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ORIGINAL ARTICLE

Association between anterior alveolar dimensions and vertical facial pattern among Saudi adults

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KEYWORDS

Anterior alveolus;
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Abstract *Objective:* To establish the anterior alveolar dimensions among a sample of Saudi subjects with different vertical facial heights.

Materials and methods: Lateral cephalometric radiographs of 63 Saudi subjects (30 males and 33 females) were included in this retrospective study. The sample was divided into high angle (SN-MP $\geqslant$ 39°), low angle (SN-MP $\leqslant$ 28°) and average angle (30° < SN-MP < 37°) groups. The anteroposterior and vertical dimensions of the alveolus surrounding the root apex of upper and lower incisors were calculated.

Results: The anterior alveolar dimensions exhibited significant differences ($p < 0.05$) between the different vertical facial height groups. The males and females demonstrated significant differences ($p < 0.05$) in the anterior alveolar dimensions for the same vertical jaw relationship.

Conclusions: Both gender and the vertical jaw relationship can be factors for different height and thickness of the anterior alveolus. Clinicians must be aware of differences in the anterior alveolar dimensions for safe and sound orthodontic tooth movement.

1. Introduction

Assessment of the vertical facial pattern is an integral part of any orthodontic case diagnosis. A vertical dimension is commonly a contributing factor in the orthodontic treatment planning decision to extract teeth or consider an orthognathic surgical intervention (Bailey et al., 1999; Sivakumar and Valiathan, 2008). The extraction of teeth due to orthodontic reasons is usually accompanied by the retraction of upper and lower incisors during treatment. The importance of maintaining the position of the upper and lower incisors in the middle of their apical base confinement relates to the enhanced periodontal support around these teeth and overall stability of treatment outcome (Handelman, 1996).

Sound orthodontic tooth movement requires careful monitoring to prevent contact between roots and surrounding bony cortical plates to avoid potential iatrogenic sequelae, such as root resorption and bone loss (Handelman, 1996; Wehrbein et al., 1996). Inevitably, incisor retraction is frequently

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associated with lingual crown/labial root tipping which has been shown to contribute to root resorption (Horiuchi et al., 1998). In general, when the roots are approximating the lingual or facial bony cortical plates, there is increased apical root resorption (Mirabella and Artun, 1995; Agarwal et al., 2014).

Saudi individuals are reported to have a more convex profile and more proclined incisors than Caucasians (Aldrees, 2011; Hassan, 2011; AlBarakati, 2011). Thus, an orthodontic treatment to enhance a profile and improve upper and lower incisors position through retraction requires careful attention to the biological boundaries represented by the alveolar enhousing of the maxillary and mandibular incisors. The relationship between the anterior alveolar dimensions and various dentofacial characteristics in different populations has been reported (Handelman, 1996; Sergl et al., 1996; Sarikaya et al., 2002; Wonglamsam et al., 2003). The anterior alveolar dimensions in Saudi individuals with a normal Class I jaw relationship and different sagittal maxillomandibular malrelationships have been previously established (Al-Barakati and Alhadlaq, 2007; Alhadlaq, 2010). The aim of the present study was to establish the anterior alveolar dimensions in Saudi subjects with different vertical facial patterns, which was determined by the amount of mandibular divergence.

2. Materials and methods

Lateral cephalometric radiographs of 63 Saudi individuals (30 males and 33 females) were obtained from orthodontic records at King Saud University, Riyadh, Saudi Arabia. All the sample subjects were healthy with no congenital or acquired medical disorder, no previous orthodontic treatment and no history of trauma to the head or neck region. All the subjects were adults with ages ranging between 18 and 36 years old for males and 17 and 42 years old for females. Appropriate ethical approval was obtained from the research center at the College of Dentistry, King Saud University.

