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The relationship between maxillary and mandibular central incisor inclination and assessment of supporting bone thickness-A cross sectional cone beam computed tomography study

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Abstract

Objectives: This study was conducted to evaluate the age and sex related changes in inclination angle, age and sex prediction on the basis of inclination angle (Linear Regression Analysis- derived mathematical equations). This study is also aimed to evaluate supporting bone thickness of maxillary central incisor/mandibular central incisors and relationship of maxillary central incisor with inclination angle and to investigate the impact of age and gender on the alveolar bone thickness. The present study also assesses the difference between supporting bone thickness of maxillary central incisor and mandibular central incisor and its relationship with inclination angle.
Material and Methods: Total 101 patients having 61 male and 40 females who met the inclusion criteria were included in study. The total maxillary (101) and mandibular incisors (101) were included in the study. The cone beam images(Sagittal sections) were obtained from Carestream 9000cc (USA) CBCT machine having FOV 17x13' with Kvp 90, mA 4,voxel size.30 with 11.30 seconds exposure. The sagittal section of roots were made to evaluate the supporting bone at the labial, lingual and palatal aspects and at three different levels, cervical, middle, apical. The angle between the axis of the maxillary right central incisor and palatal plane was determined. The palatal plane was determined by the anterior nasal spine (ANS) and the posterior nasal spine. In order to measure the bone thicknesses in the most central slice of incisor in sagittal section, the long axis of right maxillary incisor and right mandibular incisor (the reference plane) was determined by drawing a line extending from the middle of the incisal edge to the end of the apical root passing by the middle of the root canal. From this sagittal section, three points were defined on the reference plane in the cervical (2 mm from the cemento-enamel junction), middle and apical regions of the root. Then three perpendiculars were drawn from the previous points on the reference plane in order to calculate the bone thickness at these levels.
Results: The mean of inclination angle is approximately same in males and females and this correlation is statistically not significant(P value>0.05). The inclination angle in age groups are statistically nonsignificant (P value>0.05). The supporting alveolar bone thickness in maxillary labial and palatal except maxillary palatal in middle of root is statistically non-significant(P>.05). The alveolar bone thickness in mandibular labial and mandibular lingual side is also statistically non-significant(P>.05). The mathematical equation derived from linear regression analysis can be used for age prediction.
Conclusion: This study highlights the importance of inclination angle in determination of age of an individual which can be helpful in resolving many medicolegal and criminal cases. However the supporting alveolar bone thickness helps in deciding the amount of orthodontic force to be applied for correction of skeletal malocclusion.

Keywords: Maxillary incisor, Mandibular incisor, Supporting bone thickness, Cone Beam Computed Tomography

