Interrelation between Cranial Base and Facial Heights of Two Age Groups (Cross-sectional Study Using Digital Cephalometric Radiograph)

Younis MS Hasan
BDS, MSc (Asst. Lec.)
Dept of Pedod, ortho, and Prev Dentistry
College of Dentistry, University of Mosul

ABSTRACT

Aims: The aim of this study is to detect the interrelation between the cranial base and the facial heights involving age and sex differences. Materials and Methods: The study was carried out on cephalometric of 63 subjects divided into two age groups: The first group including 36 subjects of 10–15 years and the second group including 27 subjects of 16–25 years, both groups of normal Cl.I molar occlusion with full set of permanent teeth. Lateral cephalometric radiograph were selected from computer of digital radiography system (Planmeca dimaxis version 3). Nine linear measurements three for cranial base and six for facial heights with one ratio posterior to anterior facial height were evaluated. Results: There were a significant increase in means of group 2 for each cranial base and facial heights measurements, also within each age group means for male samples showed a significant increase in comparison with those of females. Posterior to anterior facial heights ratios were involved in normal range for both age groups. In addition a significant positive correlation were found between most of cranial base measurements with those of facial heights. Conclusions: Positive interrelation may be existed between growth of cranial base and growth of facial heights structures.

Key words: Cranial base, Facial heights, Digital cephalometric.

INTRODUCTION

The cranial base floor is the foundation on which the human face develops and the dimension of the middle cranial fossa influences the relationship between nasomaxillary complex and mandible(1). Growth and development of the cranial base and the face are intimately related to each other, and has therefore been a focus of interest to many researchers(2). Orthodontic treatment itself may have some effects upon the growth of the face. A basic knowledge of the process of facial growth is essential for the clinical practice of orthodontist. Mandibular growth occurs as a result of periosteal activity and the alveolar processes develop vertically to keep pace with the eruption of teeth. and it is elongated by the growth of condylar cartilage, where its growth is expressed as a downward and forward displacement along with the anterior and posterior re-
The main growth sites in the base of the skull, sphenoccipital, intersphenoidal and sphenoethmoidal synchondrosis. The sphenoccipital synchondrosis does not close until approximately 20 years of age, so it is apparently regarded as the principal contributor to the elongation of the cranial base. The growth of nasomaxillary complex, was including sutural growth, apposition and resorption, cartilaginous growth of nasal septum, functional matrix and effect of periosteal and endosteal surfaces.

The orientation of circumferencial system was that sutural growth will result in the downward and forward movement of facial complex when compared with base of skull. Lateral cephalogram are used to study anteroposterior and vertical relations.

These can be either conventional or digital computed radiography system (CR) where the latter unlike the conventional one in which a filmless imaging system breaking it into electronic pieces presenting and storing the image using a computer.

The lateral digital cephalogram's advantages include: superior gray scale resolution, reduced patient exposure to x-rays, increased speed of image viewing, lower equipment and film costs, also increased time efficiency, improved patient education, easy storage, registration and retrieval of cephalometric values and tracings while the main disadvantage were the initial set-up cost of the digital system too much expensive.

Hence, the aim of this study is to detect the interrelation between the cranial base and the facial heights involving age and gender differences.

MATERIALS AND METHODS

A total of 5567 Iraqi patient attended from various regions of Mosul city were taking different digital radiographs. The study was carried out on the cephalometric radiographs of 63 subjects who were selected from computer of digital radiography system (Planmeca dimaxis version 3) including two age groups: the first age group—G1—(10–15) years included 36 subjects; 16 males and 20 females. This group characterized by adolescent growth spurt for both genders and the second age group—G2—(16–25) years included 27 subjects; 15 males and 12 females, while the latter group was considered as the extension of adult age group for both genders also. The inclusive criteria of selection for each subject were: Class I molars and canines relations; Competent lips (rest position); no orthodontic treatment; full set of permanent dentition in both jaws excluding third molars; normal over jet and over bite about 2–4mm and normal arrangement of dentition with no apparent dental or skeletal discrepancy; and finally no massive proximal caries or fractured anterior teeth.

The identifications of cephalometric points and corresponding lines of this study were made directly on computer of CR system for each subject, then linear measurements were made via special program (Dimaxis Planmeca Pro) which were supplied in this computer.

