# Cephalometric Study of Iraqi Adult Subjects with Cl I and Cl III Skeletal Relationships and Their Effects on Masseter Muscle Thickness by Using Ultrasonography

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## ABSTRACT

Background: Masseter muscle is one of the most obvious muscles of mastication and considered as one indicator of jaw muscle activity. It has a major influence on the transverse growth of the midface and the vertical growth of the mandible. This study undertaken to determine the role of cephalometric analysis for discrimination between Cl I and Cl III skeletal relationships, determine the role of ultrasonography in determination of masseter muscle thickness, compare masseter muscle thickness between Cl I and Cl III skeletal relationships, and determine the effect of gender on masseter muscle thickness.

Material and Method: The sample of the current study consisted of 70 Iraqi subjects 40 males and 30 females with age ranging 18-25 years. They were divided into 2 groups depending on ANB angle: class I skeletal relationship 20 males and 15 females and class III skeletal relationship 20 males and 15 females. The collected sample included patients attended for different diagnostic purposes to the Dental Radiology Department at College of Dentistry/Babylon University, standardized lateral cephalogram was taken to determine facial morphology, six angular and eight linear measurements were assessed. Masseter muscle thickness measured ultrasonography in Al-Hilla General Teaching Hospital/Ultrasonorgaphic Department, in relaxation and contraction conditions for both sides.

Results: Various parameters measured for males and females in each class and the comparison shown statistically significant differences between them ($P<0.05$). No difference in muscle thickness between right and left sides in the same class ($P>0.05$). Gender variation showed significant difference in masseter muscle thickness during rest and occlusion conditions ($P<0.001$).

Conclusion: Cephalometric analysis served to demonstrate the skeletal morphologies and provide a base for discrimination between class I and class III skeletal relationships. Ultrasonographic scanning is an important imaging procedure. It is reproducible and simple method for accurately measuring masseter muscle thickness. The ultrasonorgaphic study has revealed variations in masseter muscle thickness among individuals with different skeletal morphologies in each gender on one hand and between males and females in each skeletal class on the other hand.


Key words: Masseter muscle thickness, skeletal morphology, cephalometric analysis, ultrasonorgaphic scanning. (J Bagh Coll Dentistry 2016; 28(1):84-91).

## INTRODUCTION

Masseter muscle is one of the most obvious muscles of mastication since it is the most superficial and one of the strongest. It is a broad, thick, flat rectangular muscle (almost quadrilateral) on each side of the face, anterior to parotid gland [1].

Thickness of masticatory muscles (especially masseter) have been measured and correlated with variables of facial morphology. Muscle thickness has been considered as one indicator of jaw muscle activity [2]. The masticatory muscle thickness increases with age. Males have thicker masseter muscle when compared to females [3].

Masseter muscle thickness was measured because of the fact that in the group of masticatory muscles, the masseter muscle seems to represent the functional capacity of the masticatory apparatus and is said to have major influence on the transverse growth of the midface and the vertical growth of the mandible [4], and masseter muscle is a superficial muscle and can be easily recorded on ultrasonography. However, other muscles of mastication also contribute to the interaction between muscle and facial morphology, and their influence might have biased the relation found between the masseter muscle and facial morphology [2].

The ultrasonorgaphic studies revealed variations in masseter muscle thickness (both in the relaxed and the contracted state) among individuals with different skeletal morphologies. Significant positive correlations also observed between masseter muscle thickness and various craniofacial parameters [5].

Non-invasive imaging techniques such as computerized tomography, magnetic resonance imaging (MRI), and ultrasonography (US) enable measurements of the cross-section and thickness of human jaw muscles. The first imaging technique used for direct measurements of muscle size in living human subjects was ultrasonography [6]. Therefore, ultrasonography is used for muscle examination, especially for large superficial muscle groups [7].

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Ultrasound has no ionizing radiation, no known harmful effects at the energies and doses used, in addition the technique is widely available and inexpensive [2].

The image displayed on the screen has different densities in the black/white echoes and described as hypoechoic (dark) or hyperechoic (light)[9].

