	108.10 ± 7.57	105.60 ± 8.27	ns
Inc ax/NA (°)	19.95 ± 7.97	21.85 ± 6.85	17.89 ± 9.09	ns
Inc crown-NA (mm)	6.82 ± 2.23	7.10 ± 2.36	6.54 ± 2.34	ns
Inc ax/bucc cort (°)	5.89 ± 2.30	6.61 ± 3.55	6.58 ± 3.04	ns
Inc ax/ling cort (°)	26.11 ± 6.52	23.21 ± 7.32	20.59 ± 9.78	ns
Alveolar thickness				
Bucc cort-int ling at 15 mm (mm)	7.60 ± 1.06	7.40 ± 1.26	7.09 ± 0.92	ns
Bucc cort-ext ling at 15 mm (mm)	9.39 ± 1.16	8.83 ± 1.30	8.49 ± 1.14	ns
Bucc cort-int ling at 20 mm (mm)	9.16 ± 1.74*	8.67 ± 1.98	7.57 ± 1.32	.015
Bucc cort-ext ling at 20 mm (mm)	11.15 ± 1.94**	10.65 ± 1.96	9.26 ± 1.71	.007
Bucc cort-int ling at point A (mm)	11.64 ± 2.27**	10.74 ± 2.58	9.23 ± 2.24	0.008
Bucc cort-ext ling at point A (mm)	14.06 ± 3.10*	12.97 ± 2.86	11.38 ± 2.70	.018
Apex-bucc cort (mm)	3.79 ± 1.20	3.54 ± 0.94	3.44 ± 0.94	ns
Apex-ling cort (mm)	12.02 ± 4.81*	11.85 ± 4.53	8.60 ± 3.61	.025
Alveolar height				
Dentoalv height (mm)	28.42 ± 2.67	28.70 ± 3.37	30.10 ± 4.01	ns
Bucc cort height (mm)	9.67 ± 1.92	8.92 ± 2.15	9.11 ± 1.54	ns
Ling cort height (mm)	11.80 ± 1.78	11.91 ± 2.47	11.18 ± 1.38	ns
Resist center-apex (mm)	5.24 ± 1.04	5.18 ± 1.11	5.18 ± 0.89	ns
Apex-bispin (mm)	6.56 ± 3.11	6.88 ± 3.12	8.20 ± 3.66	ns
Dental movement				
Ang vestibul (°)	19.00 ± 10.35	16.45 ± 8.73	17.60 ± 8.47	ns
Ang lingual (°)	57.60 ± 12.08	50.15 ± 18.29	45.15 ± 19.57	ns
Arc vestibul (mm)	2.01 ± 1.17	1.73 ± 1.07	1.82 ± 0.84	ns
Arc lingual (mm)	6.12 ± 1.59	5.38 ± 2.48	4.69 ± 2.12	ns
Max poss movem (mm)	8.14 ± 1.88	7.12 ± 3.10	6.50 ± 2.20	ns

* $P < .05$ vs long face type; ** $P < .01$ vs long face type; *** $P < .001$ vs long face type; ns indicates not significant.

- Distance from the buccal cortex to the internal and external lingual cortex at 20 mm from the incisal edge and at point A; and
- Distance from the apex to the lingual cortex.

The mean values for these parameters were significantly greater in short face type subjects with respect to long face type patients.