These lines including: Sella–nasion (SN) Represents the anteroposterior extent of the anterior cranial base. Sella–basion (S) or posterior cranial base which is a plane joining between sella and nasion point. Basion–nasion (BaN) or the depth of the cranial base, this distance measured between basion and nasion points. Total anterior facial height–TA (N–Me) which is the vertical distance from nasion to menton. Upper–anterior facial height–UA (N–ANS) which is the vertical distance from nasion to anterior nasal spine. Lower anterior facial height LA (ANS–Me) which is the vertical distance from anterior nasal spine to menton. Total posterior facial height–TP (S–Go) which is the vertical distance from center of sella torcica to gonion. Upper posterior facial height–UP(S–PNS) the length of the perpendicular line from posterior nasal spine on to the SN. Lower posterior facial height–LP (PNS–Go) which is the perpendicular line from the point gonion to the palatal plane. All these linear measurements are illustrated in Figure (1).
Figure (1): Linear measurements of cranial base and facial heights; SN: anterior cranial base; SBa: posterior cranial base; NBa: depth of cranial base; TA: (N–Me); total anterior facial height; UA: (N–ANS), upper anterior facial height; LA: (ANS–Me); lower anterior facial height; TP: (S–Go), total posterior facial height; UP: (S–PNS); upper posterior facial height; LP: (PNS–Go); lower posterior facial height.

Statistical Package for the Social Science (SPSS) program was used to analyze the data to obtain descriptive analysis (minimum, maximum, mean and standard deviation) of total samples and their male and females subdivisions and for both age groups. The ratio of posterior to anterior facial heights (TP/TA) which is the ratio of total posterior facial heights (SGo)×100 /total anterior facial heights (N–Me)\(^{(18)}\). Comparison between two samples within each age group or between them were determined using Students t–test at 0.05 level of significance and Pearson’s correlation coefficient analysis to explore the correlation between cranial base and facial height measurements.

RESULTS

The descriptive analysis of total, male and female samples of both groups were shown in Table (1) for cranial base measurements SN, SBa and NBa respectively, in Table (2) of total, male and female samples for anterior facial heights measurements TA, UA, LA respectively and in Table (3) of total, male and female samples for posterior facial heights measurements TP, UP and LP respectively. The results of t–test showed significant increase of mean for cranial base and anterior and posterior facial heights measurements of G2 with corresponding type and gender of G1as in Tables (1,2,3) respectively, as the mean of SN in G2 was significantly increase in comparison with SN in G1. In addition comparisons within each age group regarding genders showed significant increase of means for male samples of each cranial base and anterior and posterior facial heights measurements in comparison with those of females as in Tables (1,2,3) respectively, as mean of male UP was significantly increased in
comparison with female UP of same age group.

Table (1): Means and standard deviations for anterior, posterior and depth of cranial base of the total, male and female samples.

| Variables** | No. | Min. | Max. | SE   | Mean ± SD | t–value | p–value |
|-------------|-----|------|------|------|-----------|---------|---------|
| SNt1        | 36  | 62.34 | 70.23 | .3239 | 66.18±1.94 | 3.58    | <0.01*  |
| SNt2        | 27  | 64.72 | 68.93 | .2460 | 66.86±1.28 |         |         |
| SNm1        | 16  | 65.04 | 68.27 | .20721| 66.67±1.09 |         |         |
| SNf1        | 20  | 62.34 | 67.27 | .3818 | 65.15±1.71 | 3.39    | <0.01*  |
| SNm2        | 15  | 66.10 | 68.93 | .2672 | 67.55±1.03 | 3.21    | <0.01*  |
| SNf2        | 12  | 64.72 | 67.93 | .2917 | 65.99±1.01 |         |         |
| SNa1        | 16  |       |       |      | 66.67±1.09 | 2.49    | <0.05*  |
| SNa2        | 15  |       |       |      | 67.55±1.03 |         |         |
| SNf1        | 20  |       |       |      | 65.15±1.71 | 2.58    | <0.05*  |
| SNf2        | 12  |       |       |      | 65.99±1.01 |         |         |

*significant difference; ** Measurement of mean in millimeter unit for all types of variables; SD: standard deviation; SE: standard Error of means. SN: anterior cranial base; SBa: posterior cranial base; and NBA: depth of cranial base; t1 and t2: total sample (both male and female data) of first and second age group respectively; m1 and m2: male data of first and second age group respectively; f1 and f2: female data of first and second age group respectively.
Table (2): Means and Standard deviations for Anterior facial heights of the total, male and female samples.

