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# Assessment of Anterior Alveolar Bone Dimensions in Adolescents and Adults wth Class I Normal Occlusion

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**الخلاصة**

**الأهداف**: تهدف الدراسة إلى تقييم أبعاد العظم السنخي الأمامي للفكين العلوي و السفلي في مجموعتين عمريتين، مجموعة المراهقين و مجموعة البالغين. **المواد و طرائق البحث**: تم استخدام أشعة قياس الرأس الجانبية ل 60 مراهقا (30 كرا و30 أنثى) و 60 بالغا (30 كرا و30 أنثى) من ذوي الصنف الأول للإطباق في هذه الدراسة. تمت دراسة العظم السنخي الأمامي باستعمال أبعاد لقياس سمك و ارتفاع العظم المحيط بالقواطع العلوية و السفلية. كما تم قياس زاوية ميلان القواطع العلوية و السفلية. تم تحليل البيانات باستخدام اختبار( t ) لعينتين مستقلتين و معامل ارتباط ( Pearson). **النتائج**: تمت ملاحظة فروق معنوية بين الجنسين في سمك العظم السنخي العلوي في كلا المجموعتين العمريتين، و في ارتفاع العظم السنخي السفلي و سمك الارتفاق في مجموعة البالغين. أظهرت المقارنة بين الفئتين العمريتين عدم وجود فروقات معنوية في معظم الأبعاد في ما عدا ارتفاع العظم السنخي العلوي و السفلي و سمك الارتفاق الذي سجل قيما أعلى و بفرق معنوي في الذكور البالغين مقارنة بالذكور المراهقين. أظهر تحليل الارتباط وجود ارتباط ايجابي بين زاوية ميلان القاطع العلوي و سمك العظم السنخي العلوي من الناحية الشفوية و ارتباط سلبي بين هذه الزاوية و سمك العظم من الناحية اللسانية. كما أظهر سمك العظم السنخي الشفوي للفكين عند مستوى ذروة الجذر ارتباطا سلبيا مع ارتفاع العظم السنخي العلوي و السفلي، بينما أظهر سمك الارتفاق ارتباطا ايجابيا مع سمك العظم السنخي السفلي من الناحية اللسانية و مع ارتفاع العظم السنخي.

**الاستنتاجات**: لم تتم ملاحظة فروق معنوية بين الفئتين العمريتين في حين أظهرت كل من فئة المراهقين و البالغين فروقا معنوية بين الجنسين كما أظهرت ارتباطا معنويا مع الأبعاد الأخرى التي تم قياسها.

## ABSTRACT

**Aims**: To investigate alveolar bone dimensions in the anterior segment of maxilla and mandible in 2 age group samples; adolescents and adults. **Materials and Methods**: Cephalometric radiographs of 60 adolescent (30 males and 30 females) and 60 adult subjects (30 males and 30 females) with Class I normal occlusion were included in this study. The anterior alveolar segment was assessed using several parameters that measure the thickness (labial and lingual) and height of alveolar bone surrounding upper and lower incisors. Upper and lower incisor inclination and palatomandibular plane (PMP) angle were also measured. Independent samples t– test and Pearson correlation coefficient were used for data analysis. **Results**: Sexual dimorphism was noticed in labial and palatal alveolar bone thickness of maxilla for both adolescent and adult subjects. Adult males also demonstrated significantly higher values for lower alveolar height and symphysis width than females. The comparison between 2 age groups revealed no significant difference for most variables and the most evident finding was the significantly higher values reported for upper and lower alveolar heights and symphysis width in adult males compared to adolescent males. The results of correlation analysis showed that upper incisor inclination has positive correlation with upper labial alveolar width and negative correlation with palatal alveolar width indicating that thinner palatal bone thickness is associated with more proclined upper incisors. Labial alveolar bone thickness at apical level of maxilla and mandible showed negative correlation with upper and lower alveolar heights in both age groups and with PMP angle in adults only. While, symphysis width showed positive correlation with the width of lingual alveolar bone and with alveolar heights. **Conclusions**: No significant differences were found between the 2 age groups, however in both adolescents and adults anterior alveolar dimensions showed sexual dimorphism and correlations with other cephalometric parameters.