Each male and female sample was divided into three groups each: high angle, low angle and average based on the mandibular plane angle (SN-MP) as described in the literature (Handelman, 1996; Rongo et al., 2014). The high angle group included subjects with an SN-MP $\geqslant$ 39°. The low angle group included subjects with a SN-MP $\leqslant$ 28°. The average group included subjects with a SN-MP ranging from 30° to 37°. The age and SN-MP angle data for all the study groups are presented in Table 1.

All the lateral cephalometric radiographs were traced over an illuminated viewing box in a darkened room using a sharp 3H pencil on an acetate tracing paper. The landmarks identified on each cephalometric tracing were: sella (S), nasion (N), anterior nasal spine (ANS), posterior nasal spine (PNS), upper incisal apex (UIA), lower incisal apex (LIA), gonion (Go), and gnathion (Gn) (Fig. 1). The method of Handelman (Handelman, 1996) was followed for measuring the dimensions of the maxillary and mandibular anterior alveolus (Fig. 2). The following variables were measured on each cephalometric tracing:

- *SN-MP:* the angle formed between a line connecting Go to Gn and a line connecting S to N.
- *Occlusal plane (OC):* a line bisecting the overlapping cusps of the first molars and the incisal overbite.
- *Upper posterior alveolus width (UP):* the distance from the apex of the maxillary central incisor to the limit of the palatal cortex along a line drawn through the apex parallel to the palatal plane (ANS–PNS).
- *Upper anterior alveolus width (UA):* the distance from the apex of the maxillary central incisor to the limit of the labial cortex along a line drawn through the apex parallel to the palatal plane.
- *Upper anterior alveolus height (UH):* the shortest distance between the maxillary central incisor apex and the palatal plane.
- *Lower posterior alveolus width (LP):* the distance from the apex of the mandibular central incisor to the limit of the lingual cortex along a line drawn through the apex parallel to the occlusal plane.
- *Lower anterior alveolus width (LA):* the distance from the apex of the mandibular central incisor to the limit of the labial cortex along a line drawn through the apex parallel to the occlusal plane.
- *Lower anterior alveolus height (LH):* the shortest distance from the apex of mandibular central incisor apex to the lowest point on the mandibular symphysis that is transected by a line parallel to the occlusal plane.

All the measurements were performed manually to the nearest 0.25 mm and 0.25° values. All the linear measurements were corrected for magnification and presented as true values after subtracting the correction factor from each measured value. A magnification correction factor was established by measuring a known value (10 mm) on a ruler fixed near the subject's head during radiographic acquisition. For a reliable assessment, the identification of landmarks and tracing measurements of 10 randomly selected cephalometric radiographs were repeated two weeks later, and a correlation coefficient value between the two repeated measurements was established. An arithmetic mean and standard deviation (SD) for all the variables were calculated. An analysis of variance (ANOVA) followed by Scheffe's test was performed to detect differences between the means of corresponding variables between the dif-

Table 1 Age and SN-MP angle value for different study groups.

	Average ± SD					
	Female Group (N = 33)			Male Group (N = 30)		
	High angle (n = 10)	Low angle (n = 11)	Average (n = 12)	High angle (n = 9)	Low angle (n = 10)	Average (n = 11)
Age (years)	22.4 ± 3.59	24.3 ± 4.39	19.25 ± 2.15	24.8 ± 3.21	21.6 ± 2.66	23.3 ± 4.74
SN-MP (°)	41.65 ± 1.93	24.45 ± 2.18	34.50 ± 2.08	43.06 ± 2.13	25.75 ± 2.00	33.77 ± 1.92