Introduction

The orthodontic movement of teeth occurs within the alveolar bone but this movement is limited by the alveolar bone dimensions.[(1)] One of the most orthodontic treatment procedures affected by the anatomical limits of the supporting bone is moving the incisors in the sagittal direction.[(2)] Such movement may lead into exceeding the anatomical limits and thus will result in complications that are so-called iatrogenic effects including loosing of bone or roots resorption.[(3)] These limits depend on several factors such as the initial morphology of the alveolar bone before starting the treatment, the amount of teeth movement and its direction. The thickness of the alveolar bone around the teeth determines the amount of movements allowed.[(4,5)] In order to achieve a sound anteroposterior orthodontic tooth movement of maxillary and mandibular incisors in patients with abnormal sagittal jaw relationship, knowledge of the sagittal width of the maxillary and mandibular anterior alveolus is essential. It has been confirmed that the vertical growth affects the thickness of the supporting bone.[(6,7,8)] Patients with long face usually have less amount of supporting bones compared with normal or short vertical growth patients and this in return reduces the allowed movements available for teeth before reaching the anatomical limits. These patients are more likely to have periodontal complications caused by the orthodontic treatment. Before introducing the computed tomography in the dental use, studies made on traditional radiographs were of limited values because of dental and skeletal superimposition and thus the assessment of treatment results was restricted. As a result of curvature and rotation of the patients head while taking the radiography, double edges could be seen in areas that have bilateral structures. In addition, it was hard to evaluate the accurate position of roots or bone thickness without falling into many mistakes. With the admission of the cone beam tomo densitometry, it became possible to obtain highly accurate and reliable radiographs for teeth and surrounding bone tissue with minimal radial exposure.[9] Periago et al[10] noted that linear measurements taken from three dimensional images are considered clinically accurate and realistic. Also many studies showed the superiority of CBCT in quantitative assessment of supporting alveolar bone.[11,12] One of the multiple indications of CBCT is the assessment of the alveolar bone thickness around roots as well as the determination of the initial position of roots regarding the buccal and palatal/ lingual aspects of the maxilla and the mandible. Some researchers deem the position of the maxillary 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.[13] The correct positioning of the maxillary 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 maxillary incisors.[14] The inclination of the maxillary incisor axis with respect to the maxillary occlusal plane should be $64.3 + 3.2^0$ in women and $64.0 + 4.0^0$ in men. The vertical positioning of the maxillary 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 maxillary 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.[15] Tsunori et al[16] analyzed the correlation between the buccal-lingual inclination of the mandibular 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 normal and long face type patients. A contrasting result was reported in a later article.[17] Janson et al[18] revealed that the maxillary 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 mandibular posterior teeth between the two facial types. Legovic et al[19] 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 maxillary 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[20,21] 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.[22-24] As regards the correlation between jaw morphology and facial type, Siciliani et al[25] found that the mandibular symphysis is elongated in long face type patients and thicker in short face type patients. Tsunori et al reported that the cortex is thicker at the mandibular 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[17] also evidenced a thicker cortex at the mandibular first and second molars in short face type patients. The movement and position of the mandibular incisor play an important role in orthodontic diagnosis, treatment and management of Class II malocclusions. With this knowledge, the protrusive limits of the mandibular incisors should be established before treatment especially in patients with severe skeletal discrepancies[26] where incisor movement is limited by the status of the periodontal tissues[26] or the anatomy of the symphysis.[27] The dimensions of the anterior alveolus also appear to set limits to orthodontic treatment. Challenging these boundaries may accelerate iatrogenic sequelae.[28] Thus the treatment plan should take into account not only the position of the mandibular incisors but also the morphology of the symphysis. Mulie RM, Hoeve AT[29] supported this idea by reporting that when the roots of the incisors contacts to the cortical plate of the symphysis, orthodontic movements is inhibited to a greater degree and dehisences or fenestrations may occur. Several studies have reported differences in alveolar bone thickness or morphology according to facial type.[30-32] Handelman[28] reported that labial and lingual alveolar widths were small in high angle subjects as well as in Class III average angle individuals. Tsunori et al[31] reported correlations between facial type, mandibular cortical bone thickness and buccolingual inclinations of the first and second molars. Gracco et al[30] stated that the vestibular portion of the cancellous bone of the symphysis is greater in short face subjects when compared to long face subjects. According to Swasty et al[33] mandibular height and width differs more than cortical bone thickness among the 3 types of subjects with different vertical facial dimensions. Radiographic assessment of the mandible has become an important part of the orthodontic diagnosis and deciding the proper treatment plan. There are two main reasons which show the importance of evaluating the mandible morphology. First the mandible is considered as the most effective factor on the facial appearance and growth pattern that the mandible follows affects mainly on the facial growth in general. Second, it seems that the morphology of the mandible especially the symphysis reflects the previous growth stages and the future tendency of growth.[34] The position of the mandibular incisors in relation with their supporting bone is an important factor in determining the orthodontic treatment plan, assessment of the progress of treatment and identify the treatment requirements during the treatment stages. Therefore the initial position of the mandibular incisors can be considered as the main key to the right diagnosis and decide the proper treatment plan because of its dramatic impact on the aesthetics, stability of the treatment results and the space available in the mandibular arch. It seems that the greatest amounts of supporting bone are located in the apical region of the root for both mandibular central incisors and this is considered as a good indicator of supporting in this region while the regions which have the least thickness were located in the cervical region especially on the buccal side for both mandibular incisors and we can say that this might be an index for complications resulting from orthodontics treatment in case we did not consider these indications.