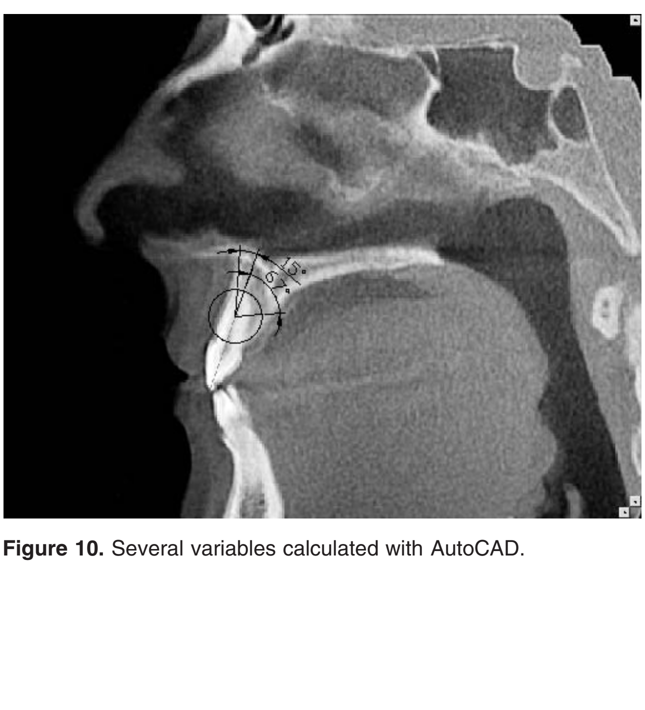

Figure 10. Several variables calculated with AutoCAD.

Concerning the upper left lateral incisor (Table 4), the ANOVA test evidenced statistically significant differences between the three groups in the following two parameters:

- Distance from the apex to the lingual cortex (greater in the norm face type group with respect to the long face type group); and
- Arc of lingualization (greater in the short face type group compared with the long face type group).

Tables 5 through 7 show the means and standard deviations of the measurements carried out for each group, the results of the ANOVA test, and the statistically significant results yielded by Tukey's test. Within the short face type group (Table 5), the ANOVA test revealed no significant differences in any of the parameters measured either when comparing the two central incisors or when comparing the two lateral incisors.

In the norm face type group (Table 6), no significant differences were revealed when comparing the two central incisors. However, the two lateral incisors dif-

Table 4. Means and Standard Deviations (SDs) of the Values Measured at the Left Lateral Incisor, Compared Among Facial Types

	Short Face Type Mean ± SD	Norm Face Type Mean ± SD	Long Face Type Mean ± SD	*P*
Dentoskeletal relationships				
Inc ax/SN (°)	106.40 ± 7.58	104.50 ± 7.81	105.50 ± 6.52	ns
Inc ax/bispin (°)	110.00 ± 5.38	106.70 ± 6.87	105.90 ± 6.40	ns
Inc ax/NA (°)	21.39 ± 7.21	21.15 ± 7.59	20.05 ± 7.07	ns
Inc crown-NA (mm)	6.48 ± 2.32	6.89 ± 2.25	6.63 ± 2.72	ns
Inc ax/bucc cort (°)	7.47 ± 6.62	6.10 ± 2.72	8.34 ± 5.55	ns
Inc ax/ling cort (°)	21.16 ± 6.89	22.18 ± 8.74	16.91 ± 8.05	ns
Alveolar thickness				
Bucc cort-int ling at 15 mm (mm)	7.47 ± 0.85	7.14 ± 1.40	6.78 ± 1.12	ns
Bucc cort-ext ling at 15 mm (mm)	9.06 ± 0.98	8.86 ± 1.50	8.17 ± 1.21	ns
Bucc cort-int ling at 20 mm (mm)	7.98 ± 1.88	7.87 ± 2.22	6.91 ± 1.98	ns
Bucc cort-ext ling at 20 mm (mm)	10.15 ± 1.92	9.81 ± 2.17	8.76 ± 2.11	ns
Bucc cort-int ling at point A (mm)	9.13 ± 1.99	8.98 ± 2.34	7.92 ± 2.49	ns
Bucc cort-ext ling at point A (mm)	11.38 ± 2.00	11.13 ± 2.46	9.98 ± 2.71	ns
Apex-bucc cort (mm)	3.95 ± 1.93	3.40 ± 0.98	3.77 ± 1.43	ns
Apex-ling cort (mm)	8.57 ± 2.58	8.76 ± 2.91*	6.67 ± 2.43	.027
Alveolar height				
Dentoalv height (mm)	28.20 ± 2.17	28.57 ± 2.34	29.70 ± 3.63	ns
Bucc cort height (mm)	8.97 ± 1.89	8.70 ± 1.67	8.36 ± 2.21	ns
Ling cort height (mm)	10.83 ± 1.57	10.47 ± 2.08	10.02 ± 1.81	ns
Resist center-apex (mm)	5.01 ± 1.01	4.77 ± 1.00	4.77 ± 1.05	ns
Apex-bispin (mm)	8.10 ± 2.69	8.52 ± 2.94	10.06 ± 3.62	ns
Dental movement				
Ang vestibul (°)	17.05 ± 12.88	16.40 ± 10.11	20.10 ± 14.20	ns
Ang lingual (°)	49.40 ± 17.27	49.45 ± 18.14	40.80 ± 12.02	ns
Arc vestibul (mm)	1.73 ± 1.53	1.61 ± 1.11	1.82 ± 1.29	ns
Arc lingual (mm)	4.97 ± 2.04*	4.80 ± 2.04	3.58 ± 1.16	.035
Max poss movem (mm)	6.70 ± 2.31	6.41 ± 2.80	5.40 ± 1.92	ns