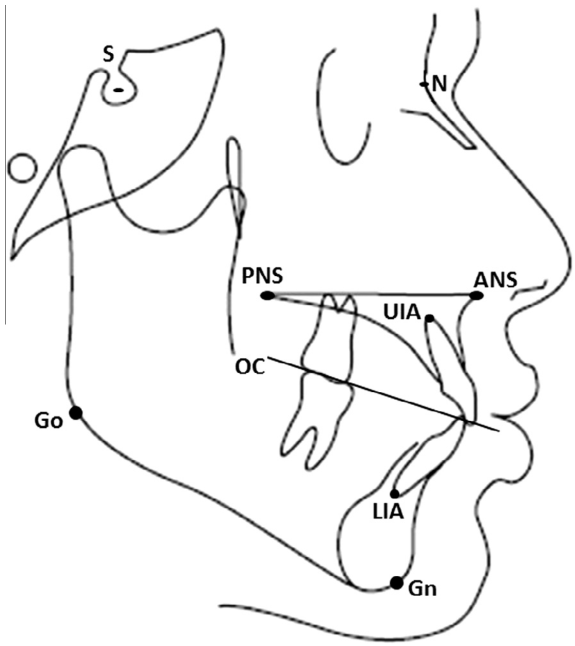

Figure 1 Identified cephalometric landmarks. S: sella; N: nasion; ANS: anterior nasal spine; PNS: posterior nasal spine; UIA: upper incisal apex; LIA: lower incisal apex; OC: occlusal plane; Go: gonion; Gn: gnathion.

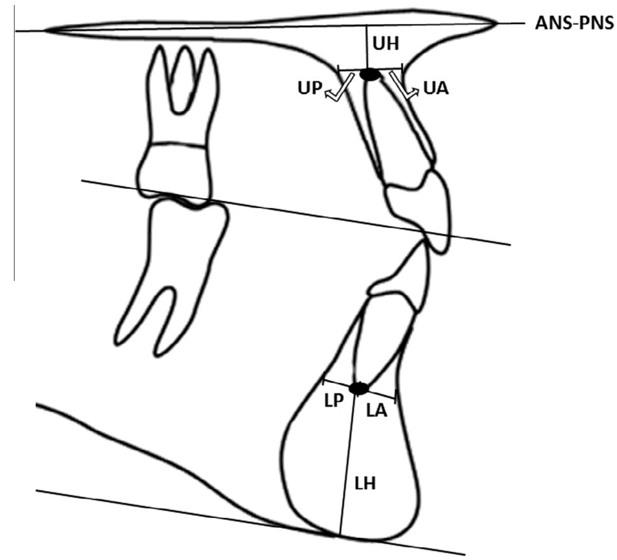

Figure 2 Measurements of the maxillary and mandibular anterior alveolus. UH: height of the upper alveolus; UA: width of the upper anterior alveolus; UP: width of the upper posterior alveolus; LH: height of the lower alveolus; LA: width of the lower anterior alveolus: LP: width of the lower posterior alveolus.

ferent study groups. For all the tests, the significance was set at $p < 0.05$ level. All statistical tests were performed utilizing SPSS version 19 (IBM Corp., Armonk, NY, USA).

3. Results

The high correlation coefficient value between the repeated tracing measurements of all the variables demonstrated reliability of the study method (r^2 value range = 0.873–0.952).

The mean ± SD of all the studied variables in the different groups are presented in Table 2. A significant difference ($p < 0.05$) between the males and females was observed in the upper posterior alveolar width and lower alveolar height in the high angle and average groups and in the lower posterior alveolar width of the average group. However, there was no significant difference ($p < 0.05$) between the males and females of the low angle group, except for the upper alveolar height.

The anterior alveolar measurements were found to be insignificantly different ($p < 0.05$) for most variables in all three SN-MP angular categories for both females and males (Figs. 3 and 4). However, the lower alveolar height was significantly different ($p < 0.05$) between all three SN-MP angular groups in both females and males (Figs. 3 and 4). While all the anterior alveolar dimensions of the low angle female subjects were insignificantly different ($p < 0.05$) from those of the average angle females, the lower alveolar height of the low angle males was found to be significantly different ($p < 0.05$) from that of the average angle males (Figs. 3 and 4). When the high and low angle groups were contrasted, both the females and males had significance differences ($p < 0.05$) in the lower alveolar height between the two angular categories. In addition, the females demonstrated a significantly different ($p < 0.05$) upper alveolar height between the high and low angle cases, while the males had a significantly different ($p < 0.05$) upper posterior alveolar width between the two angular categories (Figs. 3 and 4).