| Variables** | No. | Min. | Max. | SE  | Mean** ± SD | t-value | p-value |
|-------------|-----|------|------|-----|-------------|---------|---------|
| TAt1        | 36  | 102.38 | 108.33 | .3216 | 105.45±1.93 | 21.10   | <0.01* |
| TAt2        | 27  | 110.00 | 115.84 | .3163 | 112.93±1.64 |         |         |
| TAm1        | 16  | 105.29 | 108.33 | .2829 | 106.89±1.13 |         |         |
| TAf1        | 20  | 102.38 | 106.91 | .3630 | 104.27±1.62 | 6.97    | <0.01* |
| TAm2        | 15  | 110.00 | 115.84 | .4072 | 113.75±1.58 |         |         |
| TAf2        | 12  | 110.71 | 113.82 | .3151 | 111.91±1.09 | 2.93    | <0.05* |

| Variables | No. | Mean ± SD | t-value | p-value |
|-----------|-----|-----------|---------|---------|
| TAm1      | 16  | 106.89±1.13 | 12.62   | <0.01* |
| TAm2      | 15  | 113.75±1.58 |         |         |
| TAf1      | 20  | 104.27±1.62 |         |         |
| TAf2      | 12  | 111.92±1.09 | 15.05   | <0.01* |

| Variables | No. | Min. | Max. | SE  | Mean ± SD | t-value | p-value |
|-----------|-----|------|------|-----|-----------|---------|---------|
| UAt1      | 36  | 45.00 | 49.84 | .2686 | 47.34±1.161 | 4.52    | <0.01* |
| UAt2      | 27  | 46.00 | 50.50 | .2667 | 48.89±1.39 |         |         |
| UAm1      | 16  | 46.13 | 49.84 | .3102 | 48.27±1.24 | 5.54    | <0.01* |
| UAf1      | 20  | 45.00 | 49.28 | .3372 | 46.60±1.51 | 2.48    | <0.05* |
| UAm2      | 15  | 46.00 | 50.50 | .3419 | 49.49±1.32 |         |         |
| UAf2      | 12  | 46.34 | 49.82 | .3158 | 48.13±1.09 | 3.55    | <0.01* |

| Variables | No. | Mean ± SD | t-value | p-value |
|-----------|-----|-----------|---------|---------|
| UAm1      | 16  | 48.27±1.24 | 4.25    | <0.01* |
| UAm2      | 15  | 49.49±1.32 |         |         |
| UAf1      | 20  | 46.60±1.51 |         |         |
| UAf2      | 12  | 48.13±1.10 | 3.55    | <0.01* |

| Variables | No. | Min. | Max. | SE  | Mean ± SD | t-value | p-value |
|-----------|-----|------|------|-----|-----------|---------|---------|
| LAt1      | 36  | 57.16 | 63.78 | .2799 | 60.32±1.68 | 16.14   | <0.01* |
| LAt2      | 27  | 63.10 | 69.47 | .3526 | 66.72±1.83 |         |         |
| LAm1      | 16  | 60.42 | 63.78 | .1959 | 61.51±.78 | 5.00    | <0.01* |
| LAf1      | 20  | 57.16 | 61.49 | .3592 | 59.37±1.61 | 2.34    | <0.05* |
| LAm2      | 15  | 65.00 | 69.44 | .3722 | 67.47±1.44 |         |         |
| LAf2      | 12  | 63.10 | 69.47 | .5448 | 65.79±1.89 | 2.34    | <0.05* |

| Variables | No. | Mean ± SD | t-value | p-value |
|-----------|-----|-----------|---------|---------|
| LAm1      | 16  | 61.51±.78 | 15.03   | <0.01* |
| LAm2      | 15  | 67.47±1.44 |         |         |
| LAf1      | 20  | 59.37±1.61 |         |         |
| LAf2      | 12  | 65.79±1.89 | 12.16   | <0.01* |

*Significant difference; **Measurement of mean in millimeter unit for all types of variables; SD: standard deviation; SE: standard Error of means. TA: total anterior facial height; UA: upper anterior facial height; LA: Lower anterior facial height; t1 and t2: total sample (both male and female data) of first and second age group respectively; m1and m2: male data of first and second age group respectively; f1 and f2: female data of first and second age group respectively.
Table (3): Means and Standard deviations for Posterior facial heights of the total, male and female samples.