* $P < .05$ vs long face type; ** $P < .01$ vs long face type; *** $P < .001$ vs long face type; ns indicates not significant.

fered in the angle between the incisor axis and the bispinal plane and in the distance from the buccal cortex to the internal lingual cortex at point A.

Within the long face type group (Table 7), the ANOVA test revealed significant differences in the comparison between the two central incisors for the height of the buccal cortex and the distance from the center of resistance to the apex. When comparing the two lateral incisors, no statistically significant differences emerged.

In all three facial types, the comparison of each central incisor with the lateral incisors yielded significant differences in the following parameters:

- Angle between the incisor axis and the SN plane;
- Distance from the buccal cortex to the internal and external lingual cortex at several distance from the incisal edge or at point A;
- Distance from the apex to one of the alveolar cortices and to the bispinal plane;
- Height of one of the alveolar cortices; and
- Measurements of dental movement.

DISCUSSION

The results of our study indicated several differences among the three facial types in alveolar thickness and potential dental movement. At the two upper central incisors, the short face type group showed a greater bone thickness than the long face type group, both at 20 mm from the incisal edge and at point A. The distance from the root apex to the lingual cortex was also found to be greater in short face type patients with respect to long face type subjects, and the norm face type subjects yielded an intermediate value. At the left lateral incisor, the norm face type subjects showed a greater distance from the apex to the lingual cortex than long face type subjects. No differences among three facial types were found for the right lateral incisor. No differences among three facial types were found for the inclination of the teeth or in the alveolar height measurements for any of the four teeth.

In previously cited research dealing with the posterior teeth and lower incisors, some studies confirm our observation that the alveolar bone is thicker in short face type subjects than in long face patients.[4,5,13] In

Table 5. Means and Standard Deviations (SDs) of the Values Measured in Short Face Type Subjects, Comparing the Four Incisors