Finally, when the female and male subjects were pooled together in one sample, both the upper and lower alveolar height as well as the width of the lower posterior alveolus showed a significant difference ($p < 0.05$) between the high angle and average subjects (Fig. 5). However, the low angle subjects demonstrated a significant difference ($p < 0.05$) in the lower alveolar height only relative to the average angle cases. Nonetheless, the high angle cases differed significantly ($p < 0.05$) from the low angle cases in all the measured anterior alveolar dimensions, except the width of the lower anterior alveolus (Fig. 5).

4. Discussion

The prevalence of certain malocclusion types, such as bimaxillary dentoalveolar protrusion demands an orthodontic intervention, typically with the extraction of the four first premolars to retract the upper and lower incisors and reduce procumbency (Bills et al., 2005; Aldrees and Shamlan, 2010; AlBarakati, 2011; Aldrees, 2012; Almutairi et al., 2015). Without watchful respect to the biological boundaries of tooth structure and full control of tooth movement, unwanted consequences, such as root resorption and bone loss, can result (Handelman, 1996; Agarwal et al., 2014). This study aimed to identify the maxillary and mandibular anterior alveolar anteroposterior and vertical dimensions in a sample of Saudi individuals segregated by their vertical jaw relationship.

The anterior alveolar dimensions in Class I normal Saudi subjects and with different sagittal jaw relationships have been already established (Al-Barakati and Alhadlaq, 2007; Alhadlaq, 2010). Significant differences were reported between the majority of the anterior alveolar measurements between the different sagittal jaw relationships in Saudi subjects (Alhadlaq, 2010). The anterior alveolar dimensions in a group of Caucasians segregated by their mandibular divergence showed multiple significant differences between the anterior alveolar measurements between various groups (Handelman,

Table 2 Anterior alveolar dimensions among different groups. UP: upper posterior alveolar width, UA: upper anterior alveolar width, LP: lower posterior alveolar width, LA: lower anterior alveolar width, UH: upper alveolar height, LH: lower alveolar height.

Variable	Mean ± SD					
	Female Group (N = 33)			Male Group (N = 30)		
	High angle (n = 10)	Low angle (n = 11)	Average (n = 12)	High angle (n = 9)	Low angle (n = 10)	Average (n = 11)
UP	8.49 ± 1.21*	8.16 ± 1.31	7.68 ± 1.39*	10.33 ± 1.18	8.07 ± 2.76	9.47 ± 2.17
UA	4.35 ± 0.79	3.56 ± 1.06	3.74 ± 0.75	4.11 ± 0.70	3.81 ± 0.75	4.31 ± 0.76
UH	4.71 ± 0.32	3.43 ± 0.63*	3.86 ± 1.29	4.76 ± 0.81	4.21 ± 0.86	4.35 ± 1.02
LP	4.09 ± 0.89	3.62 ± 0.39	3.25 ± 0.68*	4.24 ± 0.59	3.83 ± 0.78	4.03 ± 0.95
LA	3.51 ± 0.70	3.66 ± 0.54	3.49 ± 0.94	3.70 ± 0.59	4.28 ± 0.85	4.11 ± 0.60
LH	19.49 ± 2.57*	16.05 ± 0.79	16.62 ± 1.63*	22.21 ± 1.31	17.58 ± 2.77	19.73 ± 1.35

* Significant difference between males and females of the same SN-MP angle category at p < 0.05.