The relationship between changes in maxillary central incisor axial inclination, the amount of incisor movement and IARR have also been examined with varying results. Approximation of maxillary incisors against the palatal cortical plate was found to be the most significant measure associated with IARR according to the findings of Horiuchi et al.(35) and Kaley and Phillips(36) in contrast to the results of Mirabella and Artun.(37) Horizontal incisor movements(38) intrusion,(39) extrusion and lingual root torque have been implicated as important factors influencing the amount of IARR. In contrast, other authors could not correlate IARR with horizontal movments,(40) intrusion,(41) extrusion, lingual root torque or with changes in axial inclination.(38) Edwards examined the anterior portion of the palate during maximum lingual movement of maxillary incisors in 188 orthodontic patients with severe class II malocclusions each having three cephalograms taken pre-treatment, during-treatment and post-treatment.(42) After lingual root-torquing forces were continued from 4-6 months after a cephalogram showed the incisor roots were against the palatal cortical plate. The author found that the position of the palatal plate could be altered in both adults and growing patients with the greatest change in the marginal area of the alveolus and progressively less alteration of the bone toward the apex of the root. While the alveolar bone directly supporting the incisors could be moved distally, the anterior portion of the palate described as the palatal plate that curves downward from a horizontal position to the author observed that the incisors seemed to move through bone as opposed to stimulating the actual movement of bony structures until the teeth came against the palatal plate of the anterior palatal process, an anatomic limitation to the distal movement of maxillary incisor teeth. Edwards also commented on the difficulty in treating patients with a narrow maxillary anterior alveolus but found no statistically significant difference in the labio-lingual width of the anterior portion of the palate when grouping patients by mandibular divergence the more vertical alveolar process did not seem to move lingually with the retraction of the maxillary incisors. In attempts to establish cephalometric norms of the width of the anterior alveolus around the maxillary incisors, Handelmann examined lateral cephalograms of 107 patients assessing palatal bone thickness in the area of the incisor apex.(43) In contrast to Edwards' findings, palatal bone was narrower in this area in patients with class II malocclusions and high mandibular plane angles. While individuals of any facial type could have a thin alveolus, it was rarely seen in low mandibular plane angle groups or in the Class I average mandibular plane angle group. By analyzing the maxilla of a deceased 19-year old woman who had undergone orthodontic therapy Wehrbein et al quantitatively investigated the sagittal movements of the maxillary incisors and also observed the accompanying hard tissue changes.(44) The incisors first underwent uncontrolled tipping then palatal root torque. In accordance with the radiologic findings of Ten Hoeve and Mulie.(45) Wehrbein et al(44) discovered palatal bone apposition in histological sections with no evidence of cortical perforation. Root resorption with an apical slope from facio-apical to linguo-coronal induced by the palatal root torque was evident in histologic sections but not in radiologic findings. The authors advised that patients with a narrow apical base and a thin labial or lingual hard tissue and soft tissue covering warrant careful consideration when pronounced sagittal anterior tooth movements are required if long-term stability is to be guaranteed.

Materials and Method

Total 101 study subjects having 61 male and 40 females who met the inclusion criteria were included in study. The maxillary (101) and mandibular incisors (101) were included in the study. The cone beam images(Sagittal sections) were obtained from Carestream 9000cc (USA) CBCT machine having FOV 17x13' with Kvp 90, mA 4, voxel size.30 with 11.30 seconds exposure. The sagittal section of roots were made to evaluate the supporting bone at the labial, lingual and palatal aspects and at three different levels, cervical, middle, apical. The angle between the axis of the maxillary right central incisor and palatal plane was determined. The palatal plane was determined by the anterior nasal spine (ANS) and the posterior nasal spine(**Fig. 1**). In order to measure the bone thicknesses in the most central slice of incisor in sagittal section, the long axis of right maxillary incisor(Fig. 2a & 2b) and right mandibular incisor(**Fig. 3a& 3b**) (the reference plane) was determined by drawing a line extending from the middle of the incisal edge to the end of the apical root passing by the middle of the root canal. From this sagittal section, three points were defined on the reference plane in the cervical (2 mm from the cemento-enamel junction), middle and apical regions of the root. Then three perpendiculars were drawn from the previous points on the reference plane in order to calculate the bone thickness at these levels.