**Key words**: Alveolar bone, Alveolar dimensions, Incisor inclination, Cephalometrics.

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## INTRODUCTION

A delineation of the limits of orthodontic tooth movement prior to the start of treatment would be extremely beneficial. The dimension of anterior alveolus appears to set these limits to orthodontic treatment and challenging these boundaries may accelerate iatrogenic sequelae.(1) Tooth movements which may decentralize teeth from alveolar ridge represent the most critical movement for developing bone dehiscences,(2) thus labial–lingual movements present more risk for breaking the limits of the alveolar bone causing labial and lingual bone plates resorption(3) and reduced alveolar bone thickness in the direction of tooth movement have been documented in several studies.(4–7)

Therefore, pretherapeutic evaluation of bone and root within the incisor region is of great significance in balancing possible iatrogenic effects against possible gain of therapy,(8) especially in border line patients where the professional seeks correction either via orthognathic surgery or dental compensation.(9) This evaluation should include the entire alveolar housing since the marginal and midroot bone widths are as important as apical width when attempting to define therapeutic limits for orthodontic tooth movement.(5)

This study aimed to: 1. Evaluate the anterior alveolar bone dimensions in 2 age groups; adolescents and adults with Class I normal occlusion. 2. Investigate sexual dimorphism in alveolar dimensions. 3.Inve stigate the relationship between alveolar dimensions and other cephalometric parameters (upper and lower incisors inclination, palate-mandibular plane angle and symphysis width).

## MATERIALS AND METHODS

The lateral cephalometric radiographs of 120 subjects were used in this study. The sample was divided into 2 groups; adult group comprised 60 subjects (30 males and 30 females) whose age ranged between 18-25 years and the adolescent group in which 60 subjects (30 males and 30 females) with age range of 12-15 years were investigated. All subjects presented with Class I molar and canine relationships, normal overjet and overbite (2–4 mm) and with no history of previous orthodontic treatment; lateral cephalometric radiograph was obtained for each subject using Cranex3+ ceph machine (Sordex Orion Corporation, Helsinki, Finland) only cephalometric records of good quality that shows clearly the outline of maxillary and mandibular anterior dento-alveolar segments were included in this investigation. The measurements used to study the anterior alveolar bone are depicted in Figure(1) and included the following:

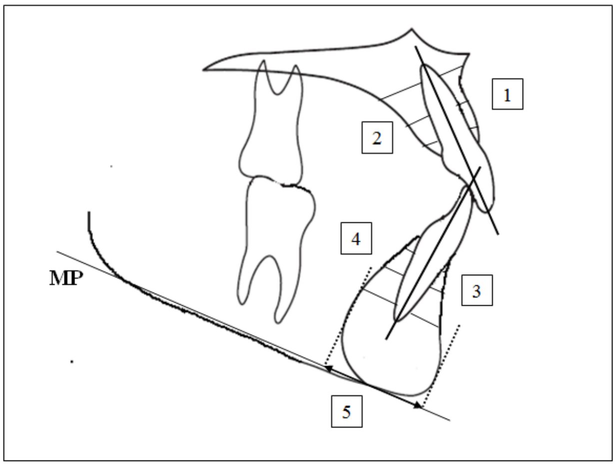
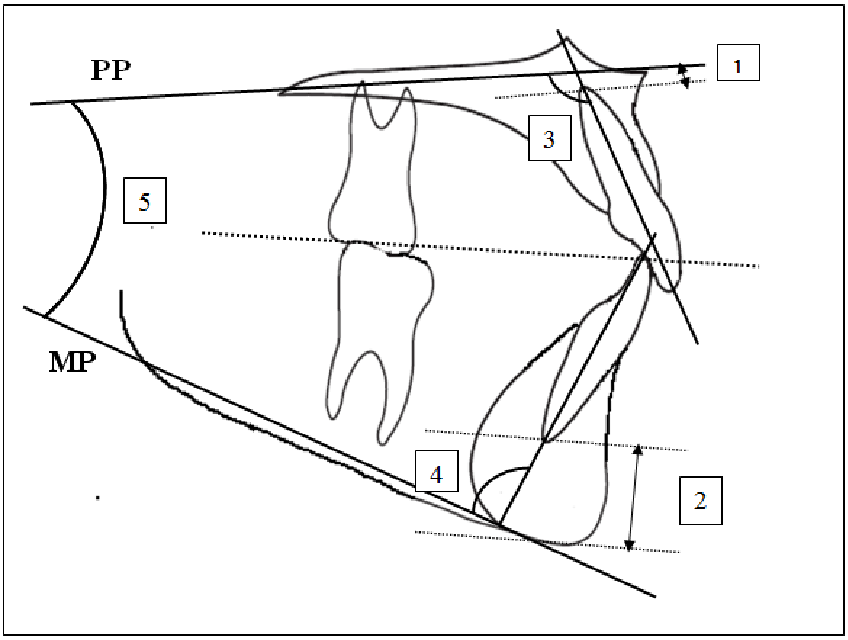



Figure (1): 1 and 2: Labial and palatal alveolar bone thickness of maxilla measured perpendicular to the long axis of upper central incisor at 3 levels; 2mm above cementoenamel junction, middle of the root and 2mm below root apex; 3 and 4: Labial and lingual alveolar bone thickness of mandible measured perpendicular to the long axis of lower central incisor at 3 levels; 2mm below cementoenamel junction, middle of the root and 2mm above root apex; 5: Width of maximum prominence of mandibular symphysis.