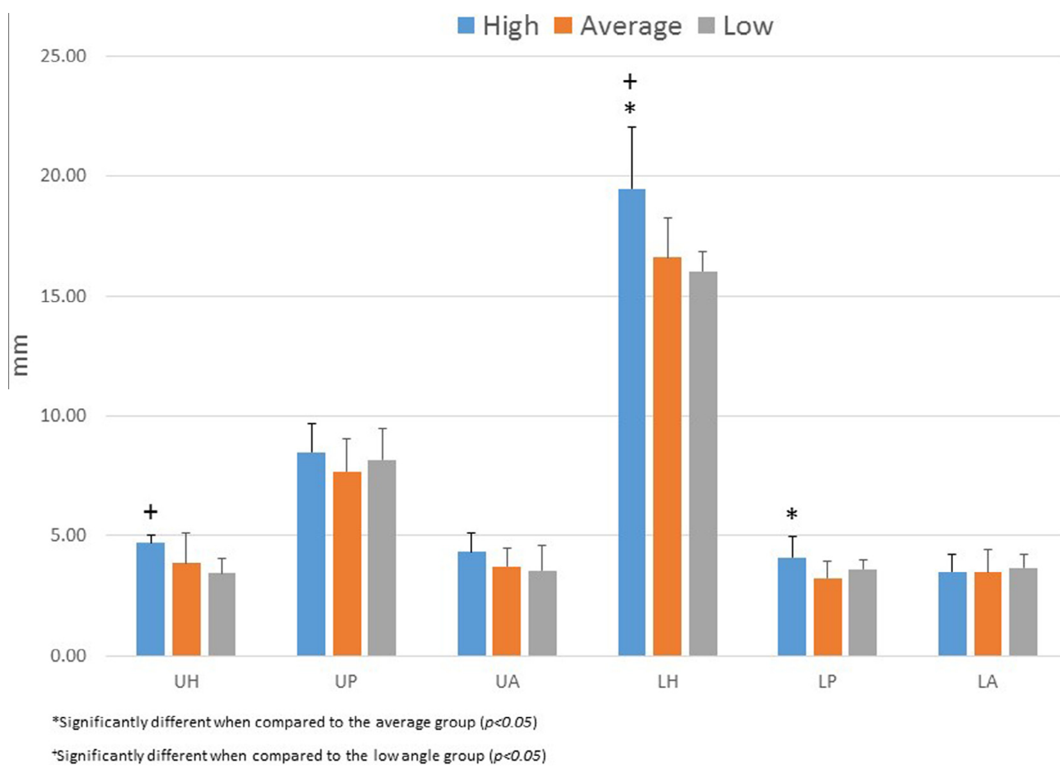

Figure 3 The mean ± SD for different anterior alveolar measurements among different SN-MP angle groups in females.

1996). Significant differences were also found in the alveolar bone height and thickness between Egyptian subjects with different vertical facial patterns (Sadek et al., 2015). These reported findings ignited interest to investigate the anterior alveolar dimensions in Saudi subjects based on the vertical jaw relationship determined by the mandibular divergence.

In general, there is a scarcity of published studies investigating the dimensions of the anterior alveolus in relation to the vertical facial height. Handelman (Handelman, 1996) reported on the anterior alveolar dimension of 107 Caucasians classified vertically based on the SN-MP angle without segregating male and female data. Thus, comparing the findings of this study when the male and female samples were pooled together in Handelman's findings is more applicable. In agreement with Handelman's report of significant differences in both the upper and lower alveolar height between high angle and average cases (Handelman, 1996), this study demonstrated the same finding. However, while Handelman reported a significant difference between the high angle and average cases in the width of the lower alveolus labial to the lower incisor apex (Handelman, 1996), the present study showed a significant difference between the high angle and average cases in the width of lower alveolus lingual to the lower incisor apex. When comparing the low angle with the average group, Handelman reported a significant difference of the upper and lower width of the alveolus lingual to upper and lower incisor apex (Handelman, 1996). In contrast, the present study detected a significant difference in only the height of lower anterior alveolus between the low angle and average groups. Interestingly, when the high and low angle cases were contrasted in Handelman's report, significant differences were found in all the anterior alveolar dimensions, except the width of the upper

