ANTERIOR ALVEOLAR DIMENSIONS IN CLASS I NORMAL SAUDI SUBJECTS

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OBJECTIVE: Contemporary orthodontic practice demands the establishment of specific racial norms for various cephalometric measurements. The objective of this study was to describe the sagittal and vertical dimensions of the maxillary and mandibular anterior alveolar bases in Class I normal Saudi subjects.

SUBJECTS AND METHOD: The sample consisted of lateral cephalometric radiographs of 60 adult Saudi individuals (30 males and 30 females) with Class I skeletal and dental relationship, and normal balanced facial profile. The height and width measurements of the upper and lower anterior alveolus were performed according to the method described by Handelman (Handelman, 1996).

RESULTS: The findings of this study resulted in establishment of the standard dimensions of the upper and lower anterior alveolus in Class I adult Saudi subjects. No significant association was found between anterior alveolar measurements and the facial pattern. Tendency toward thinner alveolus with increased proclination and protrusion of upper and lower incisors was observed within the variability range of the sample.

CONCLUSION: Significant differences among means of the alveolar height measurements were detected between Saudi population and a Caucasian group.

KEY WORDS: Anterior alveolus, cephalometric norms, class I occlusion, saudi subjects.

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INTRODUCTION

Orthodontic treatment of malocclusion often involves intended spatial tooth movement of upper and lower incisors in different directions and to a variable extent. For example, during orthodontic management of bimaxillary dentoalveolar protrusion, considerable retraction of upper and lower incisors is clinically immanent to reduce the soft tissue procumbency and optimize treatment outcome[1,2]. Likewise, orthodontic camouflage treatment of Class II and Class III malocclusions commonly requires positioning of upper and/or lower incisors beyond their normal range of labiolingual position and inclination[3-6].

The alveolar process, which houses the roots of the teeth, starts developing during the initiation of tooth emergence. It continues to grow during the migration of teeth buds from the maxillary and mandibular basal bones toward the oral cavity[7]. The existence of the alveolar process is tooth-dependent; it fails to develop where teeth are not forming and resorb as a result of tooth extraction[8]. The path of eruption of the developing tooth buds dictates the longitudinal and spatial orientation of the alveolar process[9]. The direction of growth of the anterior alveolus is forward and downward in the maxilla and forward and upward in the mandible. Corresponding to the level of the root apices of the teeth, the apical base (also known as the alveolar base), extends faciolingually along the perimeter of the upper and lower arches and marks the junction between the alveolar process and the basal bone proper[10]. The faciolingual width of the alveolar base is established upon the full eruption of the permanent teeth[11]. In general, the orthodontic tooth movement takes place within the alveolar bone, not involving the underlying basal bone.

Undoubtedly, orthodontic movement of teeth within the faciolingual boundaries of the alveolar support is practically feasible and biologically sound. However, functional limitation appears to exist whenever teeth are to be moved beyond their facial and/or lingual constraints of the alveolar bases. This limitation is evident with the subsequent iatrogenic effects, e.g. bone loss and root

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resorption, as a result of inconsiderate orthodontic movement of teeth beyond their biologically acceptable limitations[12,13]. Although not all the roots of teeth are necessarily located in the middle of the faciolingual width of the alveolar process[14], however, it is always advisable to keep the root apices close to the center of the apical base in order to maximize the bony support along the root surfaces[15]. Generally, the more the tooth is moved near the facial/labial or lingual cortical plates, the higher the risk of bone loss and/or root resorption[16-18].