	11 Mean ± SD	12 Mean ± SD	21 Mean ± SD	22 Mean ± SD	*P*
Dentoskeletal relationships					
Inc ax/SN (°)	103.00 ± 7.43	106.80 ± 9.58††	101.70 ± 7.59	106.40 ± 7.58†	.001
Inc ax/bispin. (°)	109.10 ± 6.51	111.20 ± 7.21	108.50 ± 6.58	110.00 ± 5.38	ns
Inc ax/NA (°)	21.06 ± 8.95	20.88 ± 8.03	19.95 ± 7.97	21.39 ± 7.21	ns
Inc crown-NA (mm)	7.09 ± 2.44	6.87 ± 1.96	6.82 ± 2.23	6.48 ± 2.32	ns
Inc ax/bucc cort (°)	6.82 ± 3.82	6.07 ± 3.19	5.89 ± 2.30	7.47 ± 6.62	ns
Inc ax/ling cort (°)	25.09 ± 7.68	21.32 ± 8.84*††	26.11 ± 6.52	21.16 ± 6.89**†††	.0001
Alveolar thickness					
Bucc cort-int ling at 15 mm (mm)	8.08 ± 1.44	7.72 ± 1.62	7.60 ± 1.06	7.47 ± 0.85	ns
Bucc cort-ext ling at 15 mm (mm)	9.79 ± 1.59	9.36 ± 1.52	9.39 ± 1.16	9.06 ± 0.98	ns
Bucc cort-int ling at 20 mm (mm)	9.32 ± 2.02	7.85 ± 1.78***†††	9.16 ± 1.74	7.98 ± 1.88***†††	.0001
Bucc cort-ext ling at 20 mm (mm)	11.23 ± 2.19	9.96 ± 1.88***†††	11.15 ± 1.94	10.15 ± 1.92**††	.0001
Bucc cort-int ling at point A (mm)	11.57 ± 2.81	8.95 ± 1.96***†††	11.64 ± 2.27	9.13 ± 1.99***†††	.0001
Bucc cort-ext ling at point A (mm)	14.08 ± 3.75	11.16 ± 2.56***†††	14.06 ± 3.10	11.38 ± 2.00***†††	.0001
Apex-bucc cort (mm)	3.75 ± 1.39	3.79 ± 1.11	3.79 ± 1.20	3.95 ± 1.93	ns
Apex-ling cort (mm)	11.21 ± 3.47	8.57 ± 2.59†	12.02 ± 4.81	8.57 ± 2.58†	.002
Alveolar height					
Dentoalv height (mm)	28.41 ± 2.59	27.49 ± 2.59	28.42 ± 2.67	28.20 ± 2.17	ns
Bucc cort height (mm)	8.90 ± 2.13	8.45 ± 1.69†	9.67 ± 1.92	8.97 ± 1.87	.034
Ling cort height (mm)	11.32 ± 1.92	10.61 ± 1.44†	11.80 ± 1.78	10.83 ± 1.57	.016
Resist center-apex (mm)	5.10 ± 0.85	4.84 ± 0.85	5.24 ± 1.04	5.01 ± 1.01	ns
Apex-bispin (mm)	7.19 ± 3.09	8.00 ± 2.73†	6.56 ± 3.11	8.10 ± 2.69††	.004
Dental movement					
Ang vestibul (°)	20.85 ± 11.51	17.55 ± 7.71	19.00 ± 10.35	17.05 ± 12.88	ns
Ang lingual (°)	57.40 ± 15.38	47.45 ± 12.25*†	57.60 ± 12.08	49.40 ± 17.27	.006
Arc vestibul (mm)	2.08 ± 1.01	1.71 ± 0.77	2.01 ± 1.17	1.73 ± 1.53	ns
Arc lingual (mm)	5.99 ± 1.91	4.57 ± 1.04**†††	6.12 ± 1.59	4.97 ± 2.04†	.0002
Max poss movem (mm)	8.07 ± 1.90	6.28 ± 1.35***†††	8.14 ± 1.88	6.70 ± 2.31***†††	.0001

* $P < .05$ vs 11; ** $P < .01$ vs 11; *** $P < .001$ vs 11; ns indicates not significant.
† $P < .05$ vs 21; †† $P < .01$ vs 21; ††† $P < .001$ vs 21.
# $P < .05$ vs 12; ## $P < .01$ vs 12; ### $P < .001$ vs 12.

contrast to some of these articles, we found no statistically significant correlation between facial type and the spatial inclination of the upper incisors.[4–6]