| Variables** | No. | Min. | Max. | SE  | Mean ± SD | t-value | p-value |
|-------------|-----|------|------|-----|-----------|---------|---------|
| TPt1        | 36  | 63.94| 69.89| .3308| 67.44±1.98|         |         |
| TPt2        | 27  | 70.39| 74.33| .2588| 72.63±1.34|         |         |
| TPm1        | 16  | 66.56| 69.89| .2216| 68.86±1.89|         |         |
| TPf1        | 20  | 63.94| 69.83| .4248| 66.31±1.90|         |         |
| TPm2        | 15  | 71.00| 74.15| .2775| 73.16±1.07|         |         |
| TP2         | 12  | 70.39| 74.33| .4005| 71.96±1.39|         |         |
| TPt1        | 16  |      |      |      | 68.86±1.89| 13.47   | <0.01*  |
| TPm2        | 15  |      |      |      | 73.16±1.07|         |         |
| TPf1        | 20  |      |      |      | 66.31±1.90|         |         |
| TP2         | 12  |      |      |      | 71.96±1.39| 11.74   | <0.01*  |
| UPt1        | 36  | 37.64| 43.73| .2593| 41.50±1.56| 6.17    | <0.01*  |
| UPt2        | 27  | 41.45| 46.34| .2787| 43.55±1.45|         |         |
| UPM1        | 16  | 41.43| 43.73| .1826| 42.34±1.73|         |         |
| UPF1        | 20  | 37.64| 43.69| .3845| 40.82±1.72| 4.98    | <0.01*  |
| UPM2        | 15  | 42.00| 46.34| .3740| 44.13±1.45|         |         |
| UPF2        | 12  | 41.45| 45.02| .3211| 42.82±1.11| 2.24    | <0.05*  |
| UPM1        | 16  |      |      |      | 42.34±1.73| 3.58    | <0.05*  |
| UPM2        | 15  |      |      |      | 44.13±1.45|         |         |
| UPF1        | 20  |      |      |      | 40.82±1.72| 5.01    | <0.01*  |
| UPF2        | 12  |      |      |      | 42.82±1.11|         |         |
| LPt1        | 36  | 33.25| 38.92| .2688| 36.89±1.61| 6.24    | <0.01*  |
| LPt2        | 27  | 37.25| 43.00| .3046| 39.54±1.58|         |         |
| LPM1        | 16  | 35.89| 38.87| .2191| 37.79±1.88|         |         |
| LPF1        | 20  | 33.25| 38.92| .3850| 36.17±1.72| 3.50    | <0.01*  |
| LPM2        | 15  | 37.25| 43.00| .4290| 40.11±1.66|         |         |
| LPF2        | 12  | 37.35| 41.18| .3427| 38.83±1.19| 2.25    | <0.05*  |
| LPM1        | 16  |      |      |      | 37.79±1.88| 5.18    | <0.001* |
| LPM2        | 15  |      |      |      | 40.11±1.66|         |         |
| LPF1        | 20  |      |      |      | 36.17±1.72|         |         |
| LPF2        | 12  |      |      |      | 38.83±1.19| 4.93    | <0.001* |

* Significant difference; ** Measurement of mean in millimeter unit for all types of variables; SD: standard deviation; SE: standard Error of means; TP: total posterior facial height; UP: upper posterior facial height; LP: Lower posterior facial height; t1 and t2: total sample (both male and female data) of first and second age group respectively; m1 and m2: male data of first and second age group respectively; f1 and f2: female data of first and second age group respectively.
The findings of the ratios of total posterior facial heights to the total anterior facial heights of the total, male and female samples were within the normal range. There were no significant differences of these ratios between age groups as in Table (4). The findings of Pearson's correlation coefficient analysis showed a significant positive correlation of total SN of G1 with total SN of G2 and with anterior and posterior of upper, lower and total facial heights measurements of G1. While total SN of G2 showed a significant positive correlation with LA, UP, LP and TP of G1 and with UA, TA and TP of G2. While Male SN of G1 showed a significant negative correlation with LP of G2. On the other side, female SN of G1 showed a significant positive correlation with (anterior and posterior) of (upper, lower and total) facial heights measurements of G1. Female SN of G2 showed a significant positive correlation with female UP of G1 only as in Table (5).

