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# The Relation Between Root Length and Vertical Facial Measurements in Iraqi Adults with Various Skeletal Vertical Relations

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**Abstract**

Background: Root length may affect the amount of force and the type of mechanics necessary to get a precise tooth movement with adequate force. This study was conducted to find whether there is a relation between the root length and the vertical measurements of the face in groups of Iraqi subjects with various skeletal vertical relations.

Materials and method: 75 true lateral cephalometric radiographs and 75 orthopantomograms were taken for adults attending the Orthodontic Department at the College of Dentistry, University of Baghdad, divided into three groups according to SN-Mandibular plane angle as High, Low and Normal SN-MP angle groups; the skeletal variants were measured on lateral cephalometric radiograph while root length was measured on orthopantomogram by AutoCAD program 2016.

Results: The mean length of upper and lower teeth was higher in patients with low SN-Mandibular plane angles. There was no significant difference in the mean length of the teeth in both arches except for the lower central incisor. Also, there were significant differences regarding the mandibular central incisors and canines between low and high-angle groups; moreover, SN-Mandibular plane angle and posterior facial height correlate significantly with these teeth. Furthermore, the males had a higher mean root length for all measured teeth in this study than the females.

Conclusions: Orthopantomographs cover a wide area of the jaws and teeth and can assist cephalograms in the diagnosis. A slightly longer root in low SN-Mandibular plane angles than in high and normal SN-Mandibular plane angles.

## Introduction:

Diagnosis and treatment planning for patients with maxillofacial deformities can be complex and challenging [1] Orthodontic treatment begins with diagnosing the patient's dental and skeletal problems. Treatment planning must be based on accurate treatment objectives. Treatment mechanics will be dictated by the treatment goals, determined by dental and skeletal components in all three space planes [2]**.** The location of deviant variables may complicate or simplify the treatment plan; Mechanisms may differ depending on the deviation [3]. A positive relationship between root length and face size was observed; in general, all three facial dimensions were increased in subjects with the longest roots; in addition, small changes in subject positioning and jaw geometry did not affect the systematic relationships between face size and root length[4]. Some Studies were conducted to measure the root length using orthopantomograms[5,6] and CBCT Imaging[7,8]. The main problem regarding the use of panoramic radiographs concerns the magnification effect occurring at the vertical measurements of the mandible. A significant number of studies suggested that small changes in head position do affect horizontal dimensions while vertical dimensions do not show big changes, making it possible to get the benefit of panoramic radiographs when vertical estimation is needed [9]. Ongkosuwito et al. in 2009 studied the reliability of linear mandibular measurements, comparing orthopantomograms and lateral cephalograms of a dried human skull and suggested that OPG is as accurate as a lateral cephalogram [10], other recent studies [6, 11, 12] suggested that orthopantomogram might be beneficial when evaluating vertical mandibular dimensions and its as reliable as a lateral cephalometric radiograph; while considering horizontal mandibular measurements, it requires attentive clinician as these measurements could be unpredictable. In addition, Juma et al. [13] in 2018 concluded that detailed and precise data for sagittal and vertical investigations of the facial skeletal patterns can be obtained by orthopantomograms. .So it is essential to make efficient image for giving better data to other image treating process[14]. This study was conducted to determine whether there is a relation between the root length of the teeth (measured on orthopantomogram) and angular and linear dimensions of the face (measured on lateral cephalometric radiogram) in Iraqi patients sample with variable values of Sella-Nasion-Mandibular plane angle.

## Materials and Method

This study is approved by the research and ethics committee of the dental college at Baghdad University (no. 907 / 2024).

**The sample:**

The sample was carefully selected from radiographs (including both cephalometric and orthopantomogram) of 207 subjects seeking orthodontic treatment at the College of Dentistry, University of Baghdad; only 75 fit the selection criteria, and the sample size was determined according to previous research [13], using G*Power 3.1.9.4 shows 85% power to detect a small effect size at the 0.05 significant level. The collected sample was divided into three groups (25 subjects for each) according to the value of SN-Mandibular plane angle measured on lateral cephalogram by AutoCAD program version 2016 as:

- Group 1 (High angle group): subjects with high value of Sella Nasion-Mandibular plane angle (SN-MP˚> 36.5˚) [15].
- Low angle group (Group 2): subjects with low value of Sella Nasion-Mandibular plane angle (SN-MP˚< 28˚) [15].
- Control group (Group 3): subjects with normal value of Sella Nasion-Mandibular plane angle (28˚ < SN-MP˚< 36.5˚) [15].