Although Yamada et al[20] reported that the root apex of the lower central incisors is closer to the internal labial cortex than to the lingual cortex in adult subjects with mandibular prognothism, our study found that short face type and norm face type patients present significantly greater distances from the apex to the lingual cortex than long face type subjects. This latter observation is very important during the orthodontic treatment planning, together with the evidence that all measurements of the maximum dental movement in the lingual direction are significantly greater in the short face type group than the long face type group. Kaley and Philips[12] reported a strong correlation between root resorption and impaction of the upper incisor root apex against the palatal cortex during the orthodontic treatment. The dental movement is limited by the cortical walls of the alveolar bone, defined by Handelman[10] as the "orthodontic walls." Indeed, patients with a thin alveolar bone, such as those with an excessive lower facial height, are at risk of root resorption and loss of periodontal support when subjected to marked dental movement. Therefore, it is necessary to restrict movements in the lingual direction in long face type subjects or, if this is not possible, orthognathic surgery is required to limit the risks to the periodontium.

In our study, values corresponding to the four upper incisors in each facial type were also compared. It was noted that the two central incisors were rather similar in all parameters measured, differing only in the height of the vestibular cortex and the distance from the center of resistance to the radicular apex in the long face type group. The two lateral incisors yielded similar measurements and differed only in the norm face type group in the angle between the incisor axis and the bispinal plane and in the distance from the vestibular cortex to the internal lingual cortex at point A. In each of the three facial types, the two central incisors differed significantly from the lateral incisors in the angle between the incisor axis and the SN plane, the alveolar thickness at point A, the height of the lingual cor-

Table 6. Means and Standard Deviations (SDs) of the Values Measured in Norm Face Type Subjects, Comparing the Four Incisors

	11 Mean ± SD	12 Mean ± SD	21 Mean ± SD	22 Mean ± SD	*P*
Dentoskeletal relationships					
Inc ax/SN (°)	102.70 ± 8.51	107.30 ± 8.63**†	103.80 ± 8.01	104.50 ± 7.81	.004
Inc ax/bispin (°)	108.50 ± 9.36	111.30 ± 8.36†	108.10 ± 7.57	106.70 ± 6.87##	.002
Inc ax/NA (°)	20.71 ± 7.40	23.98 ± 6.36*	21.85 ± 6.85	21.15 ± 7.59	.032
Inc crown-NA (mm)	6.58 ± 2.29	7.06 ± 2.65	7.10 ± 2.36	6.89 ± 2.25	ns
Inc ax/bucc cort (°)	6.10 ± 2.15	5.73 ± 2.43	6.61 ± 3.55	6.10 ± 2.72	ns
Inc ax/ling cort (°)	24.23 ± 7.96	19.71 ± 6.95*	23.21 ± 7.32	2.18 ± 8.74	.017
Alveolar thickness					
Bucc cort-int ling at 15 mm (mm)	7.71 ± 1.18	6.95 ± 0.99**	7.40 ± 1.26	7.14 ± 1.40	.008
Bucc cort-ext ling at 15 mm (mm)	9.18 ± 1.29	8.63 ± 1.29	8.83 ± 1.30	8.86 ± 1.50	ns
Bucc cort-int ling at 20 mm (mm)	9.23 ± 1.92	7.53 ± 2.16***††	8.67 ± 1.98	7.87 ± 2.22***	.0001
Bucc cort-ext ling at 20 mm (mm)	10.89 ± 2.01	9.47 ± 2.25***†††	10.65 ± 1.96	9.81 ± 2.19**†	.0001
Bucc cort-int ling at point A (mm)	10.54 ± 2.32	8.28 ± 1.94***†††	10.74 ± 2.58	8.98 ± 2.34##†††	.0001
Bucc cort-ext ling at point A (mm)	12.46 ± 2.52	10.42 ± 2.05***†††	12.97 ± 2.86	11.13 ± 2.46*††	.0001
Apex-bucc cort (mm)	3.80 ± 1.22	3.70 ± 1.21	3.54 ± 0.94	3.40 ± 0.98	ns
Apex-ling cort (mm)	11.14 ± 3.87	8.71 ± 3.56†	11.85 ± 4.53	8.76 ± 2.91	.015
Alveolar height					
Dentoalv height (mm)	28.05 ± 2.92	27.50 ± 3.08	28.70 ± 3.37	28.57 ± 2.34	ns
Bucc cort height (mm)	8.42 ± 2.16	8.38 ± 1.73	8.92 ± 2.15	8.70 ± 1.67	ns
Ling cort height (mm)	11.08 ± 2.21	10.58 ± 1.57†	11.91 ± 2.47	10.47 ± 2.08†	.019
Resist center-apex (mm)	4.79 ± 0.95	4.74 ± 0.78	5.18 ± 1.11	4.77 ± 1.00	ns
Apex-bispin (mm)	7.21 ± 3.30	8.09 ± 3.33	6.88 ± 3.12	8.52 ± 2.94†	.013
Dental movement					
Ang vestibul (°)	20.30 ± 9.46	19.90 ± 11.27	16.45 ± 8.73	16.40 ± 10.11*	.009
Ang lingual (°)	49.50 ± 16.67	42.05 ± 14.99	50.15 ± 18.29	49.45 ± 18.14	ns
Arc vestibul (mm)	2.03 ± 1.20	2.00 ± 1.24	1.73 ± 1.07	1.61 ± 1.11*	.014
Arc lingual (mm)	4.81 ± 2.01	4.19 ± 1.73	5.38 ± 2.48	4.80 ± 2.04	ns
Max poss movem (mm)	6.84 ± 2.67	6.20 ± 2.52	7.12 ± 3.10	6.41 ± 2.80	ns