Ultrasound is an attractive modality for imaging muscle and tendon motion during dynamic tasks and can provide a complementary methodological approach for biomechanical studies in a clinical or laboratory setting, towards this goal, methods for quantification of muscle kinematics from ultrasound imagery are being developed based on image processing[10].

Cephalometric is the scientific measurement of the dimensions of the head; cephalic pertains to head, metric means measurements, and thus cephalometric radiograph means head measurement with the X-ray[11].

A cephalometric analysis identifies anatomical landmarks on the film measuring the angular and linear relationships between them. This numerical assessment can provide detailed information on the relationship of skeletal, dental and soft tissue elements within the craniofacial region[12]. That's why cephalometer is used to obtain standardized and comparable craniofacial images on radiographic films[13].

Antero-posterior skeletal relationships are commonly defined by the relationship of the maxilla and mandible to the cranium. Class I skeletal relationship defined as the condition of occlusion between maxilla and mandible in their normal antero-posterior relationship. Class III skeletal relationship defined as the condition of occlusion in which the mandible is placed in a relatively protrusive position[11,12].

The current study measures and compare masseter muscle thickness and craniofacial morphology in class I and class III skeletal relationships using cephalometric and ultrasonorgaphic investigation.

## MATERIALS AND METHODS

Prospective study of cephalometric radiographs and ultrasonorgaphic scans taken for 70 Iraqi subjects (40 males and 30 females) with age ranging (18-25 years) selected in the study sample, the collected sample included patients attended for different diagnostic purposes to the Dental Radiology Department at College of Dentistry/ Babylon University, standardized lateral cephalogram was taken to determine facial morphology, six angular and eight linear measurements were assessed. Masseter muscle thickness measured ultrasonography in Al-Hilla General Teaching Hospital/ Ultrasonorgaphic Department, in relaxed and contraction conditions for both sides.

**Distribution of Sample**

The subjects were divided according to the skeletal relationships into 2 groups:

Group A: Consists of 20 males and 15 females. The subjects in this group have skeletal class I relationship with ANB angle (2°-4°) and bilateral class I molar relationship based on Angle's classification, in which the mesiobuccal cusp of the maxillary first molar should occlude with the buccal groove of the mandibular first molar. The incisal relationship was normal overbite and overjet (2-4 mm).

Group B: Consists of 20 males and 15 females. The subjects in this group have skeletal class III relationship with ANB angle < 2° and bilateral class III malocclusion based on Angle's classification, in which the mesiobuccal cusp of the maxillary first molar lies posteriorly to the mesiobuccal groove of the mandibular first molar and the overbite and overjet of the anterior teeth were zero.

**The Inclusion Criteria of Sample Selection**

All subjects with skeletal class III relationship should have dental class III and the incisal relationship should have zero overbite and zero overjet, (edge to edge).

1. All the subjects should be free from extreme body mass index.
2. All the subjects are free from TMJ problems including rheumatoid arthritis and osteoid arthritis (Clinical and OPG Examinations).
3. All the subjects are free from cross bite, deep bite, reversed overjet, spacing, and crowding (clinically assessed by senior orthodontist).
4. No missing teeth (regardless the wisdom teeth).
5. No history of orthodontic treatment, orthopedic or facial surgical treatment.
6. No history of facial trauma or surgery.
7. No history of abnormal habits, bruxism and clinching.
8. All the subjects asked about chewing on bilateral sides, right and left, to exclude masseter muscle hypertrophy on the chewing side.

**Body Mass Index (BMI):**

BMI is composited of weight and height that represents a summary measurement of the distribution of corporal mass[14]. For each participant, the height (in centimeters) and the weight (in kilograms) were recorded. BMI was calculated using the equation **weight/height² (kg/m²)**. The entire participants have normal range 18.50 - 24.9.

**Methodology:**

**Patients' Preparation of Radiographs:**

The patients were prepared for the exposure by asking them to remove any spectacles, hearing aids, and personal jewelry such as ear rings, necklaces, and hairpins, these entire things may effect on the important anatomical landmarks like ear ring may cover the Articulare point.