Orthodontic tooth movement in any direction is practically made possible by the process of alveolar bone remodelling. Nonetheless, it has long been recognized that alveolus remodelling during incisor palatal retraction and root torquing is restricted by the impingement on the palatal cortical plate[16]. Similar observations have been documented when the roots of maxillary or mandibular incisors are pounded against the labial and/or lingual cortical plates[19,20]. Violation of such anatomic and biologic limitation by forcing the root against the cortical plate will result in increased risk of apical root resorption and/or fenestration and dehiscence[17]. In clinical practice, limitation of alveolar remodeling has been demonstrated to be differentially allocated along the long axis of the alveolus. Specifically, the ability of the alveolus to remodel at the level of the alveolar margin and the mid-root is routinely illustrated in regional superimposition of treated orthodontic cases where significant retraction of maxillary incisors has been performed[21,22]. On the other hand, the width of the alveolar ridge remains unchanged at the level of the root apices, despite the pronounced palatal retraction of maxillary incisors[16,19]. Thus, a tapering pattern of remodeling potential of the maxillary and mandibular anterior alveolus in the direction of the alveolar base and incisor root apices seems to be evident.

Functional limitation to orthodontic tooth movement of upper and lower incisors in the labiolingual direction due to thin anterior alveolus is well documented[16,19,20,23]. The association between maxillary and mandibular anterior alveolar dimensions and certain dentofacial characteristics has been investigated. For example, in a Caucasian sample, the incidence of a thin labiolingual width of the mandibular anterior alveolus was found be greater in individuals with high mandibular plane angle, whereas thin alveolar width lingual to the maxillary incisors was found to be more prevalent in Class II high angle cases[17]. However, Edwards[16] failed to demonstrate any significant difference in the width of the maxillary anterior alveolus between cases with variant mandibular plane angles[16]. Using direct measurements of dentoalveolar and basal structures of dried Thai skulls, an inverse relationship was demonstrated between the width of the mandibular anterior alveolus and the mandibular plane angle, and between the maxillary anterior alveolus and the gonial angle[15]. More recent, bimaxillary protrusion has been stereotyped with thin and elongated maxillary and mandibular anterior alveolar processes as compared with individuals with normal occlusion[22].

The aim of the present investigation was to establish the lateral cephalometric norms for the width and height of the maxillary and mandibular anterior alveolar apical bases surrounding the maxillary and mandibular central incisors, respectively, in a Saudi sample. Also, the degree of association between the maxillary and mandibular anterior alveolar apical base dimensions and some selected lateral cephalometric measurements was studied within the sample.

MATERIAL AND METHODS

The sample of this study consisted of standardized lateral cephalometric radiographs of 60 Saudi subjects (30 males and 30 females) who were 22 to 23 years of age. The selection criteria for subjects to be included in the study were:

- Pleasant and balanced facial profile with competent lips;
- Class I molar and canine relationship with normal overbite and overjet;
- No obvious craniofacial deformities;
- No history of previous orthodontic treatment.

All lateral cephalometric radiographs were obtained in centric occlusion with head in natural head position and lips in repose state. Tracing of all cephalometric radiographs was performed by a single examiner (experienced orthodontist) using a sharp 3H pencil on acetate tracing paper over an illuminated viewing box in a darkened room. Several landmarks were identified (Figure I) and cephalometric measurements were made according to the definitions shown in Table I. The dimensions of the maxillary and mandibular anterior alveolus, as described by Handelman (Handelman, 1996), were performed (Figure II). All linear measurements were corrected for magnification and presented as true values for comparison. Measurements were performed manually to the nearest 0.25 mm or 0.25°. To assess error of the method, landmarks were re-identified and all tracing measurements were repeated two weeks later for 15 randomly selected cephalometric radiographs by the same examiner. No significant difference between the two