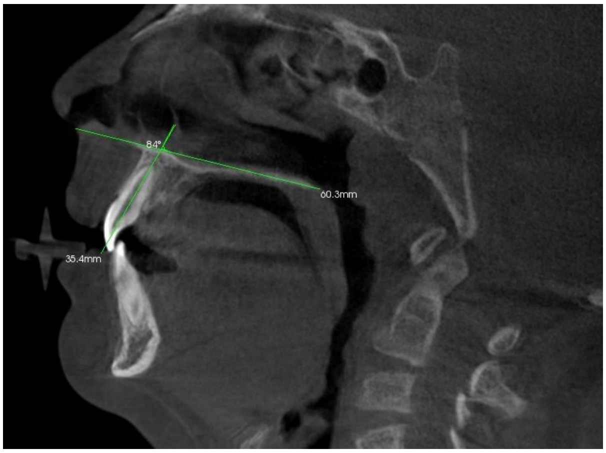


Fig. 1

Fig. 2a

Fig. 2b

Fig. 3a

Fig. 3b

Mandibular right central incisor: The inclusion criteria for mandibular right central incisor were Class I skeletal malocclusion, Normal vertical growth, No previous orthodontic treatment, absence of root resorption, absence of bone pathologies however the exclusion criteria were bone pathologies previous orthodontic treatment, periodontal diseases and root resorption. Images were obtained from Carestream 9000cc (USA) CBCT machine having FOV 17x13 with Kvp 90, mA 4, voxel size.300 with 11.30 seconds exposure. All the measurements are done on sagittal sections by using Trophy Dicom Ink software programme. In order to measure bone thicknesses in the most central slice of the incisor in the sagittal section, the long axis of right central incisor (the references plane) was determined by drawing a line extended from the middle of the incisal edge to the end of the apical root passing the middle of root canal. From this sagittal section, three points were defined on the reference plane in: cervical (after 2 mm from the cemento-enamel junction), middle of the root and apical regions. Then three perpendiculars were created from the previous points on the reference plane in order to calculate the bone thickness through them.

Maxillary right central incisor: The inclusion criteria for maxillary right central incisor were class I skeletal malocclusion, normal vertical growth, no previous orthodontic treatment, absence of root resorption, absence of bone pathologies however the exclusion criteria were bone pathologies previous orthodontic treatment, periodontal diseases and root resorption. All the CBCT images(sagittal sections) are obtained at 90 Kvp, 4 mA for 11.3 seconds at FOV(17"x13.5") voxel size of 300. All the measurements are done on sagittal sections by using Trophy Dicom Ink software programme.

The angle between the axis of the maxillary right central incisor and palatal plane (SPP) was determined. The palatal plane (SPP) was determined by the anterior nasal spine (ANS) and the posterior nasal spine (PNS)). In order to measure the bone thicknesses in the most central slice, the long axis of maxillary right central incisor (the reference plane) was determined by drawing a line extending from the middle of the incisal edge to the end of the apical root passing by the middle of the root canal. From this sagittal section, three points were defined on the reference plane in the cervical (2 mm from the cemento-enamel junction), middle and apical regions of the root. Then three perpendiculars were drawn from the previous points on the reference plane in order to calculate the bone thickness at these levels.

Statistical Analysis: The categorical variables are presented in number and percentage (%) and continuous variables are presented as mean and SD. Quantitative variables are compared using unpaired t-test between two groups and ANOVA test between three groups. Pearson correlation coefficients were used to determine the relationship between two scale parameters while correlation was defined as a measure of the strength of a linear relationship between two variables i.e. Pearson correlation coefficient was calculated to determine the linear association between bone tissue thicknesses. A p value of <0.05 will be considered statistically significant. The data will be entered in MS Excel spreadsheet and analysis will be done using Statistical Package for Social Sciences (SPSS) version 21.0.

Results

The study population consists of 101 study subjects having 61 male and 40 females who met the inclusion criteria were included in study. The total maxillary (101) and mandibular incisors(101) were included in the study. The study population is divided in 3 age groups.

The Unpaired t-test is used to know the sex related changes in inclination angle and it was found that the mean of inclination angle is approximately same in males and females and this correlation is statistically not significant(P value>0.05)(**Table 1**). The one way ANOVA test is used to evaluate the age related changes in inclination angle and it is found that mean of inclination angle in all 3 age groups are approximately same. So it is concluded that inclination angle in age groups are statistically nonsignificant (P value>0.05(**Table 2**).