The patient was positioned within the cephalostat as shown in (figure1) with vertical sagittal plane of the head, the Frankfort plane horizontal (determined visually) and the teeth were in centric occlusion, then using certain exposure factors for each gender (male and female) according to user manual.

**Figure1:Patient Position for Cephalometric Radiography.**

**Cephalometric Analysis:**

Every lateral cephalometric radiograph was analyzed by Auto CAD program 2010 to calculate the angular and linear measurements after magnification was corrected, after the measurements were saved on an excel sheet with their records in degrees for angular measurement and in millimeters for linear measurements.

**Linear Measurements Used in Cephalometric study [3] (Figure 2):**

1. Antigonial notch depth (AND):Mandibular notch depth, it represented a line drawn from Gonion to Menton, **(Go-Me)**.
2. Anterior lower facial height (ALFH):a line extended from Anterior nasal spine to Menton, **(ANS-Me).**
3. Anterior total facial height (ATFH):a line extended from Nasion to Menton, **(N-Me).**
4. Posterior total facial height (PTFH): a line extended from Silla to Gonion, **(S-Go).**
5. Jarabak ratio:represented a ratio between Posterior total facial height to Anterior total facial height, **(PTFH/ATFH)**.
6. Mandibular ramus height (MRH):a line extended from Condylion to Gonion, **(Cd-Go).**
7. Maxillary length (Max L):a line extended from point A to Pterygomaxillary fissure, **(A-Ptm).**
8. Mandibular length (Mand L): a line extended from Condylion to Gonion,**(Cd-Gn).**

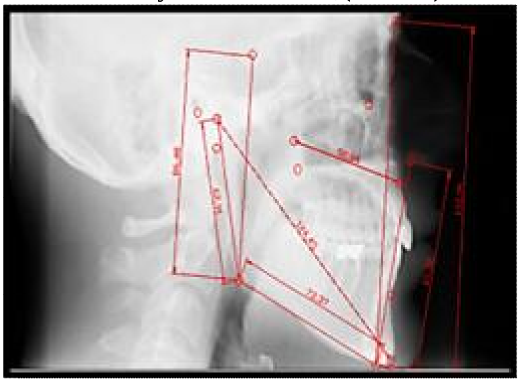

**Figure 2: Linear Measurements Obtained from Cephalometric Radiography.**

**Angular Measurements Used in Cephalometric study [3] (Figure2):**

1. SNA: The angle between a line joining Sella and Nasion (S-N) and a line joining Nasion and point A (N-point A).
2. SNB: The angle between a line joining Silla and Nasion (S-N) and a line joining Nasion and point B (N-point B).
3. Mandibular plane angle (MP angle): The angle between Mandibular plane (Go-Me) and Frankfort plane (Or-Po).
4. Upper gonial angle (Gonial U): The angle between a line joining the ascending ramus (Ar-Go) and a line joining the Nasion-Gonion.
5. Lower gonial angle (Gonial L): The angle between line joining Nasion-Gonion and mandibular plane (Go-Me).
6. Palatal plane/Mandibular plane angle (PP-MP angle): The angle between a line joining ANS-PNS and mandibular plane (Go-Me).
7. Saddle angle: The angle between anterior cranial base (N-S) and posterior cranial base (N-Ar).
8. Articular angle: The angle between posterior cranial base (S-Ar) and a line joining Articulare and Gonion (Ar-Go).

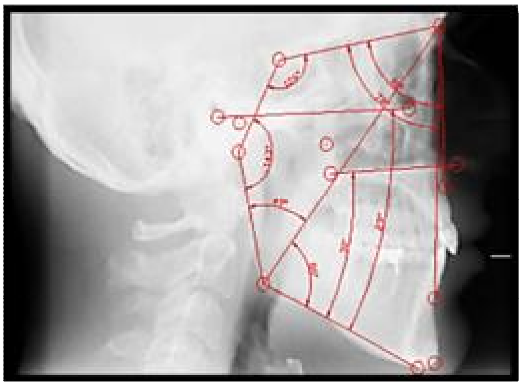

**Figure 3: Angular Measurements Obtained from Cephalometric Radiography.**

**<u>Patients' Preparation for Ultrasonographic Scanning:</u>**

The muscle thickness measured ultasonographically in millimeters by asking the participant to seat in a supine position and gently turns his/her head to expose the area we need to make the measurements.