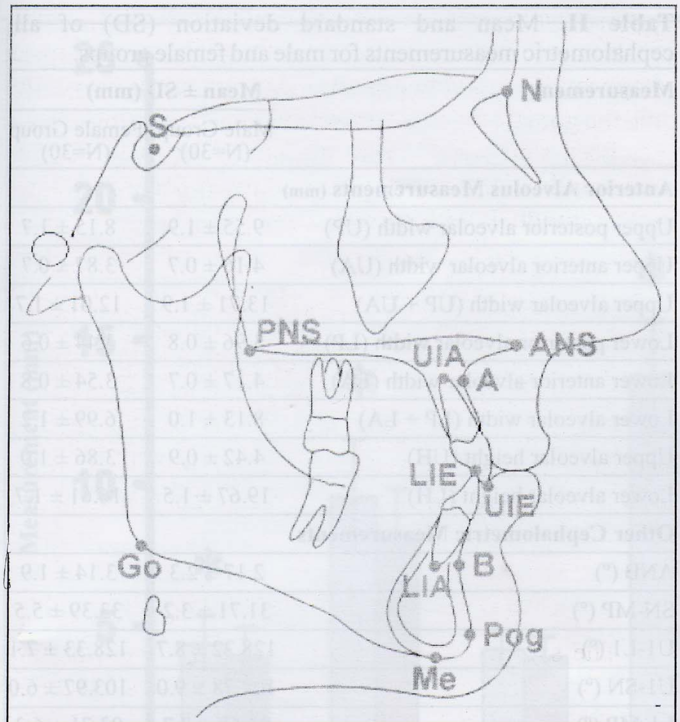


Figure I. Identified cephalometric landmarks: Nasion (N); Sella(S); Anterior nasal spine (ANS); Posterior nasal spine (PNS); Point A (A); Point B (B); Pogonion (Pog), Menton (Me); Gonion (Go); Upper incisal apex (UIA); Upper incisal edge (UIE); Lower incisal edge (LIE); Lower incisal apex (LIA).

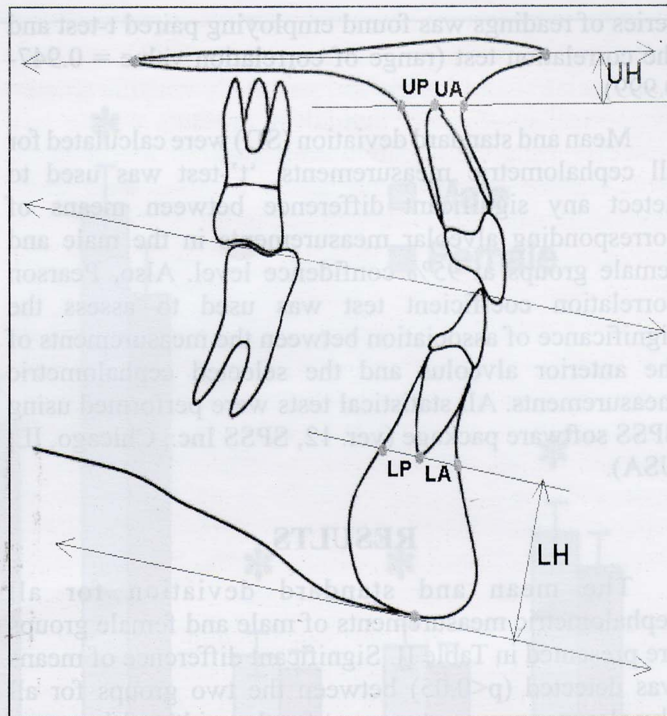


Figure II. Cephalometric measurements of the maxillary and mandibular anterior alveolus. UH: height of the upper alveolus; UA: width of the upper anterior alveolus; UP: width of the upper posterior alveolus; LH: height of the lower alveolus; LA: width of the lower anterior alveolus: LP: width of the lower posterior alveolus.

Table I. Cephalometric measurements.