Table (4): the ratio of total posterior facial heights to total anterior facial heights of the total, male and female samples.

| Variables*     | Mean ± SD | t-value | p-value |
|----------------|-----------|---------|---------|
| TPt1/TAt1      | 63.97±1.56| 1.38    | > 0.05**|
| TPt2/TAt2      | 64.32±1.34|         |         |
| TPm1/TAm1      | 64.42±0.88| 1.19    | > 0.05**|
| TPf1/TAf1      | 63.61±1.89|         |         |
| TPm2/TAm2      | 64.34±1.43| 1.14    | > 0.05**|
| TPf2/TAf2      | 64.30±1.28|         |         |

*Variables mean were measured in millimeter unit; **Not significant; SD: standard deviation; TP: total posterior facial height; TA: total anterior facial height; t1 and t2: total sample (both male and female data) of first and second age group respectively; m1 and m2: male data of first and second age group respectively; f1 and f2: female data of first and second age group respectively.

Table (5): Correlation Coefficient for Anterior Cranial Base versus Facial Heights

**Correlation regarding total Measurements**

| Variables     | UA1       | LA1       | TA1       | UP1       | LP1       | TP1       | SN1       | UA2       | LA2       | TA2       | UP2       | LP2       | TP2       |
|---------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| SNt1          | .604**    | .777**    | .729**    | .627**    | .716**    | .668**    | .484*     | .165      | .148      | .197      | .127      | .042      | .195      |
| SNt2          | .290      | .422*     | .289      | .413*     | .479*     | .462*     | .389*     | .322      | .404*     | .263      | .051      | .459*     |

**Correlation regarding male group**

| Variables     | UA1       | LA1       | TA1       | UP1       | LP1       | TP1       | SN1       | UA2       | LA2       | TA2       | UP2       | LP2       | TP2       |
|---------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| SNm1          | .422      | .046      | .474      | .317      | -.341     | .256      | .055      | .169      | -.254     | -.044     | -.015     | -.536*    | -.013     |
| SNm2          | .405      | .180      | .062      | .381      | -.080     | -.441     | .430      | -.129     | .256      | -.117     | -.206     | -.005     |           |

**Correlation regarding Female group**

| Variables     | UA1       | LA1       | TA1       | UP1       | LP1       | TP1       | SN1       | UA2       | LA2       | TA2       | UP2       | LP2       | TP2       |
|---------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| SNf1          | .532*     | .854**    | .632**    | .519*     | .734**    | .684**    | .556      | -.206     | .442      | -.143     | .312      | -.219     | .369      |
| SNf2          | .275      | .387      | .422      | .822**    | .467      | .373      | -.364     | .340      | -.234     | .115      | -.433     | .524      |           |

*Correlation is significant at the p ≤ 0.05; ** Correlation is significant at the p ≤ 0.01; SN: anterior cranial base; t1 and t2: total sample (both male and female data) of first and second age group respectively; m1 and m2: male data of first and second age group respectively; f1 and f2: female data of first and second age group respectively.
On the other side the findings of Table (6) showed significant positive correlation of total SBa of G1 with LA, TA, and LP of G1, while total SBa of G2 showed a significant positive correlation with LA of G1 only and TA and UP of G2. The male SBa of G1 and G2 showed a non significant different positive and negative correlation with facial heights measurements. While, the female SBa of G1 showed a significant negative correlation with female LA of G2 only.

| Correlation regarding total Measurements | UA1 | LA1 | TA1 | UP1 | LP1 | TP1 | SN12 | UA2 | LA2 | TA2 | UP2 | LP2 | TP2 |
|-----------------------------------------|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|-----|-----|-----|
| SBat1                                   | .308 | .335* | .525** | .282 | .341* | .287 | .064 | -.055 | -.143 | .041 | -.027 | -.282 | .063 |
| SBat2                                   | .263 | .430* | .278 | .199 | .357 | .274 | .287 | .181 | .368 | .403* | .559** | .304 | .333 |

| Correlation regarding male group         | UAm1 | LAm1 | TAM1 | UPm1 | Lpm1 | TPM1 | SNm2 | UAm2 | LAm2 | TAM2 | UPm2 | Lpm2 | TPM2 |
|------------------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| SBam1                                   | -.085 | .032 | -.098 | -.074 | -.045 | -.265 | -.447 | .216 | .145 | .170 | -.101 | .271 | .92  |
| SBam2                                   | .020 | .196 | -.198 | -.397 | -.164 | .486 | .287 | .108 | .167 | -.001 | .413 | -.241 | .204 |

| Correlation regarding Female group       | UAf1 | LAf1 | TAf1 | UP1 | LP1 | TP1 | SN12 | UAf2 | LAf2 | TAf2 | UP2 | LP2 | TP2 |
|------------------------------------------|------|------|------|-----|-----|-----|------|------|------|------|-----|-----|------|
| SBaf1                                   | -.026 | -.175 | .233 | -.052 | .039 | -.234 | .290 | -.037 | -.587* | -.275 | .246 | -.280 | -.234 |
| SBaf2                                   | .411 | .479 | .546 | .171 | .425 | .230 | .287 | -.217 | .232 | .299 | .436 | .366 | .054 |