A water-based gel was applied to the probe before the imaging procedure, then the transducer was held perpendicular to the surface of the skin and care was taken to avoid excessive pressure then apply the probe at a point representing the halfway between the zygomatic arch and gonial angle and this point represented the thickest part of the masseter muscle [2,5,11].

As shown in figures (4 and 5), the imaging and measurements were performed bilaterally under rest and maximum clinching conditions; when teeth are occluding gently with muscle in a relaxed condition and during maximal clenching with the masseter muscle contracted.

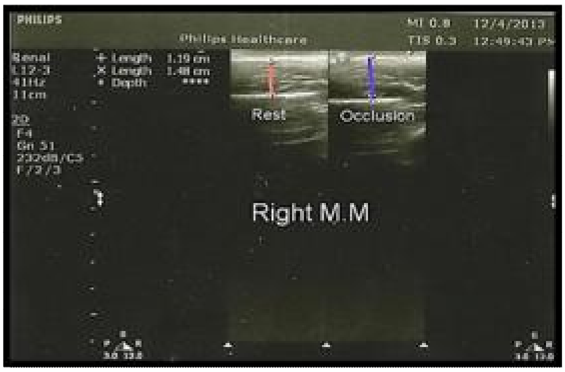


**Figure 4: Right Masseter Muscle Thickness Scanning, the Red Arrow Representing the Masseter Muscle Thickness (mm) under Rest Condition, the Blue Arrow Representing the Masseter Muscle Thickness (mm) under Occlusion Condition.**

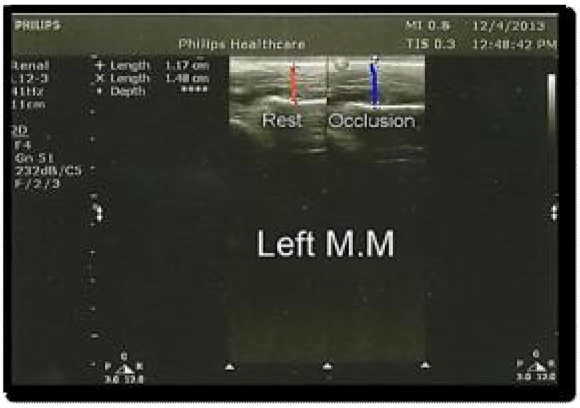


**Figure 5: Left Masseter Muscle Thickness Scanning, the Red Arrow Representing Masseter Muscle Thickness (mm) under Rest Condition, and the Blue Arrow Representing Masseter Muscle Thickness (mm) under Occlusion Condition.**

**<u>Statistical Analysis:</u>**

Data analysis was computer aided by using SPSS version 21 computer software (Statistical Package for Social Sciences).

# RESULTS

Table 1 shows the difference between skeletal class I and class III relationships in selected measurements stratified by gender. Various parameters measured for males and females in each class and the comparison shown statistically significant differences between them ($P<0.05$), except SNA°, upper gonial angle, saddle angle, articular angle, and maxillary length shown statistically non-significant differences between them ($P>0.05$).

Table 2 shows gender effect on selected measurements in each class. Gender variation shown statistically non-significant differences in angular measurements between males and females in the same class ($P>0.05$), while the linear measurements shown statistically significant difference between males and females in the same class ($P<0.05$).

Table 3 shows right to left side differences in masseter muscle thickness in each class. The results show no difference in muscle thickness between right and left sides in the same class ($P>0.05$).

Table 4 shows effect of occlusion compared to rest stratified by gender and class. Gender variation shows significant difference in masseter muscle thickness during rest and occlusion conditions ($P<0.001$).

Table 5 shows the effect of gender on masseter muscle thickness under rest and occlusion conditions in each class. The results show statistically significant difference in masseter muscle thickness for males and females during rest and occlusion conditions (P<0.05).

Table 6 shows the effect of skeletal relationships on masseter muscle thickness among males and females. The results show statistically significant differences in masseter muscle thickness in skeletal class I and class III relationships for males and females during rest and occlusion conditions (P<0.001).