Table 1

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Inclination Angle	Male	61	70.38	9.374	1.200
	Female	40	69.85	11.037	1.745

Applied unpaired t-test for significance P value=0.797

Table 2

Age intervals	N	Mean	Std. Deviation	95% Confidence Interval for Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
Upto 20 years	18	71.28	8.956	66.82	75.73	57	88
20 to 40 years	50	70.44	10.653	67.41	73.47	42	96
41 to 60 years	33	69.15	9.757	65.69	72.61	50	86
Total	101	70.17	10.015	68.19	72.15	42	96

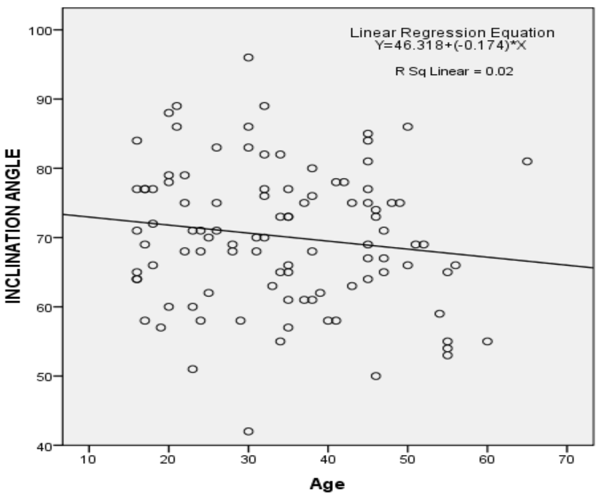
Applied one way ANOVA for significance (P value=0.745)

The co-relation between age and inclination angle is calculated by using Pearson co-relation coefficient which shows Pearson coefficient (r)=-0.142, P value=0.156 which was not significant. It was concluded that there is no co-relation between age and inclination angle.

However the linear regression analysis is performed for age prediction on the basis of inclination angle and a mathematical equation is derived- **Y=46.318+(-0.174)*X**

i.e. if the inclination angle is known, the age of an individual can be predicted with help of above equation.(**Graph 1**)

Graph 1



The supporting bone (alveolar bone) thickness around maxillary central incisor and mandibular central incisor is evaluated in both males and females by using unpaired t-test and it is found that alveolar bone thickness in maxillary palatal side in middle of root is statistically significant in both males and females(P<.05). However the supporting alveolar bone thickness in maxillary labial and palatal except maxillary palatal in middle of root is statistically non-significant(P>.05).The alveolar bone thickness in mandibular labial and mandibular lingual side is also statistically non-significant(P>.05) (**Table 3**). By using, unpaired t-test of significance, the mean of maxillary palatal alveolar bone thickness is compared in males and females. The alveolar bone thickness is statistically significant (p<0.05) in both males and females however it is higher in males than females. The mean of total supporting alveolar bone thickness in maxillary labial side, mandibular labial side and Mandibular lingual is approximately same i.e. statistically not significant (p>0.05) in males and females (**Table 4**). The one way ANOVA test is applied to compare supporting alveolar bone thickness of maxillary central incisor and mandibular central incisor in all 3 age groups. The mean of supporting alveolar bone thickness in maxillary labial side, palatal side at all 3 levels (cervical, middle and apical level) were approximately same and statistically non-significant. However the mean of supporting alveolar bone thickness in mandibular labial side at cervical and middle level was statistically significant(P<.05) while mandibular apical region in apical side is statistically non-significant(P>.05). The overall total mean of supporting alveolar bone thickness in mandibular labial side was nearly statistically significant. In mandibular lingual side, the supporting alveolar bone thickness in apical region is statistically significant(P<.05) while in cervical and middle region it was statistically non-significant(P>.05)(**Table 5**). The co-relation between inclination angle and supporting bone thickness of maxillary incisor (labial side) were evaluated by Pearson's correlation coefficient and it was found that there was no obvious significant correlation between inclination angle with Maxillary labial cervical and Maxillary middle supporting alveolar bone thickness. However Maxillary labial apical supporting alveolar bone thickness were directly associated with inclination angle and demonstrate a significant negative relation (r=-0.283, p=0.004)(**Table 6**). The co-relation between inclination angle and supporting bone thickness of maxillary incisor (lingual side) were evaluated by Pearson's correlation coefficient and it was found that there was no obvious significant correlation between inclination angle with Maxillary Labial (Total) and Maxillary palatal cervical region. However the supporting alveolar bone thickness in Maxillary palatal middle, Maxillary palatal apical and Maxillary palatal (Total) were directly associated with inclination angle and demonstrate a significant positive relation i.e. (r=0.232, p=0.019, r=0.399, p=<0.001 and r=0.307, p=0.002 respectively)(**Table 7**).