* $P < .05$ vs 11; ** $P < .01$ vs 11; *** $P < .001$ vs 11; ns indicates not significant.
† $P < .05$ vs 21; †† $P < .01$ vs 21; ††† $P < .001$ vs 21.
# $P < .05$ vs 12; ## $P < .01$ vs 12; ### $P < .001$ vs 12.

tex and the distance from the apex to the bispinal plane.

The possibility of distinguishing between the right and left incisors, to observe the alveolar bone structure in great detail and to carry out measurements of the alveolar thickness, was possible in this study by the use of CBCT. Among the aforementioned studies, only a few used computed tomography[4,5,20]; the others used latero-lateral teleradiography.[6,7,10,13] In contrast with conventional teleradiography, in which the images are often characterized by magnification and distortion, CBCT yields three-dimensional images that are much more accurate and have a 1:1 relationship between the real and reproduced image. Consequently, the study of the labio-lingual bony incisor support using teleradiography can be plagued by projection errors. In contrast, the NewTom 3G software used to process images obtained via CBCT permits acquisition of very precise linear and angular measurements. In fact, the secondary reconstructions permit detailed quantitative and qualitative evaluation of the structure of the alveolar bone and the relationship between the incisors and the alveolar bone.[21,22]

CONCLUSIONS

- At the two upper central incisors, short face type patients present a greater alveolar bone thickness than long face type patients.
- The root apex of the upper incisors is farther away from the lingual cortex in short face type patients and norm face type patients than in long face type patients.
- No difference emerged between the three facial types concerning the inclination of the teeth or the measurements of alveolar height.
- Comparing the measurements corresponding to the four upper incisors in each facial type, in all three facial types the central incisors were less inclined with respect to the SN plane, presented a greater alveolar thickness and a higher lingual cortex, and were closer to the bispinal plane with respect to the lateral incisors.