Measurement	Definition
Anterior Alveolus Measurements (mm)	
UP	Bone posterior (palatal) to upper incisor apex. Apex of the maxillary central incisor to the limit of the palatal cortex, along a line parallel to the palatal plane (ANS-PNS), drawn through the apex
UA	Bone anterior (labial) to upper incisor apex. Apex of the maxillary central incisor to the limit of the labial cortex, along a line parallel to the palatal plane, drawn through the apex
LP	Bone posterior (lingual) to mandibular incisor apex. Apex of the mandibular central incisor to the limit of the lingual cortex, along a line parallel to the occlusal plane, drawn through the apex
LA	Bone anterior (labial) to mandibular incisor apex. Apex of the mandibular central incisor to the limit of the labial cortex, along a line parallel to the occlusal plane, drawn through the apex
UH	Bone superior to upper incisor apex. The shortest distance from the maxillary incisor apex to the palatal plane
LH	Bone inferior to mandibular incisor apex. The shortest distance from the apex of mandibular incisor apex to the lowest point on the mandibular symphysis that is transected by a line parallel to the occlusal plane
Other Cephalometric Measurements	
ANB (º)	Angle between NA and NB lines
SN-MP (º)	Mandibular plane angle: angle between Menton-Gonion line and SN line
U1-L1 (º)	Interincisal angle: angle between the long axis of upper central incisor (UIA-UIE) and long axis of the lower central incisor (LIA-LIE)
U1-SN (º)	Upper incisor inclination: angle between upper central incisor and SN line
L1-MP (º)	Lower incisor inclination: angle between lower central incisor and mandibular plane
U1-Apo (mm)	Upper incisor position: distance between the labial surface of the upper central incisor and A-Pog line
L1-Apo (mm)	Lower incisor position: distance between the labial surface of the lower central incisor and A-Pog line

series of readings was found employing paired t-test and the correlation test (range of correlation value = 0.947-0.999).

Mean and standard deviation (SD) were calculated for all cephalometric measurements. 't'-test was used to detect any significant difference between means of corresponding alveolar measurements in the male and female groups at 95% confidence level. Also, Pearson correlation coefficient test was used to assess the significance of association between the measurements of the anterior alveolus and the selected cephalometric measurements. All statistical tests were performed using SPSS software package (ver. 12, SPSS Inc., Chicago, IL, USA).

RESULTS

The mean and standard deviation for all cephalometric measurements of male and female groups are presented in Table II. Significant difference of means was detected ($p<0.05$) between the two groups for all alveolar measurements except for the width of the upper anterior alveolus (Figure III). The correlation and level of significance of association between various alveolar measurements and the selected cephalometric measurements are tabulate in Table III and IV for the female and male groups, respectively. For the female group, statistically significant, though weak, negative association was found between the width of lower anterior alveolus and the inclination and protrusion of upper and lower incisors (Table III). Similar negative association with the lower incisor inclination was also noticed for the width of the lower posterior alveolus (Table III). For the