Table 3

	Gender	**N**	**Mean**	**Std. Deviation**	**P value**
Maxillary Labial Cervical	Male	61	3.6902	3.49088	.403
	Female	40	3.2200	.68057	.
Maxillary Labial Middle	Male	61	3.3033	.70189	.689
	Female	40	3.2475	.65201	
Maxillary Labial Apical	Male	61	2.9721	1.01080	.080
	Female	40	2.6250	.88860	
Maxillary Palatal Cervical	Male	61	4.0033	.63560	.172
	Female	40	3.8400	.49084	
Maxillary Palatal Middle	Male	61	6.0164	1.15977	.003*
	Female	40	5.2925	1.22650	
Maxillary Palatal Apical	Male	61	7.8230	1.77091	.131
	Female	40	7.1775	2.48580	
Mandibular Labial Cervical	Male	61	3.3000	.60277	.057
	Female	40	3.0600	.62626	
Mandibular Labial Middle	Male	61	3.1410	.62433	.654
	Female	40	3.0775	.79081	
Mandibular Labial Apical	Male	61	4.0311	1.30391	.887
	Female	40	4.0725	1.59132	
Mandibular Lingual Cervical	Male	61	3.1492	.70607	.311
	Female	40	3.0200	.46696	
Mandibular Lingual Middle	Male	61	3.6623	.86971	.919
	Female	40	3.6450	.77491	
Mandibular Lingual Apical	Male	61	3.6754	1.22769	.159
	Female	40	4.1000	1.78369	

Applied Unpaired t test for significance

Table 4

	Gender	N	Mean	Std. Deviation	P value
Maxillary Labial_Total	Male	61	9.9656	3.38900	0.136
	Female	40	9.0925	1.73078	
Maxillary Platal Total	Male	61	17.8426	3.03850	0.022*
	Female	40	16.3100	3.54197	
Mandibular Labial Total	Male	61	10.4721	1.92303	0.547
	Female	40	10.2100	2.42093	
Mandibular Lingual Total	Male	61	10.4869	2.32734	0.564
	Female	40	10.7650	2.41454	

Applied unpaired t test for significance

Table 5

		N	Mean	Std. Deviation	P value
Maxillary Labial Cervical	Upto 20 years	18	3.5389	.63629	0.680
	20 to 40 years	50	3.2800	.63310	
	41 to 60 years	33	3.8242	4.75046	
	Total	101	3.5040	2.74696	
Maxillary Labial Middle	Upto 20 years	18	3.2611	.57715	0.705
	20 to 40 years	50	3.3360	.69363	
	41 to 60 years	33	3.2091	.72127	
	Total	101	3.2812	.67981	
Maxillary Labial Apical	Upto 20 years	18	3.1278	1.29561	0.253
	20 to 40 years	50	2.8480	.87207	
	41 to 60 years	33	2.6545	.91142	
	Total	101	2.8347	.97472	
Maxillary Labial Total	Upto 20 years	18	9.9278	1.78945	0.833
	20 to 40 years	50	9.4640	1.61987	
	41 to 60 years	33	9.6879	4.46611	
	Total	101	9.6198	2.87117	
Maxillary Palatal Cervical	Upto 20 years	18	3.8944	.66197	0.665
	20 to 40 years	50	3.9920	.65273	
	41 to 60 years	33	3.8818	.42090	
	Total	101	3.9386	.58549	
Maxillary Palatal Middle	Upto 20 years	18	5.5222	.66999	0.730
	20 to 40 years	50	5.7900	1.38994	
	41 to 60 years	33	5.7515	1.23443	
	Total	101	5.7297	1.23301	
Maxillary Palatal Apical	Upto 20 years	18	7.8389	1.31647	0.827
	20 to 40 years	50	7.4820	2.47549	
	41 to 60 years	33	7.5485	1.83527	
	Total	101	7.5673	2.09576	
Maxillary Platal Total	Upto 20 years	18	17.2556	2.12443	0.994
	20 to 40 years	50	17.2640	3.86939	
	41 to 60 years	33	17.1818	3.00764	