Table 7. Means and Standard Deviations (SDs) of the Values Measured in Long Face Type Subjects, Comparing the Four Incisors

	11 Mean ± SD	12 Mean ± SD	21 Mean ± SD	22 Mean ± SD	*P*
Dentoskeletal relationships					
Inc ax/SN (°)	100.60 ± 8.80	103.40 ± 8.09	99.83 ± 8.83	105.50 ± 6.52**††	.001
Inc ax/bispin (°)	106.60 ± 8.59	107.40 ± 7.56	105.60 ± 8.27	105.90 ± 6.40	ns
Inc ax/NA (°)	18.62 ± 7.03	18.49 ± 7.01	17.89 ± 9.09	20.05 ± 7.07	ns
Inc crown-NA (mm)	6.75 ± 1.95	6.64 ± 2.26	6.54 ± 2.34	6.61 ± 2.72	ns
Inc ax/bucc cort (°)	6.21 ± 2.59	6.60 ± 4.23	6.58 ± 3.04	8.34 ± 5.55	ns
Inc ax/ling cort (°)	21.06 ± 7.85	19.30 ± 8.50	20.59 ± 9.78	16.91 ± 8.05	ns
Alveolar thickness					
Bucc cort-int ling at 15 mm (mm)	7.38 ± 1.16	7.01 ± 1.22	7.09 ± 0.92	6.78 ± 1.12	ns
Bucc cort-ext ling at 15 mm (mm)	8.71 ± 1.35	8.28 ± 1.33	8.49 ± 1.14	8.17 ± 1.21	ns
Bucc cort-int ling at 20 mm (mm)	7.86 ± 1.69	7.16 ± 2.07	7.57 ± 1.32	6.91 ± 1.98	ns
Bucc cort-ext ling at 20 mm (mm)	9.53 ± 2.12	8.89 ± 2.17	9.26 ± 1.71	8.76 ± 2.11	ns
Bucc cort-int ling at point A(mm)	9.56 ± 3.18	8.54 ± 3.20	9.23 ± 2.24	7.92 ± 2.49*	.028
Bucc cort-ext ling at point A (mm)	11.58 ± 3.27	10.85 ± 3.34	11.38 ± 2.70	9.98 ± 2.71*	.041
Apex-bucc cort (mm)	3.60 ± 0.97	4.19 ± 1.14†	3.44 ± 0.94	3.77 ± 1.43	.042
Apex-ling cort (mm)	8.26 ± 2.76	7.22 ± 2.59	8.60 ± 3.61	6.67 ± 2.43	ns
Alveolar height					
Dentoalv height (mm)	29.52 ± 3.73	29.04 ± 3.83	30.10 ± 4.01	29.70 ± 3.63	ns
Bucc cort height (mm)	8.02 ± 1.24†	8.48 ± 1.41	9.11 ± 1.54	8.36 ± 2.21	.033
Ling cort height (mm)	10.36 ± 1.24	9.92 ± 1.06†	11.18 ± 1.38	10.02 ± 1.81†	.008
Resist center-apex (mm)	4.64 ± 0.59†	4.54 ± 0.64†	5.18 ± 0.89	4.77 ± 1.05	.012
Apex-bispin (mm)	8.72 ± 3.46	9.35 ± 4.11	8.20 ± 3.66	10.06 ± 3.62*††	.003
Dental movement					
Ang vestibul (°)	18.60 ± 8.92	20.50 ± 11.08	17.60 ± 8.47	20.10 ± 14.20	ns
Ang lingual (°)	42.15 ± 17.46	38.30 ± 15.98	45.15 ± 19.57	40.80 ± 12.02	ns
Arc vestibul (mm)	1.73 ± 0.75	1.88 ± 1.06	1.82 ± 0.84	1.82 ± 1.29	ns
Arc lingual (mm)	4.02 ± 1.57	3.59 ± 1.55††	4.69 ± 2.12	3.58 ± 1.16††	.002
Max poss movem (mm)	5.75 ± 1.91	5.46 ± 2.11††	6.50 ± 2.20	5.40 ± 1.92††	.003

* $P < .05$ vs 11; ** $P < .01$ vs 11; *** $P < .001$ vs 11; ns indicates not significant.
† $P < .05$ vs 21; †† $P < .01$ vs 21; ††† $P < .001$ vs 21.
# $P < .05$ vs 12; ## $P < .01$ vs 12; ### $P < .001$ vs 12.

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