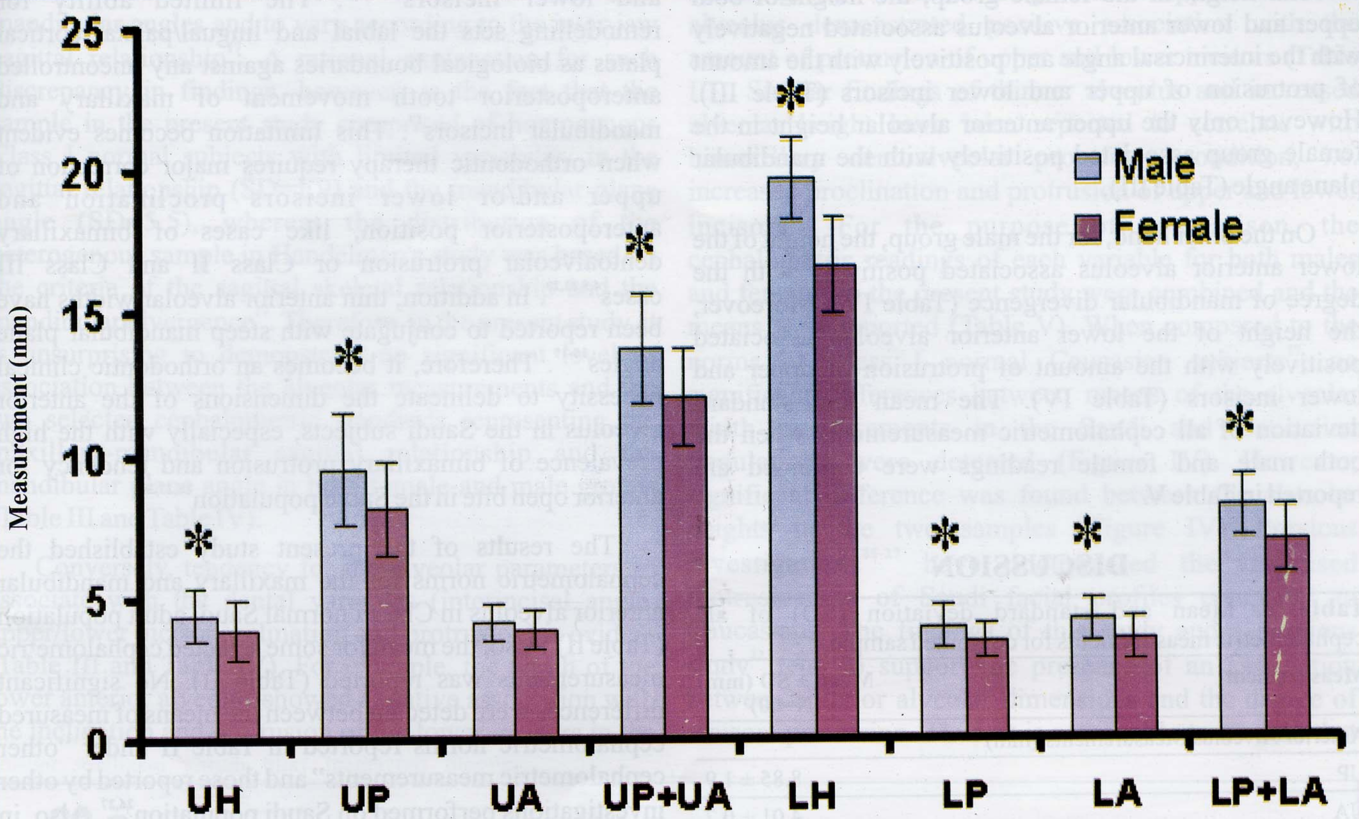
Table II. Mean and standard deviation (SD) of all cephalometric measurements for male and female groups.

Measurement	Mean ± SD (mm) Male Group (N=30)	Mean ± SD (mm) Female Group (N=30)
Anterior Alveolus Measurements (mm)		
Upper posterior alveolar width (UP)	9.55 ± 1.9	8.15 ± 1.7
Upper anterior alveolar width (UA)	4.16 ± 0.7	3.87 ± 0.7
Upper alveolar width (UP + UA)	13.71 ± 1.9	12.01 ± 1.7
Lower posterior alveolar width (LP)	3.96 ± 0.8	3.44 ± 0.6
Lower anterior alveolar width (LA)	4.17 ± 0.7	3.54 ± 0.8
Lower alveolar width (LP + LA)	8.13 ± 1.0	6.99 ± 1.2
Upper alveolar height (UH)	4.42 ± 0.9	3.86 ± 1.0
Lower alveolar height (LH)	19.67 ± 1.5	16.61 ± 1.7
Other Cephalometric Measurements		
ANB (°)	2.17 ± 2.3	3.14 ± 1.9
SN-MP (°)	31.71 ± 3.2	33.39 ± 5.5
U1-L1 (°)	128.22 ± 8.7	128.33 ± 7.1
U1-SN (°)	107.78 ± 9.0	103.97 ± 6.0
L1-MP (°)	94.68 ± 7.7	93.71 ± 6.3
U1Apo (mm)	6.27 ± 1.9	5.74 ± 1.9
L1-Apo (mm)	4.03 ± 2.0	3.01 ± 1.7

Table III. Association between anterior alveolar dimensions and cephalometric measurements in the female group.