1. Labial alveolar bone thickness of maxilla measured perpendicular to the long axis of upper central incisor at 3 levels; 2mm above cementoenamel junction, middle of the root and 2mm below root apex.[10]
2. Palatal alveolar bone thickness of maxilla measured perpendicular to the long axis of upper central incisor at 3 levels; 2mm above cementoenamel junction, middle of the root and 2mm below root apex.[10]
3. Labial alveolar bone thickness of mandible measured perpendicular to the long axis of lower central incisor at 3 levels; 2mm below cementoenamel junction, middle of the root and 2mm above root apex.[10]
4. Lingual alveolar bone thickness of mandible measured perpendicular to the long axis of lower central incisor at 3 levels; 2mm below cementoenamel junction, middle of the root and 2mm above root apex.[10]
5. The width of maximum prominence of mandibular symphysis measured between tangents to the most prominent anterior point and the most prominent posterior point of symphysis; drawn perpendicular to mandibular plane.[11]
6. Upper anterior alveolar height: measured as the shortest distance from maxillary incisor apex to palatal plane (Figure 2).[1]
7. Lower anterior alveolar height: measured as the shortest distance from the apex of mandibular incisor to the lowest point on mandibular symphysis that is transected by a line parallel with mandibular Occlusal plane(Figure 2).[1]




Figure(2): 1: upper anterior alveolar height; 2: lower anterior alveolar height; 3: upper incisor palatal plane (PP) angle; 4:lower incisor mandibular plane (MP) angle; 5: palatomandibular plane angle.

In addition 3 angular measurements were included in the study (Figure 2):

1. Upper incisor palatal plane angle.[12]
2. Lower incisor mandibular plane angle.[13]
3. Palatomandibular plane angle(PMP).[12]

The data were analyzed using SPSS statistical software (version 12). descriptive statistics for all variables were calculated, difference between adult and adolescent groups along with sexual dimorphism within each group were tested using independent samples t–test at $p<0.05$ level of significance. Correlation between alveolar dimensions and other cephalometric parameters was studied using pearson correlation coefficient.

## RESULTS

Descriptive statistics of all variables along with comparison between males and females for both adolescents and adults are presented in Tables (1) and (2) respectively. In both age groups the areas of thickest alveolar bone were represented by apical zones of palatal aspect of maxilla and labial aspect of mandible.

**Table (1):** Descriptive statistics for adolescent group (12-15 years) with comparison between males and females.

| Variable | Gender | No. | Mean | ±SD | Sig. | *t*–value |
|---|---|---|---|---|---|---|
| **UBD1** | male | 30 | 1.083 | 0.558 | 0.021* | 2.379 |
| | female | 30 | 0.800 | 0.337 | | |
| **UBD2** | male | 30 | 1.833 | 0.634 | 0.001** | 3.483 |
| | female | 30 | 1.266 | 0.626 | | |
| **UBD3** | male | 30 | 4.800 | 1.725 | 0.002** | 3.269 |
| | female | 30 | 3.516 | 1.283 | | |
| **UPD1** | male | 30 | 1.266 | 0.468 | 0.385 | 0.876 |
| | female | 30 | 1.150 | 0.559 | | |
| **UPD2** | male | 30 | 3.550 | 0.834 | 0.008** | 2.728 |
| | female | 30 | 2.900 | 1.003 | | |
| **UPD3** | male | 30 | 6.533 | 1.181 | 0.005** | 2.928 |
| | female | 30 | 5.550 | 1.410 | | |
| **LBD1** | male | 30 | 0.683 | 0.245 | 0.267 | 1.120 |
| | female | 30 | 0.616 | 0.215 | | |
| **LBD2** | male | 30 | 1.383 | 0.536 | 0.227 | 1.222 |
| | female | 30 | 1.216 | 0.520 | | |
| **LBD3** | male | 30 | 3.700 | 1.387 | 0.838 | 0.205 |
| | female | 30 | 3.633 | 1.113 | | |
| **LLD1** | male | 30 | 0.566 | 0.217 | 0.980 | 0.140 |
| | female | 30 | 0.566 | 0.217 | | |
| **LLD2** | male | 30 | 1.200 | 0.637 | 0.910 | –0.114 |
| | female | 30 | 1.216 | 0.485 | | |
| **LLD3** | male | 30 | 2.116 | 0.953 | 0.820 | 0.228 |
| | female | 30 | 2.066 | 0.727 | | |
| **Upper anterior alveolar height** | male | 30 | 5.000 | 1.732 | 0.137 | –1.506 |
| | female | 30 | 5.616 | 1.424 | | |
| **Lower anterior alveolar height** | male | 30 | 19.833 | 2.692 | 0.579 | 0.557 |
| | female | 30 | 19.483 | 2.139 | | |
| **Symphysis width** | male | 30 | 16.250 | 1.860 | 0.494 | –0.688 |
| | female | 30 | 16.550 | 1.499 | | |
| **1 inclination** | male | 30 | 113.866 | 3.901 | 0.219 | 1.242 |
| | female | 30 | 112.400 | 5.156 | | |
| **1 inclination** | male | 30 | 97.566 | 5.630 | 0.901 | –0.125 |
| | female | 30 | 97.733 | 4.623 | | |
| **PMP angle** | male | 30 | 27.133 | 3.559 | 0.302 | –1.041 |
| | female | 30 | 28.100 | 3.632 | | |