The criteria of sample selection:

1. All subjects are Adult Iraqi, Arabic in origin, and the age range is 18-30 years to exclude the effects of

vertical dimension changes of the jaw due to growth[16].

2. Subjects with no previous orthodontic intervention.
3. No craniofacial disorder.
4. No severe jaws and facial soft tissue trauma.
5. All the permanent dentitions should exist except the third molar.

**Radiographical analysis:** Lateral cephalometric radiographs and orthopantomograms were analyzed by a specialized computer program (AutoCAD version 2016); the readings were multiplied by the magnification factor found by a ratio of the actual measurement scale to the equal distance measurement of this scale to correct the magnification errors of the lateral cephalometric radiograph. The same examiner did the tracing procedure of the panoramic measurements for the left and right sides to minimize interexaminer variability [17].
After the digitalization procedure, angular and linear measurements were processed using the Microsoft Office Professional Plus 2010 Excel program.

**Cephalometric Landmarks:**

The following landmarks were identified:

1. Point S (Sella): the centre of the hypophysial fossa [18].
2. Point N (Nasion): the most anterior point on the nasofrontal suture in the median plane [19].
3. Point Me (Menton): the lowest point on the symphysial shadow of the mandible seen on a lateral cephalogram.
4. Point Go (Gonion): A point on the angle of the mandible located by bisecting the angle formed by the lines tangent to the inferior border of the mandible and posterior ramus [18].
5. Point Ar (Articulare): the point of intersection of the external dorsal contour of the mandibular condyles and the temporal bone[20].

**Cephalometric angular and linear measurements:**

1. SN-Mandibular plane angle (SN-MP): the angle of mandibular inclination with the anterior cranial base, its normal range 28° -36 ° [3,18].
2. Basal plane angle (PP-MP): the inclination angle of the mandible to the maxillary base .
3. Saddle angle (N-S-Ar): the angle between the anterior and posterior cranial base .
4. Articular angle (S-Ar-Go): the angle between the posterior cranial base and the ramal plane .
5. Gonial angle: is an expression of the form of the mandible regarding the relation between body and ramus.
6. Anterior facial height: is the distance between Nasion and Menton .
7. Posterior facial height: formed by a line joining Sella and Gonion[20].
8. Overbite: the distance between the incisal tips of the mandibular and maxillary central incisors perpendicular to the occlusal plane measured when the teeth are in centric occlusion[19].

**Orthopantomograph Linear Measurements (Figures 1 and 2):**

The vertical linear measurements for each patient are the root length of the teeth mentioned below, measured as the distance from root apex to a midpoint on a line joining the points of deepest concavity of the curvature of the cementoenamel junction on mesial and distal sides of the root [5], the teeth included in this study are:

1. Upper right central incisor (U-R-1)
2. Upper right lateral incisor (U-R-2)
3. Upper right canine (U-R-3)
4. Upper right first molar (U-R-6)
5. Upper left central incisor (U-L-1)
6. Upper left lateral incisor (U-L-2)
7. Upper left canine (U-L-3)
8. Upper left first molar (U-L-6)
9. Lower right central incisor (L-R-1).

10. Lower right lateral incisor (L-R-2).
11. Lower right canine (L-R-3).
12. Lower right first molar (L-R-6).
13. Lower left central incisor (L-L-1).
14. Lower left lateral incisor (L-L-2).
15. Lower left canine (L-L-3).
16. Lower left first molar (L-L-6).

**Statistical Analysis**

The collected data analyzed by Statistical Package for Social Sciences (SPSS) version 2011 as:

1. Descriptive Statistics: include Mean and Standard deviation (SD).
2. Inferential Statistics: Analysis of Variance Test (ANOVA) to evaluate the differences among the three groups, followed by LSD test to illustrate the differences between each two groups; Pearson's correlation coefficient test to study the relation of root length with other vertical facial measurements, the following levels of significance were used for statistical evaluation: $P > 0.05$, which is non-significant, and $0.05 \geq P$ is significant.