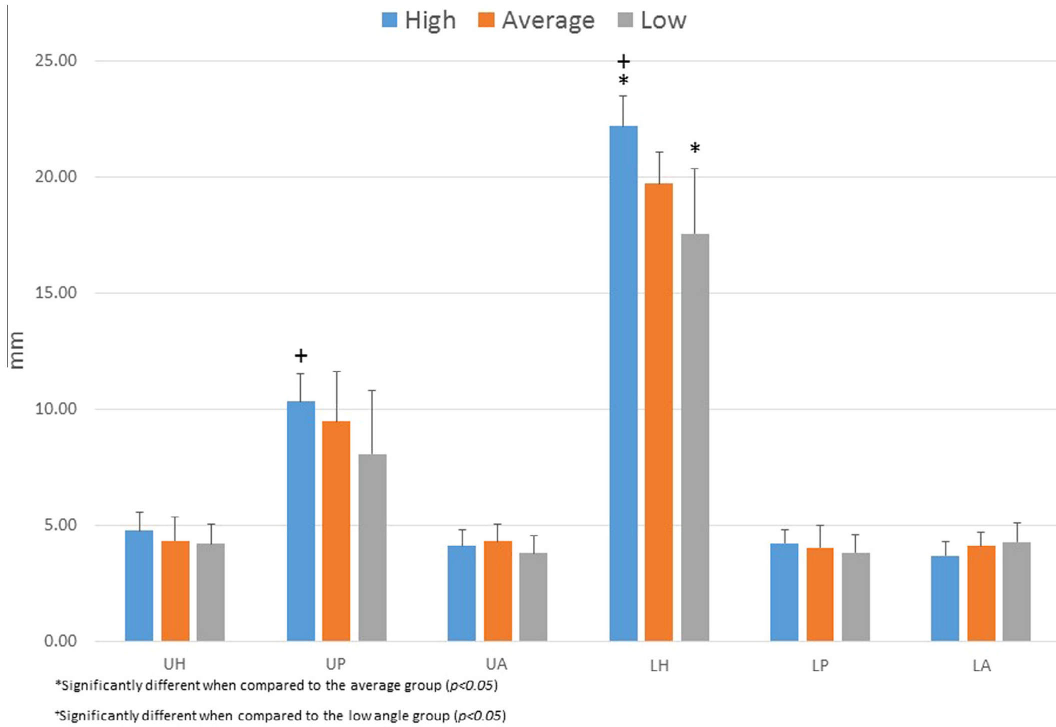

Figure 4 The mean ± SD for different anterior alveolar measurements among different SN-MP angle groups in males.