No=number; SD=standard deviation; U=upper; L=lower; B=labial; P=palatal; LL=lower lingual; D1= alveolar dimension at 2mm below CE junction; D2=alveolar dimension at mi-droot level; D3= alveolar dimension at 2mm above apex; PMP=palatomandibular plane angle. *significant difference at p≤0.05; ** significant difference at p≤0.01.

**Table (2):** Descriptive statistics for adult group (18-25 years) with comparison between males and females.

| Variable | Gender | No. | Mean | ±SD | Sig. | *t*–value |
|---|---|---|---|---|---|---|
| **UBD1** | male | 30 | 1.142 | 0.356 | 0. 214 | 1.257 |
| | female | 30 | 1.016 | 0.404 | | |
| **UBD2** | male | 30 | 1.857 | 0.448 | 0.035* | 2.162 |
| | female | 30 | 1.586 | 0.598 | | |
| **UBD3** | male | 30 | 3.803 | 1.293 | 0.046* | 2.036 |
| | female | 30 | 3.166 | 1.085 | | |
| **UPD1** | male | 30 | 1.267 | 0.726 | 0.926 | –0.094 |
| | female | 30 | 1.283 | 0.520 | | |
| **UPD2** | male | 30 | 3.964 | 1.008 | 0.000*** | 4.202 |
| | female | 30 | 2.983 | 0.759 | | |
| **UPD3** | male | 30 | 6.517 | 1.258 | 0.001** | 3.647 |
| | female | 30 | 5.316 | 1.249 | | |
| **LBD1** | male | 30 | 0.732 | 0.318 | 0.412 | –0.862 |
| | female | 30 | 0.816 | 0.444 | | |
| **LBD2** | male | 30 | 1.285 | 0.479 | 0.319 | –1.006 |
| | female | 30 | 1.416 | 0.509 | | |
| **LBD3** | male | 30 | 2.892 | 0.984 | 0.117 | 1.592 |
| | female | 30 | 2.433 | 1.194 | | |
| **LLD1** | male | 30 | 0.571 | 0.178 | 0.928 | 0.091 |
| | female | 30 | 0.566 | 0.217 | | |
| **LLD2** | male | 30 | 1.410 | 0.624 | 0.315 | 1.013 |
| | female | 30 | 1.250 | 0.583 | | |
| **LLD3** | male | 30 | 2.357 | 0.691 | 0.622 | 0.496 |
| | female | 30 | 2.250 | 0.926 | | |
| **Upper anterior alveolar height** | male | 30 | 6.964 | 2.305 | 0.173 | 1.381 |
| | female | 30 | 6.200 | 1.901 | | |
| **Lower anterior alveolar height** | male | 30 | 22.839 | 2.697 | 0.006** | 2.856 |
| | female | 30 | 20.716 | 2.943 | | |
| **Symphysis width** | male | 30 | 17.517 | 1.897 | 0.000*** | 3.780 |
| | female | 30 | 15.766 | 1.628 | | |
| **1 inclination** | male | 30 | 111.964 | 6.557 | 0.886 | –0.144 |
| | female | 30 | 112.200 | 5.921 | | |
| **1 inclination** | male | 30 | 94.964 | 6.477 | 0.649 | –0.458 |
| | female | 30 | 95.666 | 5.161 | | |
| **PMP angle** | male | 30 | 22.428 | 4.803 | 0.040* | –2.108 |
| | female | 30 | 25.066 | 4.726 | | |

No=number; SD=standard deviation; U=upper; L=lower; B=labial; P=palatal; LL=lower lingual; D1= alveolar dimension at 2mm below CE junction; D2=alveolar dimension at mi-droot level; D3= alveolar dimension at 2mm above apex; PMP=palatomandibular plane angle.