	Total	101	17.2356	3.31658	
Mandibular Labial Cervical	Upto 20 years	18	3.4722	.79838	0.004*
	20 to 40 years	50	3.2880	.48975	
	41 to 60 years	33	2.9333	.60810	
	Total	101	3.2050	.62038	
Mandibular Labial Middle	Upto 20 years	18	3.3333	.88118	0.020*
	20 to 40 years	50	3.2140	.61909	
	41 to 60 years	33	2.8485	.61752	
	Total	101	3.1158	.69192	
Mandibular Labial Apical	Upto 20 years	18	4.2778	1.52144	0.657
	20 to 40 years	50	4.0640	1.48238	
	41 to 60 years	33	3.8970	1.27561	
	Total	101	4.0475	1.41708	
Mandibular Labial Total	Upto 20 years	18	11.0833	2.51472	0.050*
	20 to 40 years	50	10.5660	2.07547	
	41 to 60 years	33	9.6788	1.82599	
	Total	101	10.3683	2.12631	
Mandibular Lingual Cervical	Upto 20 years	18	3.2056	.77647	0.253
	20 to 40 years	50	2.9940	.51919	
	41 to 60 years	33	3.1970	.66825	
	Total	101	3.0980	.62305	
Mandibular Lingual Middle	Upto 20 years	18	3.6944	.97707	0.801
	20 to 40 years	50	3.6940	.81301	
	41 to 60 years	33	3.5758	.78821	
	Total	101	3.6554	.82951	
Mandibular Lingual Apical	Upto 20 years	18	3.9944	1.14300	0.001*
	20 to 40 years	50	4.2760	1.62889	
	41 to 60 years	33	3.1061	1.10310	
	Total	101	3.8436	1.47942	
Mandibular Lingual Total	Upto 20 years	18	10.8944	2.37697	0.101
	20 to 40 years	50	10.9640	2.42620	
	41 to 60 years	33	9.8788	2.12423	
	Total	101	10.5970	2.35421	

Applied one way ANOVA test for significance

Table 6

		Inclination Angle	**Maxillary Labial Cervical**	**Maxillary Labial Middle**	**Maxillary Labial Apical**
Inclination Angle	Pearson Correlation	1	.103	-.107	-.283**
	Sig. (2-tailed)		.305	.287	.004
	N	101	101	101	101

**Correlation is significant at the 0.01 level (2-tailed)

Table 7

		Inclination Angle	Maxillary Labial (Total)	Maxillary Palatal Cervical	Maxillary Palatal Middle	Maxillary Palatal Apical	Maxillary Platal_(Total)
Inclination Angle	Pearson Correlation	1	-.023	-.180	.232*	.399**	.307**
	Sig. (2tailed)		.820	.071	.019	.000	.002
	N	101	101	101	101	101	101

*Correlation is significant at the 0.05 level (2tailed)
**Correlation is significant at the 0.01 level (2-tailed)

Table 8

Group	N	Mean	Std. Deviation	P value
Maxillary Labial (Total)	101	9.6198	2.87117	0.036*
Mandibular Labial(Total)	101	10.3683	2.12631	

Applied Unpaired t test for significance

Table 9

Group	N	Mean	Std. Deviation	P value
Maxillary Palatal(Total)	101	17.2356	3.31658	<0.001*
Mandibular Lingual (Total)	101	10.5970	2.35421	

Applied Unpaired t test for significance

The supporting alveolar bone thickness of maxillary and mandibular central incisor is compared using unpaired t-test. On comparison between the mean of total maxillary labial side alveolar bone thickness(cervical, middle and apical) and mean of total mandibular labial side alveolar bone thickness(cervical, middle and apical), the unpaired t test showed statistically significant ($P<0.05$) difference between both. However the mandibular labial alveolar bone thickness is greater than maxillary labial alveolar bone thickness (**Table 8**). The supporting alveolar bone thickness of maxillary and mandibular central incisor is compared using unpaired t-test. On comparison between the mean of total maxillary palatal side alveolar bone thickness(cervical, middle and apical) and mean of total mandibular lingual side alveolar bone thickness(cervical, middle and apical), the unpaired t test showed statistically significant ($P<0.05$) difference between both. However the maxillary palatal alveolar bone thickness is greater than mandibular lingual alveolar bone thickness (**Table 9**).