## Results:

The study sample includes the central incisors, lateral incisors, canine and first molar teeth in both arches of 75 patients; Table 1 shows descriptive statistics of root length and angular facial measurement of the total sample**.** Table (2) (gender difference of the root length) shows that males have a higher root length mean of all measured teeth. However, this increase is statistically insignificant except for the lower central incisor. As demonstrated in Table (3), the Low SN-Mandibular plane angle group shows the highest root length readings of all measured teeth except the maxillary canine, which shows the highest mean in the normal SN-Mandibular plane angle group; in comparison, root length measurements among the study groups showed a non-significant difference except Lower central incisor which shows significant results between high angle and low angle groups, and between low angle and normal groups Table (4).Table (5) illustrates the correlation between root length and facial measurements, revealing non-significant results except for three teeth: lower central incisor, which is significantly correlated with SN-Mandibular plane angle and saddle angle. The lower lateral incisor is significantly correlated with saddle angle, and the lower canine is significantly correlated with posterior facial height.

## Discussion:

Teeth have been widely used in anthropological studies as they are the most unaffected and abundant remains in archaeological and forensic records [21]. Root length is also important in designing accurate and effective orthodontic treatment plans. A small correlation had been noticed between the humans` stature and tooth size [22,23]. This study utilises Orthopantomogragh to compare the root length of teeth among Iraqi samples**.** Only necessary X-rays should be performed since there are small risks in every radiological examination, as explained by The International Commission on Radiation Protection, as the effects originate from mutational changes in the cellular DNA that may eventually lead to the development of radiation-induced cancer and hereditary changes that could be transmitted to descendants of exposed individuals [24]; CBCT can be used to compare root length, but the radiation dose is several times higher than that of conventional lateral cephalograms and orthopantomograms [25], making it reasonable to get full benefits of these routine radiographic record for all orthodontic patients.

The rotational panoramic technique covered a greater area in the molar and postmolar regions, which is the major advantage of the panoramic radiograph [26,27]. Srivastava et al. [6] showed that vertical measurements are more accurate than horizontal and angular measurements in orthopantomography, but they still do

not truly represent real objects; Tronje et al. [28]claimed that vertical measurements on orthopantomograms are relatively more predictable and accurate as compared to the horizontal measurements and may be used if the patient's head is in proper position. Then, in 2017, Kumar et al. [12] found that OPG can be used to determine angular and vertical mandibular dimensions accurately as a lateral cephalometric radiograph, which agreed with the results of Juma et al. [13] in 2018 who concluded that a detailed and precise data for sagittal and vertical investigations of the facial skeletal patterns can be obtained by orthopantomograms. Depending on the results of these studies [11-13,29], we utilised an Orthopantomograph to compare root length among Iraqi patients sample. Statistical analysis revealed that males had a higher mean of root length for all measured teeth than females, which comes in agreement with Jazrawi [30] and Dashrath et al. [31] in addition to the CBCT-based length measurement conducted by Kim et al. [32], who found that total lengths were significantly greater in male; this increase is non-significant except for the lower central incisor root, which is significantly longer in males than females. Patients with low SN-Mandibular plane angle showed the highest mean length of most measured teeth; However, it statically insignificant increase, which is agreed with the results of Betzenberger et al. [33], who stated that in the permanent tooth period, subjects with a high SN-MP angle have decreased heights of upper and lower posterior dentoalveolar complex, and agreed with Yousif [34] the SN-MP angle positively correlated with the height of maxilla or the mandibular molar region. While Larheim et al. [35] observed small differences when dealing with the mean tooth lengths. Also the bone height influenced by gender in addition to the age and hormonal varaitions [36]. Root length of the measured teeth showed no significant correlation with vertical facial measurements except for mandibular anterior incisors, which are significantly correlated with SN-Mandibular plane angle and saddle angle, in addition to the lower canine, which is significantly correlated to posterior facial height, these results might be due to difficulty in identifying the roots length of mandibular anterior teeth in most Panoramic radiographs, as they were either overlapped or blurry and not clear in this region [37],

## Conclusions:

Orthopantomographs cover a wide area of the jaws and teeth and can assist cephalograms in the diagnosis. A slightly longer root would be expected in subjects with low SN-Mandibular plane angles, in contrast to subjects with high and normal SN-Mandibular plane angles. In addition, the root length of mandibular anterior teeth is significantly correlated with the posterior facial height.

**Data Availability**

Raw data of this study are available from the corresponding author upon request.