*significant difference at p≤0.05; **significant difference at p≤0.01; ***significant difference at p≤0.001.

Sexual dimorphism was noticed in adolescent subjects only for upper anterior alveolar dimensions both labially and palatally, as males showed larger anterior alveolar width than females. Adult males also showed significantly larger upper anterior alveolar width at midroot and apical levels both labially and palatally, they also demonstrated significantly larger lower anterior alveolar height and symphysis width.

When the 2 age groups were compared (Tables 3 and 4) different findings were noticed for males and females. As Table (3) shows adolescent males demonstrated significantly thicker upper and lower labial alveolar bone at apical level than adult males. On the other hand, adult males possessed significantly longer upper and lower anterior alveolar heights and greater symphyseal width.

**Table (3):** Comparison of alveolar dimensions between adolescent and adult males.

| Variable | Gender | No. | Mean | ±SD | Sig. | *t*–value |
|---|---|---|---|---|---|---|
| **UBD1** | adolescent | 30 | 1.083 | 0.558 | 0.633 | –0.480 |
| | adult | 30 | 1.142 | 0.356 | | |
| **UBD2** | adolescent | 30 | 1.833 | 0.634 | 0.870 | –0.164 |
| | adult | 30 | 1.857 | 0.448 | | |
| **UBD3** | adolescent | 30 | 4.800 | 1.725 | 0.016* | 2.475 |
| | adult | 30 | 3.803 | 1.293 | | |
| **UPD1** | adolescent | 30 | 1.266 | 0.468 | 0.994 | –0.007 |
| | adult | 30 | 1.267 | 0.726 | | |
| **UPD2** | adolescent | 30 | 3.550 | 0.834 | 0.093 | –1.709 |
| | adult | 30 | 3.964 | 1.008 | | |
| **UPD3** | adolescent | 30 | 6.533 | 1.181 | 0.962 | 0.048 |
| | adult | 30 | 6.517 | 1.258 | | |
| **LBD1** | adolescent | 30 | 0.683 | 0.245 | 0.514 | –0.657 |
| | adult | 30 | 0.732 | 0.318 | | |
| **LBD2** | adolescent | 30 | 1.383 | 0.536 | 0.469 | 0.729 |
| | adult | 30 | 1.285 | 0.479 | | |
| **LBD3** | adolescent | 30 | 3.700 | 1.387 | 0.014* | 2.539 |
| | adult | 30 | 2.892 | 0.984 | | |
| **LLD1** | adolescent | 30 | 0.566 | 0.217 | 0.928 | –0.091 |
| | adult | 30 | 0.571 | 0.178 | | |
| **LLD2** | adolescent | 30 | 1.200 | 0.637 | 0.209 | –1.270 |
| | adult | 30 | 1.410 | 0.624 | | |
| **LLD3** | adolescent | 30 | 2.116 | 0.953 | 0.279 | –1.093 |
| | adult | 30 | 2.357 | 0.691 | | |
| **Upperanterior alveolar height** | adolescent | 30 | 5.000 | 1.732 | 0.001** | –3.685 |
| | adult | 30 | 6.964 | 2.305 | | |
| **Lower anterior alveolar height** | adolescent | 30 | 19.833 | 2.692 | 0.000*** | –4.245 |
| | adult | 30 | 22.839 | 2.697 | | |
| **Symphysis width** | adolescent | 30 | 16.250 | 1.860 | 0.013* | –2.568 |
| | adult | 30 | 17.517 | 1.897 | | |

No=number; SD=standard deviation; U=upper; L=lower; B=labial; P=palatal; LL=lower lingual; D1= alveolar dimension at 2mm below CE junction; D2=alveolar dimension at mi-droot level; D3= alveolar dimension at 2mm above apex.

*significant difference at p≤0.05; **significant difference at p≤0.01; ***significant difference at p≤0.001.