	ANB	SN-MP	U1-L1	U1-SN	L1-MP	U1-Apo	L1-Apo
UA	0.239	0.139	-0.331	0.290	-0.106	0.047	0.234
Sig.	(0.204)	(0.464)	(0.074)	(0.120)	(0.577)	(0.804)	(0.214)
UP	-0.208	-0.258	0.218	0.085	-0.091	-0.105	0.022
Sig.	(0.271)	(0.168)	(0.246)	(0.654)	(0.633)	(0.582)	(0.906)
UP + UA	-0.101	-0.192	0.071	0.207	-0.133	-0.082	0.122
Sig	(0.596)	(0.310)	(0.708)	(0.273)	(0.483)	(0.668)	(0.522)
LA	0.141	-0.309	0.289	-0.448	-0.363	-0.386	-0.418
Sig.	(0.458)	(0.097)	(0.121)	(0.013)*	(0.049)*	(0.035)*	(0.021)*
LP	0.003	-0.270	-0.102	-0.011	-0.369	0.093	0.092
Sig.	(0.986)	(0.148)	(0.593)	(0.954)	(0.045)*	(0.625)	(0.630)
LP + LA	0.094	-0.339	0.139	-0.301	-0.425	-0.207	-0.229
Sig.	(0.621)	(0.067)	(0.464)	(0.106)	(0.019)*	(0.272)	(0.223)
UH	0.090	0.386	-0.419	0.035	0.132	0.534	0.464
Sig.	(0.635)	(0.035)*	(0.021)*	(0.856)	(0.486)	(0.002)**	(0.003) **
LH	0.194	0.354	-0.377	0.082	0.012	0.491	0.480
Sig.	(0.304)	(0.055)	(0.040)*	(0.665)	(0.949)	(0.006)**	(0.007)**

* Correlation is significant at $p<0.05$ level
** Correlation is significant at $p<0.01$ level



* Significant difference between means at p<0.05 level

Figure III. Bar graph representing the mean ± SD of all alveolar measurements in the male and female groups.

Table IV. Association between anterior alveolar dimensions and cephalometric measurements in the male group.

male	ANB	SN-MP	U1-L1	U1-SN	L1-MP	U1-Apo	L1-Apo
UA	0.110	0.028	-0.193	-0.113	0.166	0.121	-0.094
Sig.	(0.562)	(0.883)	(0.316)	(0.552)	(0.380)	(0.525)	(0.620)
UP	-0.243	0.032	0.019	-0.086	-0.074	-0.001	0.099
Sig.	(0.195)	(0.867)	(0.923)	(0.652)	(0.697)	(0.996)	(0.603)
UP + UA	-0.207	0.042	-0.045	-0.124	-0.018	0.040	0.067
Sig.	(0.273)	(0.827)	(0.817)	(0.515)	(0.924)	(0.836)	(0.724)
LA	0.063	-0.052	0.031	-0.032	0.325	-0.072	-0.187
Sig.	(0.739)	(0.642)	(0.873)	(0.868)	(0.079)	(0.704)	(0.324)
LP	-0.109	-0.252	0.033	-0.044	-0.044	0.106	-0.075
Sig.	(0.567)	(0.178)	(0.867)	(0.817)	(0.817)	(0.576)	(0.693)
LP + LA	-0.037	-0.050	0.046	-0.054	0.185	0.029	-0.180
Sig.	(0.845)	(0.745)	(0.814)	(0.779)	(0.327)	(0.881)	(0.342)
UH	-0.039	-0.140	-0.349	0.167	-0.104	0.077	0.007
Sig.	(0.838)	(0.462)	(0.064)	(0.377)	(0.583)	(0.686)	(0.969)
LH	-0.069	0.363	-0.028	-0.199	0.021	0.395	0.430
Sig.	(0.719)	(0.049)*	(0.884)	(0.291)	(0.911)	(0.031)*	(0.018)*

* Correlation is significant at p<0.05 level
** Correlation is significant at p<0.01 level

alveolar height in the female group, the height of both upper and lower anterior alveolus associated negatively with the interincisal angle and positively with the amount of protrusion of upper and lower incisors (Table III). However, only the upper anterior alveolar height in the female group associated positively with the mandibular plane angle (Table III).