**Authors' Contributions**

Hiba M. Hussein Al-Chalabi was involved in measurement supervision and critically reviewed the study. Sara M. Al-Mashhadany designed, wrote, and critically reviewed the article and performed a literature search. Zainab Mousa Kadhom collected data and analysed the study.

**Conflicts of Interest**

The authors have no conflicts of interest.

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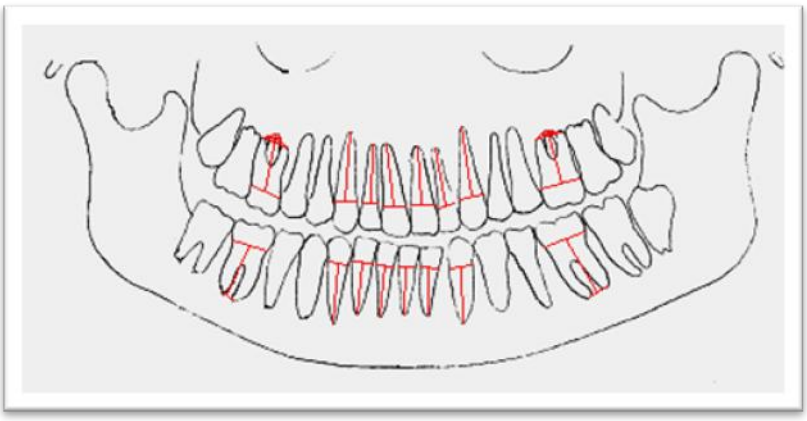

Figure (1): dental measurements.

Figure (2): Dental measurements by using the AutoCAD program.

Table (1): descriptive statistics of root length and Angular measurement of the total sample.

| Root length | Mean | S. D | Angular measurement | Mean | S. D |
|---|---|---|---|---|---|
| Upper central incisor | 25.28 | 2.29 | SNMP | 33.60 | 6.59 |
| Upper lateral incisor | 24.03 | 3.88 | BPA | 27.55 | 6.41 |
| Upper canine | 31.01 | 3.51 | SADDLE | 122.12 | 5.63 |
| Upper first molar | 23.53 | 2.27 | ARTICULAR | 145.27 | 6.76 |
| Lower central incisor | 17.30 | 3.02 | GONIAL | 126.13 | 5.37 |
| Lower lateral incisor | 18.83 | 3.17 | OVERBITE | 3.47 | 2.57 |
| Lower canine | 25.09 | 3.46 | AFH | 114.91 | 7.57 |
| Lower first molar | 25.02 | 2.16 | PFH | 76.20 | 6.61 |

Table (2): gender difference of the root length

| Root no. | Gender | N | Mean | Std. Deviation | Independent sample test |
|---|---|---|---|---|---|
| Upper central incisor | Male | 24 | 25.74 | 2.58 | 0.201 |
| | Female | 51 | 25.05 | 2.13 | |
| Upper lateral incisor | Male | 24 | 24.88 | 3.2 | 0.31 |
| | Female | 51 | 23.62 | 4.13 | |
| Upper canine | Male | 24 | 31.68 | 3.29 | 0.49 |
| | Female | 51 | 30.69 | 3.59 | |
| Upper first molar | Male | 24 | 24 | 2.62 | 0.323 |
| | Female | 51 | 23.3 | 2.07 | |
| Lower central incisor | Male | 24 | 18.03 | 2.22 | 0.027 |
| | Female | 51 | 16.94 | 3.29 | |
| Lower lateral incisor | Male | 24 | 20.03 | 2.43 | 0.081 |
| | Female | 51 | 18.26 | 3.33 | |
| Lower canine | Male | 24 | 25.84 | 3.16 | 0.227 |
| | Female | 51 | 24.73 | 3.56 | |
| Lower first molar | Male | 24 | 25.31 | 2.06 | 0.392 |
| | Female | 51 | 24.87 | 2.21 | |

Table (3): Descriptive statistics and comparison among the three groups.