**Table (4):** Comparison of alveolar dimensions between adolescent and adult females.

| Variable | Gender | No. | Mean | +SD | Sig. | *t*–value |
|---|---|---|---|---|---|---|
| **UBD1** | adolescent | 30 | 0.800 | 0.337 | 0.028* | –2.254 |
| | adult | 30 | 1.016 | 0.404 | | |
| **UBD2** | adolescent | 30 | 1.266 | 0.626 | 0.052 | –2.239 |
| | adult | 30 | 1.586 | 0.598 | | |
| **UBD3** | adolescent | 30 | 3.516 | 1.283 | 0.259 | 1.141 |
| | adult | 30 | 3.166 | 1.085 | | |
| **UPD1** | adolescent | 30 | 1.150 | 0.559 | 0.343 | –0.956 |
| | adult | 30 | 1.283 | 0.520 | | |
| **UPD2** | adolescent | 30 | 2.900 | 1.003 | 0.718 | –0.363 |
| | adult | 30 | 2.983 | 0.759 | | |
| **UPD3** | adolescent | 30 | 5.550 | 1.410 | 0.500 | 0.678 |
| | adult | 30 | 5.316 | 1.249 | | |
| **LBD1** | adolescent | 30 | 0.616 | 0.215 | 0.031* | –2.217 |
| | adult | 30 | 0.816 | 0.444 | | |
| **LBD2** | adolescent | 30 | 1.216 | 0.520 | 0.138 | –2.093 |
| | adult | 30 | 1.416 | 0.509 | | |
| **LBD3** | adolescent | 30 | 3.633 | 1.113 | 0.000** | 4.025 |
| | adult | 30 | 2.433 | 1.194 | | |
| **LLD1** | adolescent | 30 | 0.566 | 0.217 | 0.787 | 0.272 |
| | adult | 30 | 0.566 | 0.217 | | |
| **LLD2** | adolescent | 30 | 1.216 | 0.485 | 0.811 | –0.240 |
| | adult | 30 | 1.250 | 0.583 | | |
| **LLD3** | adolescent | 30 | 2.066 | 0.727 | 0.397 | –0.852 |
| | adult | 30 | 2.250 | 0.926 | | |
| **Upper anterior alveolar height** | adolescent | 30 | 5.616 | 1.424 | 0.184 | –1.345 |
| | adult | 30 | 6.200 | 1.901 | | |
| **Lower anterior alveolar height** | adolescent | 30 | 19.483 | 2.139 | 0.069 | –1.856 |
| | adult | 30 | 20.716 | 2.943 | | |
| **Symphysis width** | adolescent | 30 | 16.550 | 1.499 | 0.057 | 1.939 |
| | adult | 30 | 15.766 | 1.628 | | |

No=number; SD=standard deviation; U=upper; L=lower; B=labial; P=palatal; LL=lower lingual; D1= alveolar dimension at 2mm below CE junction; D2=alveolar dimension at midroot level; D3= alveolar dimension at 2mm above apex.
*significant difference at $p\leq 0.05$; **significant difference at $p\leq 0.001$.

Adult females showed significantly thicker labial alveolar bone at cervical level in maxilla and mandible, while adolescent females showed significantly wider apical alveolar bone on labial aspect of mandible (Table 4).

The results of Pearson correlation coefficient are presented in Table (5) for adolescent subjects and Table (6) for adult subjects. In adolescents, upper incisor inclination demonstrated significant positive correlation with upper labial alveolar dimensions at midroot and apical levels and significant negative correlation with upper palatal alveolar dimensions at all 3 levels. While, lower incisor inclination showed only a significant positive correlation with lower labial alveolar dimension at apical level. The palatomandibular plane angle (PMP) demonstrated significant positive correlation with upper anterior alveolar height. Adolescents also showed significant negative correlation between the width of upper labial alveolar bone at apical level and upper and lower anterior alveolar heights and between the width of lower labial alveolar bone at apical level and lower alveolar height. Symphysis width showed significant positive correlation with lower apical alveolar width on both labial and lingual aspects, lower lingual midroot alveolar width, and lower anterior alveolar height.

**Table (5):** Correlation of alveolar dimensions and other cephalometric parameters for combined adolescent group.

| | 1 inclination | -- 1 inclination | PMP angle | Upper anterior alveolar height | Lower anterior alveolar height | Symphysis width |
|---|---|---|---|---|---|---|
| **UBD1** | 0.169 | _ | 0.120 | –0.092 | –0.036 | –0.207 |
| **UBD2** | 0.398** | _ | 0.001 | –0.037 | –0.086 | –0.054 |
| **UBD3** | 0.542** | _ | –0.097 | –0.440** | –0.267* | –0.232 |
| **UPD1** | –0.342** | _ | 0.218 | 0.044 | 0.082 | 0.049 |
| **UPD2** | –0.294* | _ | 0.042 | 0.004 | 0.210 | 0.107 |
| **UPD3** | –0.431** | _ | 0.075 | –0.157 | 0.112 | 0.086 |
| **LBD1** | _ | 0.167 | –0.195 | –0.184 | 0.108 | 0.236 |
| **LBD2** | _ | 0.086 | –0.041 | –0.031 | –0.011 | 0.096 |
| **LBD3** | _ | 0.289* | –0.182 | –0.196 | –0.371** | 0.263* |
| **LLD1** | _ | –0.048 | –0.054 | –0.061 | –0.232 | 0.089 |
| **LLD2** | _ | –0.063 | –0.232 | –0.176 | –0.237 | 0.323* |
| **LLD3** | _ | –0.113 | –0.254 | –0.169 | –0.234 | 0.351** |
| **Upper alveolar height** | –0.135 | –0.040 | 0.315* | 1 | 0.511** | 0.188 |
| **Lower alveolar height** | –0.098 | –0.072 | 0.124 | 0.511** | 1 | 0.277* |
| **Symphysis width** | –0.002 | 0.115 | –0.258 | 0.188 | 0.277* | 1 |