On the other hand, for the male group, the height of the lower anterior alveolus associated positively with the degree of mandibular divergence (Table IV). Moreover, the height of the lower anterior alveolus associated positively with the amount of protrusion of upper and lower incisors (Table IV). The mean and standard deviation of all cephalometric measurements when the both male and female readings were combined are reported in Table V.

DISCUSSION

Table V. Mean and standard deviation (SD) of all cephalometric measurements for combined sample.

Measurement	Mean ± SD (mm) (N=60)
Anterior Alveolus Measurements (mm)	
UP	8.85 ± 1.9
UA	4.01 ± 0.7
UP + UA	12.86 ± 2.0
LP	3.70 ± 0.7
LA	3.86 ± 0.8
LP + LA	7.56 ± 1.3
UH	4.14 ± 1.0
LH	18.14 ± 2.2
Other Cephalometric Measurements	
ANB (°)	2.65 ± 2.2
SN-MP (°)	32.55 ± 4.5
U1-L1 (°)	128.28 ± 7.8
U1-SN (°)	105.87 ± 7.9
L1-MP (°)	94.20 ± 7.0
U1-Apo (mm)	3.52 ± 1.9
L1-Apo (mm)	4.13 ± 2.2

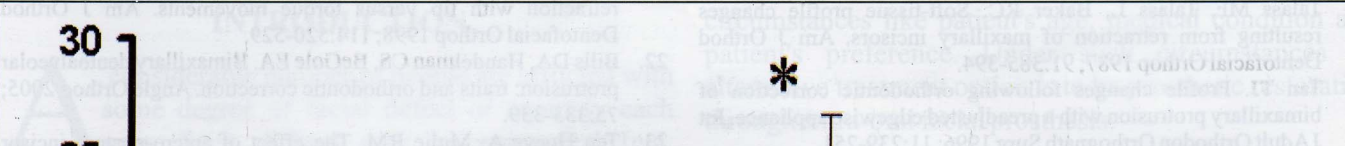
This study is the first to report on the cephalometric alveolar dimensions in Saudi subjects. Several other studies have investigated various cephalometric measurements and analyses in the Saudi population[24-27], but failed short to establish the height and width of the maxillary and mandibular alveolus. At present, it is well documented that determination of the anterior alveolar thickness is a clinical diagnostic prerequisite for biologically sound orthodontic tooth movement of upper and lower incisors[12,22,28]. The limited ability for remodelling sets the labial and lingual/palatal cortical plates as biological boundaries against any uncontrolled anteroposterior tooth movement of maxillary and mandibular incisors[17]. This limitation becomes evident when orthodontic therapy requires major correction of upper and/or lower incisors proclination and anteroposterior position, like cases of bimaxillary dentoalveolar protrusion or Class II and Class III cases[4,5,22,29]. In addition, thin anterior alveolar widths have been reported to conjugate with steep mandibular plane angles[15-17]. Therefore, it becomes an orthodontic clinical necessity to delineate the dimensions of the anterior alveolus in the Saudi subjects, especially with the high prevalence of bimaxillary protrusion and tendency for anterior open bite in the Saudi population[25-27,30].