*Correlation is significant at the \( p \leq 0.05 \); **Correlation is significant at the \( p \leq 0.01 \); SBa: posterior cranial base; t1 and t2: total sample (both male and female data) of first and second age group respectively; m1 and m2: male data of first and second age group respectively; f1 and f2: female data of first and second age group respectively.

Lastly, the findings of Table (7) showed a significant positive correlation of total NBa of G1 with all total anterior and posterior facial heights measurements of G1 and just LA of G2.

While total NBa of G2 showed a significant positive correlation with all total anterior and posterior facial heights measurements of G2. The male NBa of G1 showed a significant positive correlation with just male LP of G1. Finally female NBa of G1 showed a significant positive correlation with female UA, LA, TA, LP and TP of G1.
**DISCUSSION**

The findings indicated that samples of cranial base SN, SBA, NBA and facial heights linear measurements TA, UA, LA, TP, UP and LP of total, male and female types were significantly increase with age. These were agreed with study of Swennen (14) who found that cranial base–related landmarks such as Sella and Nasion are not absolutely fixed and can be changed during growth. Rakosi (18) determined the mean annual growth rate from age 1 to 18 years, he showed about 3/4 mm of annual increase for S–N and various growth rates for different craniofacial measurements. Moldez (19) showed clinically the developmental processes, especially from puberty to adulthood, are major considerations in orthopedic, orthodontic, and orthognathic surgical planning.

Profitt (20) showed an increase in facial height and concomitant eruption of teeth continue throughout life, but the decline to adult level often does not occur until the early twenties in boys, somewhat earlier in girls. In addition within each age group, the means of male samples of these craniofacial measurements showed significant increases in comparison with those of females, these gender variations probably occur, because males grow at faster rates and over a longer period of time than females, this agreed with Henneberke (21) who found size differences between boys and girls were largely established before 7 years of age and increased after 10.5 years of age, this is especially for the distances S–N and N–Ba and length of the distance S–Ba increases slowly, but constantly, until early adulthood 17 years for both boys and girls. Marshall’s (22) study on adolescent girls and Bishara’s (22) longitudinal study between 5–25 years of age agreed with these gender variations. Also, the same findings were shown in studies of SN by Johannsdottir (23), Bishara (24), Woodworth (25), Afifi (26), Gasgoos (27) and Paulsson (28), also Sossa’s study (29) on SN and SBA. Contrary to this Kerr (17) showed no significant differences in normal class I for NBA. But for N–ANS and S–PNS the results agreed with studies of Biggerstaff (30).

Study on Greek and American Caucasians by Argyropoulos (31) also agreed for N–ANS and S–PNS. Finally for N–ANS the findings agreed with Flynn’s (32) study on American Black and White samples, Park’s (33) study on Koreans and Bascifti (34).

The findings of the ratio of total posterior facial heights to total anterior facial heights of the total, male and female samples were within normal mean value and...
their comparisons showed no significant differences within or between age groups. The results agreed with the study of Rakosi (18) who reported that the mean value for posterior to anterior facial height is 62–65%. Issacson (26) reported that the changes related to the facial growth are also the result of differences in the anterior and posterior facial heights development.