No=number; SD=standard deviation; U=upper; L=lower; B=labial; P=palatal; LL=lower lingual; D1= alveolar dimension at 2mm below CE junction; D2=alveolar dimension at midroot level; D3= alveolar dimension at 2mm above apex. PMP=palatomandibular plane angle. *correlation is significant at p≤ 0.05; ** correlation is significant at p≤ 0.01.

**Table (6):** Correlation of alveolar dimensions and other cephalometric parameters for combined adult group.

| Variable | $\underline{1}$ inclination | $\overline{1}$ inclination | PMP angle | Upper anterior alveolar height | Lower anterior alveolar height | Symphysis width |
|---|---|---|---|---|---|---|
| **UBD1** | –0.051 | _ | –0.117 | –0.055 | –0.051 | 0.023 |
| **UBD2** | 0.034 | _ | –0.156 | –0.007 | –0.007 | 0.031 |
| **UBD3** | 0.469** | _ | –0.408** | –0.302* | –0.075 | 0.104 |
| **UPD1** | –0.191 | _ | 0.105 | 0.042 | 0.025 | 0.219 |
| **UPD2** | –0.109 | _ | –0.097 | 0.139 | 0.206 | 0.464** |
| **UPD3** | –0.349** | _ | –0.077 | 0.076 | 0.248 | 0.358** |
| **LBD1** | _ | –0.041 | 0.095 | 0.030 | –0.126 | –0.163 |
| **LBD2** | _ | –0.038 | –0.005 | –0.007 | –0.150 | –0.182 |
| **LBD3** | _ | 0.414** | –0.283* | –0.317* | –0.298* | 0.078 |
| **LLD1** | _ | 0.003 | –0.220 | –0.064 | –0.177 | 0.025 |
| **LLD2** | _ | –0.021 | –0.128 | 0.030 | –0.030 | 0.388** |
| **LLD3** | _ | 0.018 | 0.079 | 0.150 | 0.109 | 0.398** |
| **Upper alveolar height** | –0.369** | –0.222 | 0.555** | 1 | 0.572** | 0.306* |
| **Lower alveolar height** | –0.228 | –0.074 | 0.541** | 0.572** | 1 | 0.534** |
| **Symphysis width** | –0.065 | 0.138 | 0.063 | 0.306* | 0.534** | 1 |

No=number; SD=standard deviation; U=upper; L=lower; B=labial; P=palatal; LL=lower lingual; D1= alveolar dimension at 2mm below CE junction; D2=alveolar dimension at midroot level; D3= alveolar dimension at 2mm above apex. PMP=palatomandibular plane angle.
*correlation is significant at $p \leq 0.05$; ** correlation is significant at $p \leq 0.01$.

Table (6) reveals correlations among variables for adult subjects. The width of upper labial alveolar bone at apical level showed significant positive correlation with upper incisor inclination, the latter also demonstrated significant negative correlation with upper palatal alveolar dimension at apical level and with upper alveolar height. Only the width of apical alveolar bone at labial aspect of mandible showed a significant positive correlation with lower incisor inclination. While, PMP angle showed significant negative correlation with apical alveolar dimensions on labial aspects of maxilla and mandible, it also demonstrated significant positive correlation with both upper and lower anterior alveolar heights. Significant negative correlation was noticed between the width of upper labial alveolar bone at apical level and upper anterior alveolar height and between the width of lower labial alveolar bone at apical level and both upper and lower anterior alveolar heights. Symphysis width showed significant positive correlation with lower lingual alveolar width at midroot and apical levels, and with upper and lower anterior alveolar heights.