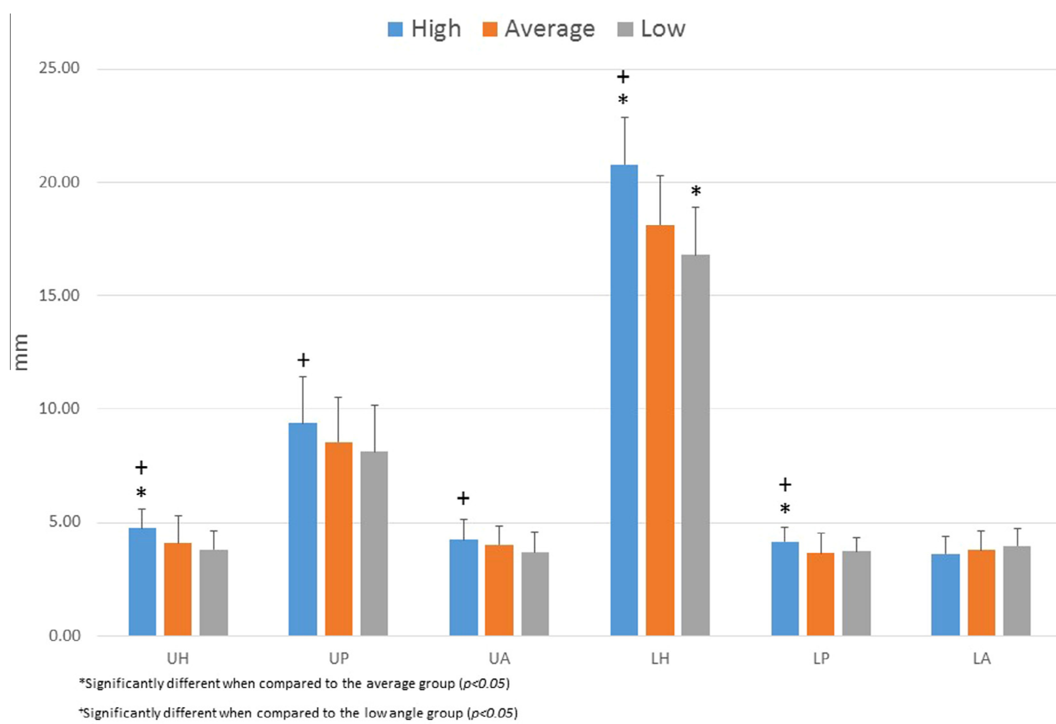

Figure 5 The mean ± SD for different anterior alveolar measurements among different SN-MP angle groups of pooled female and male sample.

alveolus labial to the upper incisor apex (Handelman, 1996). The present study showed an exception for the significant differences in all the anterior alveolar dimensions to the width of the lower alveolus labial to the lower incisor apex. Because the same methodology and categorization of vertical facial patterns based on the SN-MP angle that Handelman used were followed by the present study, the only potential explanation for these differences in findings is the different ethnic backgrounds of the samples between the two studies which has been the basis for differences in other studies (Uysal et al., 2011).

Similar to Handelman's findings and our results, Sadek's group reported a larger anterior dentoalveolar height in the high angle cases compared to normal cases in both the maxilla and mandible (Sadek et al., 2015). In addition, the high angle group was reported to have thinner anterior alveolus in both the maxilla and mandible (Sadek et al., 2015). This was in contrast to our results and Handelman's findings that did not show high angle cases with a significantly different thickness of the upper anterior alveolus. However, the present study demonstrated a significant difference between the high angle group and average angle group in the thickness of the anterior alveolus only lingual to the lower incisor root apex (Fig. 5). Nonetheless, differences in study methodology and categorization approach used to segregate cases based on their vertical facial height could account for the discrepant findings between the two studies.

None of the comparable studies have segregated their sample based on subject gender. Interestingly, when gender was considered, the males and females showed significant differences in most of the anterior alveolar dimensions when the different sagittal jaw relationships were considered (Alhadlaq, 2010). However, when the vertical jaw relationship was considered in the present study, only a few of the variables of the anterior alveolar dimensions showed a significant difference between males and females (Table 2).

The limitations of this study include the limited sample size and the narrow geographic distribution of the sample. The correlation study between the alveolar dimensions and other jaw relationships, such as transverse discrepancy, warrants further investigation.

5. Conclusions

The anterior alveolar dimensions were significantly different between the Saudi individuals with different vertical facial heights, except for the alveolar thickness labial to the lower incisor root apex. The high angle individuals presented with a significantly different height of the upper and lower anterior alveolus and alveolar thickness lingual to the lower incisor root apex compared to the normal angle individuals. The low angle individuals were only significantly different in the height of the lower anterior alveolus compared to the normal angle individuals. Clinicians should be aware of these differences in the dimensions of the anterior alveolus for better control and sound orthodontic tooth movement of the upper and lower incisors.

Conflict of interest

We have no conflict of interest to declare.

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