The total SN of G1 gave rise significant positive correlation with the total SN of G2. This accepted by Mitchel (31) and Sejersen (36) as the sphenoccipital synchondrosis of cranial base does not close until approximately 20 years of age. So, it apparently the principal contributor of the elongation of the cranial base and as suture position anterior to TMJ, but posterior to anterior cranial fossa, so it influences significantly the overall facial skeletal pattern. In addition total SN of G1 showed a significant positive correlation with facial heights measurements TA, UA, LA, TP, UP and LP of G1. This approved by the study of Henneberke (2) where Growth of the anterior part of the cranial base is still necessary after the brain has virtually ceased to grow, at 7 to 8 years, to allow for facial growth. The greatest amount of which is still to come. Also the study of Afifi (26) showed that the SN significantly and positively influence UA and Kasai’s (35) studied the variation in anterior cranial base was associated with the difference in anterior facial height and lower anterior facial height. Male SN of G1 showed a significant negative correlation with male LP of G2, while female SN of G2 showed a significant positive correlation with female UP of G1 only. This disagrees with Afifi’s (26) study who showed SN significant and negative influence UP. The total SBA of G1 gave rise significant positive correlation with LA, TA and LP of G1, while total SBA of G2 showed a significant positive correlation with LA of G1 and TA and UP of G2. On the other side female SBA of G1 showed a significant negative correlation with female LA of G2 only. Hayashi (38) reported that this may be due to the anteroposterior position of the glenoid fossa in relation to the position of the maxilla. The length and inclination of the cranial base, which is related to Ba point, that might influence the position of the glenoid fossa. Therefore Andria (39) found an elongated cranial base would bring the glenoid fossa backward and place the mandible in retrusive position which make it rotate in downward and backward direction. The total NBa of G1 gave rise to the significant positive correlation with facial heights measurements of G1 TA, UA, LA, TP, UP and LP and just LA of G2. While total NBa of G2 showed a significant positive correlation with TA, UA, LA, TP, UP and LP of G2 only. Such positive correlation may be attributed to the association between the elongation of cranial base length NBa and the underlying maxillary complex and the position of glenoid fossa that influences their articulating mandibul development (3).

**CONCLUSIONS**

It can be concluded from this study that proceeding from adolescent to adult age group showed a significant increase for means of all craniofacial linear measurement, whether cranial base of anterior, posterior and depth or facial heights of anterior and posterior and of upper, lower and total measurements. In addition, means of male samples of all these measurements gave rise to the significantly higher values than those of female one. The ratios of posterior to anterior facial heights for total, male and female were within normal range of both groups. There were a non significant differences between them. Finally, there was a significant positive correlation between means of anterior, posterior and depth of cranial base with means of most of upper, lower and total measurements of both anterior and posterior facial heights that may refer to positive interrelation between growth of cranial base and growth of facial heights structures.

**REFERENCES**

1. Enlow D, McNamara JA. The neurocranial basis for facial form and pattern. *Angle Orthod.* 1973; 43: 256–270.
2. Henneberke M, Prahl–Andersen B. Cranial base growth for Dutch boys and girls: A multilevel approach. *Am J Orthod Dentofacial Orthop.* 1994; 106: 503–512.
3. Mitchell L, Carter NE. An Introduction to orthodontics. 2nd ed. Oxford University
Interrelation between Cranial Base and Facial Heights of Two Age Groups