## DISCUSSION

Cephalometric norms for anterior alveolar width and height were presented in this study for adolescents and adults with Class I normal occlusion. The assessment of these dimensions should be incorporated in cephalometric evaluation during planning treatment as it will determine if sufficient alveolar bone is available for safe movement of incisors to correct skeletal discrepancy; especially in border line patients who may appear to be within the range for orthodontic therapy but, who upon closer cephalometric examination will require surgery because of limited alveolar width.(1)

The results of this study showed sexual dimorphism in the width of upper anterior alveolus in both age groups, as males demonstrated thicker labial and palatal alveolar bone than females. This finding comes in agreement with Al Hadlaq(14)who investigated upper and lower alveolar dimensions in Saudi adults. However, lower alveolar width dimensions failed to show significant difference between genders which comes in accordance with the observations of Choe et al.,(15) who reported no significant difference between males and females in almost all lower anterior alveolar dimensions (except for labial alveolar width at cervical level) in both adolescent and adult subjects.

In addition, adult males showed significantly larger value for lower anterior alveolar height than females which comes in agreement with the observations of other investigators.(14,16) They also demonstrated greater symphyseal width which is consistent with the findings reported by Aki et al.,(17) and Mangla et al.,(11).

When the 2 age groups were compared no significant difference was noticed for almost all alveolar width dimensions which supports the claim of independent relationship between thickness of alveolar bone and pateint’s age that has been reported by other investigators(9,18). However, adolescent males demonstrated thicker labial alveolar dimensions at apical level of maxilla and mandible, while adolescent females showed thicker apical alveolar width of labial aspect of mandible. This observation may be attributed to the effect of surface remodeling which removes bone from anterior surface of maxilla and of mandible, in the area above the chin to the base of alveolar process, during active growth of facial skeletal structures. (19)

On the other hand, anterior alveolar heights and symphysis width showed significantly higher values in adult males compared to adolescent males, while the difference in females was insignificant, which is explained by the fact that in girls skeletal pattern matures between 12 and 14 years and is not significantly different from that of women while boys continue to grow significantly in the post pubertal years (until 18 years of age).(20,21)

Correlation analysis revealed significant positive correlation of upper incisor inclination with labial alveolar dimensions and negative correlation with palatal alveolar dimensions of maxilla, indicating that decreased palatal alveolar thickness is associated with more proclined upper incisors. No relevant studies could be found in the literature for comparison of findings and the few studies available concerning this aspect of the study confined their investigation on the association between lower incisor inclination and surrounding mandibular morphology.(22,23) Those studies found significant correlation of lower incisor inclination with labial and lingual alveolar bone thickness, where thinner lingual bone was observed with more proclined lower incisor. However, the findings of current study revealed weak correlation between lower incisor inclination and associated bone thickness. This variation in findings may be related to difference in criteria of sample selection as this study was confined to subject presented with Class I normal occlusion while the above mentioned studies investigated subjects with varying degrees of malocclusion.

The palatomandibular plane angle is considered as a measure of lower facial and alveolar height, which was evident as it showed positive correlation with both upper and lower anterior alveolar heights. It has been postulated that increased lower facial height is associated with thinness of alveolar bone(1,9,10,18,24–26) and a more narrowed and elongated shape of symphysis.(1,24) The results of the present study showed significant negative correlation between labial alveolar width at apical level in maxilla and mandible and upper and lower anterior alveolar heights in both age groups and between these dimensions and PMP angle in adult group. The fact that the correlation was restricted to apical level comes in agreement with findings of Ferreira(27) who reported that the thickness of alveolar bone plate at the level of cervical and middle thirds of the root is very similar in different vertical facial patterns. The findings of present study also coincides with the observations of Kim et al.,(10) and Gama et al.,(18) who investigated mandibular alveolar thickness in different facial patterns and reported thinner labial alveolar bone width in high angle subjects. These findings implies careful orthodontic planning in patients with increased lower facial height who require incisor movement in labial direction.

On the other hand, the current study did not show any association between PMP angle and symphysis width neither in adolescents nor adults. But, it revealed significant positive correlation of symphysis width with lower anterior alveolar height in adolescents and with both upper and lower anterior alveolar heights in adults; indicating that the increase in symphysis width coincides with increase in its height. Symphysis width also showed significant positive correlation with lingual alveolar bone width at midroot and apical levels in adolescent and adult subjects, thus it can be concluded that subjects with narrow symphyseal width need careful planning for retraction of lower incisors due to limited alveolar housing.

## CONCLUSIONS

It can be inferred from the findings of the current study that adolescents and adults do not vary significantly in their alveolar dimensions, however variations do exist between genders of each age group and mainly in upper alveolar bone thickness. In addition, alveolar bone width especially at apical and midroot levels showedvarious degree of association with other cephalometric parameters the most evident correlation was with upper incisor inclination and symphysis width.

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