| Root no. | Group | N | Mean | S. D | F - test | Sig. |
|---|---|---|---|---|---|---|
| Upper central incisor | High | 25 | 25.04 | 1.98 | 0.27 | 0.764 |
| | Low | 25 | 25.52 | 2.6 | | |
| | Normal | 25 | 25.27 | 2.3 | | |
| Upper lateral incisor | High | 25 | 23.54 | 3.55 | 1.01 | 0.369 |
| | Low | 25 | 24.93 | 3.24 | | |
| | Normal | 25 | 23.61 | 4.68 | | |
| Upper canine | High | 25 | 30.92 | 4.14 | 0.035 | 0.965 |
| | Low | 25 | 30.94 | 3.28 | | |
| | Normal | 25 | 31.16 | 3.17 | | |
| Upper first molar | High | 25 | 23.5 | 2.09 | 0.206 | 0.814 |
| | Low | 25 | 23.75 | 2.55 | | |
| | Normal | 25 | 23.34 | 2.2 | | |
| Lower central incisor | High | 25 | 16.45 | 3.02 | 3.674 | 0.03 |
| | Low | 25 | 18.56 | 2.93 | | |
| | Normal | 25 | 16.87 | 2.77 | | |
| Lower lateral incisor | High | 25 | 18.28 | 3.29 | 1.51 | 0.228 |
| | Low | 25 | 19.71 | 3 | | |
| | Normal | 25 | 18.49 | 3.13 | | |
| Lower canine | High | 25 | 24.25 | 3.43 | 2.423 | 0.096 |
| | Low | 25 | 26.27 | 3.46 | | |
| | Normal | 25 | 24.73 | 3.28 | | |
| Lower first molar | High | 25 | 24.64 | 1.89 | 0.581 | 0.562 |
| | Low | 25 | 25.27 | 2.24 | | |
| | Normal | 25 | 25.13 | 2.34 | | |

Table (4): LSD test for Lower central incisor root length.

| Root no. | LSD | | Mean difference | Sig. |
|---|---|---|---|---|
| Lower central incisor | high | low | -2.11200* | 0.013 |
| | high | normal | -0.4202 | 0.612 |
| | low | normal | 1.69180* | 0.044 |

Table (5): Correlation between root length and facial measurements.

| Root no. | | SNMP | BPA | SADDLE | ARTICULAR | GONIAL | AFH | PFH |
|---|---|---|---|---|---|---|---|---|
| Upper central incisor | Pearson Correlation | -0.096 | -0.087 | -0.052 | 0.047 | -0.103 | 0.096 | 0.18 |
| | Sig. | 0.413 | 0.457 | 0.656 | 0.689 | 0.378 | 0.413 | 0.122 |
| Upper lateral incisor | Pearson Correlation | -0.106 | -0.111 | -0.009 | -0.087 | -0.022 | 0.043 | 0.139 |
| | Sig. | 0.367 | 0.344 | 0.94 | 0.457 | 0.855 | 0.715 | 0.233 |
| Upper canine | Pearson Correlation | 0.019 | 0.078 | -0.054 | 0.015 | 0.016 | 0.185 | 0.156 |
| | Sig. | 0.872 | 0.505 | 0.644 | 0.9 | 0.894 | 0.112 | 0.182 |
| Upper first molar | Pearson Correlation | -0.028 | -0.001 | 0.007 | -0.042 | 0.059 | 0.041 | 0.082 |
| | Sig. | 0.814 | 0.991 | 0.955 | 0.72 | 0.613 | 0.728 | 0.482 |
| lower central incisor | Pearson Correlation | -.275* | -0.181 | -.263* | -0.091 | 0.05 | -0.091 | 0.212 |
| | Sig. | 0.017 | 0.12 | 0.023 | 0.435 | 0.67 | 0.439 | 0.068 |
| Lower lateral incisor | Pearson Correlation | -0.176 | -0.103 | -.254* | -0.065 | 0.129 | 0.037 | 0.225 |
| | Sig. | 0.13 | 0.381 | 0.028 | 0.577 | 0.269 | 0.753 | 0.053 |
| Lower canine | Pearson Correlation | -0.226 | -0.157 | -0.194 | -0.038 | -0.058 | 0.036 | .260* |
| | Sig. | 0.051 | 0.178 | 0.096 | 0.749 | 0.62 | 0.762 | 0.024 |
| Lower first molar | Pearson Correlation | -0.105 | -0.071 | -0.098 | 0.081 | -0.124 | 0.14 | 0.222 |
| | Sig. | 0.372 | 0.543 | 0.404 | 0.488 | 0.288 | 0.229 | 0.055 |

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