press. 1998; Pp: 31–42.
4. Bishara SE. Textbook of orthodontics. W.B. Saunders Company. 2001; Pp: 43–53.
5. Sejrsen B, Jakobsen J, Skovgaard LT, Kjaer I. Growth in the external cranial base evaluated on human skulls using nerve canal opening as a reference. Acta Odontologica Scandinavica. 1997; 55: 356–364.
6. Bendes M, Hagg U, Rabie B. Growth and treatment changes in patients treated with a headgear–activator appliance. Am J Ortho Dentofacial Orthop. 2002; 121(4):376–84.
7. Scott JH. Dentofacial development and growth porgamon press.1967.
8. Graber TM, Vanarsdall BF. Orthodontics current principles and techniques. 3rd ed. The CV Mosby Co. 2000; Pp: 355–360.
9. Harrying JJ, Jansen L. Dental radiography: Principles and Techniques. The WB Saunders Co. 2000; Pp: 384–394.
10. Athanasiou AE. Orthodontic cephalometry. Mosby–Wolfe. 1995; Pp: 221–231.
11. Park I, Bowman D, Klapper L. A cephalometric study of Korean adults. Am J Ortho Dentofacial Orthop.1989; 96 (1): 54–59.
12. Ishii N, Deguchi T, Hunt NP. Craniofacial morphology of Japanese girls with CL II division I malocclusion. J Orthod. 2001; 28 (3): 211–215.
13. Wallis SF. Integration of certain variants of the facial skeleton in class II Division 2 Malocclusion. Angle Orthod. 1963; 33(1): 60–67.
14. Swennen GR, Schutysr F, Hausamen J. Three–Dimensional Cephalometry. A Color Atlas and Manual. Springer–Verlag Berlin Heidelberg. 2006; Pp: 100–106.
15. Courtney M, Hardness M, Herpison P. Maxillary and cranial base changes during treatment with functional appliances. Am J Ortho Dentofacial Orthop. 2001; 120 (3): 18–19.
16. Tsai HH. Cephalometric characteristics of bimaxillary dentofacial protraction in early mixed dentition. J Clin Pediat Dent. 2002; 26(4): 363–370.
17. Kerr WJ, Ford I. The variability of some craniofacial dimensions. Angle Orthod. 1991; 61(3): 205–210.
18. Rakosi T. An atlas and manual of cephalometric radiography. Wolfe Medical Pub-licat.1982; Pp: 55–65.
19. Moldez MA, Sato K, Sugawara J, Mitani H. Linear and Angular Filipino Cephalometric Norms According to Age and Sex. Angle Orthod. 2006; 76(5): 798–803.
20. Proftt WR, Fields HW, Sarver DM. Contemporary orthodontics. 4th ed. The CV Mosby Company. 2007; Pp: 27–35.
21. Marshall WA, Tanner JM. Variation in pattern of pubertal changes in girls. Arch Dis Child.1969; 44: 291–303.
22. Bishara SE, Petson L, Bishara, EC. Changes in facial dimensions and relationships between the ages of 5 and 25 years. Am J Ortho. 1984; 85 (3): 238–252.
23. Johannsdotir B, Thordarson A, Magnusson TE. Craniofacial morphology in 6–year–old Icelandic Children. Eur J Orthod. 1999; 21(3): 283–90.
24. Bishara SE, Jacobson JR. A longitudinal changes in three normal facial types. Am J Orthod. 1985; 88: 466–502.
25. Wood worth DA, Sinclair PM, Alexander RG. Bilateral congenital absence of maxillary lateral Incisors: A cranio–dentofacial deformities. Am J Orthod. 1985; 87 (4): 280–293.
26. Afifi HA. Variations of sella tursico position in different groups of anteroposterior Jaw relationship. Egyptian Ortho J. 1993; 7 (1): 57–64.
27. Gasgoos SSM. Three Dimensional Analysis of Naso maxillary complex of Iraq. Adults (18–25Years) in Mosul city with CI I Normal occlusion. MSc. Thesis. Mosul University. Iraq. 2000.
28. Paulsson L. The Angle Orthodontist: Craniofacial Morphology in Prematurely Born Children. Angle Orthod. 2008; 79(2): 276–283.
29. Sossa FA, Graber TM, Muller TP. Post pharyngeal lymphoid tissue in Angle class I and class II malocclusions. Am J Ortho Dentofacial Orthop.1982; April: 299–309.
30. Biggerstaff RH, Allen RC, Tuncay OC, Berkowitz J. A vertical cephalometric analysis of the human craniofacial complex. Am J Ortho.1977; 72 (4): 397–405.
31. Argyropoulos E, Sassouni V. Comparison of the dento–facial patterns for native Greek and American–Caucasian adolescents. Am J Ortho Dentofacial Orthop. 1989; 95 (3): 238–249.
32. Flynn TR, Ambrogi RI, Zeichnner S J.
Cephalometric Norms for Orthognathic surgery in Black American adult. *J Oral Maxillofac Surg*. 1989; 47: 30–39.

33. Park I, Bowman D, Klapper L. A cephalometric study of Korean adults. *Am J Ortho Dentofacial Orthop*. 1989; 96 (1): 54–59.

34. Basciftci FA, Uysal T, Buyukerkmen A. Craniofacial structure of Anatolian Turkish adults with normal occlusions and well balanced faces. *Am J Ortho Dentofacial Orthop*. 2004; 125 (3): 366–72.

35. Issacson RJ, Zapfed RJ, Worms FW, Erdman AG. Effects of rotational jaw growth on the occlusion and profile. *Am J Ortho Dentofacial Orthop*. 1977; 72: 276–286.

36. Sejrsen B, Jakobsen, J, Skovgaard LT, Kjaer I. Growth in the external cranial base evaluated on human skulls using nerve canal opening as a reference. *Acta Odontologica Scandinavica*. 1997; 55: 356–364.

37. Kasai K, Moro T, Kanazawa E, Iwasawa T. Relationship between cranial base and maxillofacial morphology. *Eur J Orthod*. 1995; 17:403–410.

38. Hayashi I. Morphological relationship between the cranial base and dentofacial complex obtained by reconstructive computer tomographic images. *Eur J Orthod*. 2003; 25: 385–391.

39. Andria LM, Leite LP, Prevatte TM, King LB. Correlation of the cranial base angle and its components with other dental/skeletal variables and treatment time. *Angle Orthod*. 2004; 74(3): 361–366.