Discussion

Even though there have been numerous publications about the orthodontic movement of the lower incisors and the related periodontal effects(46,47,48) surprisingly no studies have been published on the quantitative relationship between the maxillary anterior bone support and the inclination of the upper incisors and their role in gender determination. Yamada et al(49) made the first effort to evaluate the bone tissue amount of buccal and lingual surfaces of the upper central incisors and to relate the bone tissue quantity to the inclination of the incisors. Nauert and Berg(46) et al stated that accurate assessment of the bone support of the lower incisors is only possible through the use of computed tomography. Nahas Scocate et al(50) stated that the inclination of the upper central incisors in subjects examined in this study showed significant positive linear correlation with the apical buccal thickness (tooth 11, P, .034; tooth 21, P, .009). No correlation was found for all other measurements of bone thickness with inclination of the incisors. These findings are consistent with those of Nauert and Berg(5) who documented no relationship between the amount of bone tissue and tooth inclination of the lower incisors. Dayoub N. S et al(51) stated that there were no significant differences in bone thickness between males and females which was supported by the Yu et al(52) and Gracia et al(53) who also found no differences in bone thickness between males and females. On the other hand Uysal(54) and Dempsy et al(55) who documented that males have greater dimensions in bone tissue than females in lower central incisors. Osborne JW, Mao J(56) stated that Males had greater bone tissue thickness in the palatal side. This can be attributed to the fact that they had greater biting force than females (190). Newtons for males and 50 Newtons for females). On the other side, in our study we found that the mean of inclination angle is approximately same in males and females and this correlation is statistically not significant(P value>0.05). We also found no co-relation between age and inclination angle. It is founded that alveolar bone thickness in maxillary palatal side in middle of root is statistically significant in both males and females(P<.05). However the supporting alveolar bone thickness in maxillary labial and palatal except maxillary palatal in middle of root is statistically non-significant(P>.05). The alveolar bone thickness in mandibular labial and mandibular lingual side is also statistically non-significant(P>.05). The alveolar bone thickness is statistically significant (p<0.05) in both males and females however it is higher in males than females. The mean of total supporting alveolar bone thickness in maxillary labial side, mandibular labial side and Mandibular lingual is approximately same i.e. statistically not significant (p>0.05) in males and females. The mean of supporting alveolar bone thickness in maxillary labial side, palatal side at all 3 levels (cervical, middle and apical level) were approximately same and statistically non-significant. However the mean of supporting alveolar bone thickness in mandibular labial side at cervical and middle level was statistically significant(P<.05) while mandibular apical region in apical side is statistically non-significant(P>.05). The overall total mean of supporting alveolar bone thickness in mandibular labial side was nearly statistically significant. In mandibular lingual side, the supporting alveolar bone thickness in apical region is statistically significant(P<.05) while in cervical and middle region it was statistically non-significant(P>.05). We found that there was no obvious significant correlation between inclination angle with Maxillary labial cervical and Maxillary middle supporting alveolar bone thickness. However Maxillary labial apical supporting alveolar bone thickness were directly associated with inclination angle and demonstrate a significant negative relation (r=-0.283, p=0.004). Also there was no obvious significant correlation between inclination angle with Maxillary Labial (Total) and Maxillary palatal cervical region. However the supporting alveolar bone thickness in Maxillary palatal middle, Maxillary palatal apical and Maxillary palatal (Total) were directly associated with inclination angle and demonstrate a significant positive relation. It is to be noted that the mandibular labial alveolar bone thickness is greater than maxillary labial alveolar bone thickness and the maxillary palatal alveolar bone thickness is greater than mandibular lingual alveolar bone.

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