The results of the present study established the cephalometric norms for the maxillary and mandibular anterior alveolus in Class I normal Saudi adult population (Table II). Also, the mean for some selected cephalometric measurements was reported (Table II). No significant differences were detected between the means of measured cephalometric norms reported in Table II under "other cephalometric measurements" and those reported by other investigations performed on Saudi population[26,27]. Also, in an agreement with similar studies[26,27], no significant differences were detected between male and female readings for the selected "other cephalometric measurements". However, in the present study, significant differences were found between the two sexes when the means of almost all the alveolar measurements were compared (Figure III). No obvious explanation for such finding can be provided and no report of a similar or dissimilar finding is present in the literature due to failure of other related investigations to segregate their samples based on gender[15-17].

In the present study, the association between the anterior alveolar measurements and the various selected cephalometric readings was separately tested within each group, in the light of the statistically significant differences between males and females for the mean values of reported alveolar measurements (Figure III). The test of significance for association between alveolar measurements and the selected cephalometric variables in the female group revealed no significant association between alveolar dimensions and the sagittal maxillary-mandibular relationship or the steepness of the mandibular plane, except for the height of the upper alveolus which associated positively with the mandibular plane angle (Table III). This finding is in contrast to the results of Handelman[17] and Edwards[16], who reported

thinner alveolar widths to be associated with high mandibular angles and to vary according to the inter-jaw sagittal relationship[17]. A rational explanation for such discrepancy in findings, however, is the fact that the sample in the present study comprised of homogenous Class I normal subjects with limited variability in the sagittal relationship (SD=1.9) and the mandibular plane angle (SD=5.5), whereas the distribution of the heterogenous sample in Handelman's study was based on the criteria of the sagittal skeletal relationship and the mandibular divergence[17]. Therefore, in the present study, it is unsurprising to demonstrate no significant level of association between the alveolar measurements and the two selected cephalometric standards representing the maxillary-mandibular sagittal relationship and the mandibular plane angle in both female and male groups (Table III and Table IV).

Conversely, tendency for the alveolar parameters to associate with the dental variables (interincisal angle, upper/lower incisor inclination and protrusion) is evident (Table III and Table IV). For example, the width of the lower anterior alveolus showed negative association with the inclination and protrusion of the lower incisors in the female group, while the height of the upper and lower alveolus demonstrated positive association with the amount of protrusion of upper and lower incisors (Table III). Similar findings of thinner alveolus and increased alveolar height have been reported to correlate with bimaxillary dentoalveolar protrusion condition, i.e. increased proclination and protrusion of upper and lower incisors[22]. For the purpose of comparison, the cephalometric readings of each variable for both males and females in the present study were combined and the means were reported (Table V). When compared to the norms of Class I normal Caucasian subjects[17], no significant differences between means of the alveolar width measurements in the Saudi and Caucasian populations were detected (Figure IV). However, significant difference was found between the alveolar heights in the two samples (Figure IV). Previous investigations[25-27] have documented the increased protrusiveness of Saudi facial profiles compared to Caucasians. The findings of this study and a previous study[22] tend to support the presence of an association between anterior alveolar dimensions and the degree of incisors protrusion. Thus, it is reasonable to assume that



* Significant difference between means at $p<0.05$ level

Figure IV. Bar graph demonstrating differences in mean of anterior alveolus measurements between Saudi subjects and Caucasians (Handelman, 1996).

the differences in the alveolar dimensions between the two samples are related to the more prominent protrusion features of the Saudi subjects compared to Caucasians (Figure IV). Nevertheless, further studies to investigate the association between the anterior alveolar measurements and various dentofacial characteristics in the Saudi population are orthodontically immanent.

CONCLUSIONS

The following conclusions can be drawn with caution:

1. Cephalometric norms for the anterior alveolar measurements were established for both male and female Saudi adult subjects.
2. Decreased width and increased height of the maxillary and mandibular anterior alveolar bases tend to accompany more proclination and protrusion of upper and lower incisors.
3. The sagittal and vertical dimensions of the upper and lower anterior alveolus in Saudi adults were less than those reported for Caucasian subjects.

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