**Table 1: Difference between Skeletal Class I and Class III Relationships in Selected Measurements Stratified by Gender**

| Variables | | Female (N = 15) | | | | Male (N = 20) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Cl I Mean | Cl III Mean | Cohen's d | P(T-test) | Cl I Mean | Cl III Mean | Cohen's d | P (t-test) |
| Angular Measurements (°) | SNA | 82.1 | 81.4 | 0.46 | 0.24[NS] | 82.3 | 81.7 | 0.4 | 0.37[NS] |
| | SNB | 78.9 | 81.2 | 1.47 | <0.001 | 79.1 | 81.4 | 1.25 | <0.001 |
| | FMPA | 25.9 | 21.1 | 2 | <0.001 | 25.9 | 23.1 | 1.42 | <0.001 |
| | Gonial U | 52.8 | 52 | 0.37 | 0.32[NS] | 52.1 | 52.6 | 0.2 | 0.58[NS] |
| | Gonial L | 71.7 | 73.5 | 1.65 | <0.001 | 72.1 | 74.4 | 2.66 | <0.001 |
| | PP-MPA | 24.4 | 21.1 | -2.86 | <0.001 | 24.8 | 21.5 | -2.21 | <0.001 |
| | N-S-Ar | 122.3 | 123.1 | 0.44 | 0.14[NS] | 122.8 | 123.6 | 0.46 | 0.16[NS] |
| | S-Ar-Go | 137.9 | 138.2 | 0.29 | 0.35[NS] | 137.6 | 138 | 0.2 | 0.75[NS] |
| Linear Measurements (mm) | AND | 71.4 | 78.9 | 2.3 | <0.001 | 75.5 | 80.6 | 1.8 | <0.001 |
| | ALFH | 70.7 | 67.1 | 1.84 | <0.001 | 73.7 | 70.7 | 2.1 | <0.001 |
| | ATFH | 124.8 | 120.4 | 2.17 | <0.001 | 130.5 | 126.8 | -1.9 | 0.008 |
| | PTFH | 78.8 | 83.8 | 3.5 | <0.001 | 87.5 | 92.4 | 1.45 | <0.001 |
| | J-ratio | 0.63 | 0.71 | 4 | <0.001 | 0.67 | 0.73 | 5 | <0.001 |
| | MAXL | 51 | 52.2 | 0.5 | 0.16[NS] | 53.9 | 56.6 | 0.58 | 0.83[NS] |
| | MANDL | 117.5 | 121.2 | 1.57 | <0.001 | 118.6 | 122.5 | 1.4 | <0.001 |
| | M Ramus H | 55.6 | 57.2 | 1.2 | <0.001 | 62 | 64.2 | 1.3 | <0.001 |

**Table 2: Gender Effect on Selected Measurements Stratified by Class**

| Variables | | Class I [N = 35] | | | | Class III [N = 35] | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Female [N = 15] Mean | Male [N = 20] Mean | Cohen's d | P(T-test) | Female [N = 15] Mean | Male [N = 15] Mean | Cohen's d | P (t-test) |
| Angular Measurements (°) | SNA | 82.1 | 82.3 | 0.12 | 0.68[NS] | 81.4 | 81.7 | 0.49 | 0.43[NS] |
| | SNB | 78.9 | 79.1 | 0.14 | 0.7[NS] | 81.2 | 81.4 | 0.46 | 1[NS] |
| | FMPA | 25.9 | 26.2 | 0.13 | 0.66[NS] | 22.8 | 23.1 | 0.56 | 0.15[NS] |
| | Gonial U | 51.8 | 52.1 | 0.12 | 0.78[NS] | 52 | 52.6 | 0.44 | 0.19[NS] |
| | Gonial L | 71.7 | 72.1 | 0.27 | 0.52[NS] | 73.5 | 74.4 | 0.56 | 0.09[NS] |
| | PP-MPA | 24.4 | 24.8 | 0.4 | 0.1[NS] | 21.1 | 21.5 | 0.46 | 0.1[NS] |
| | N-S-Ar | 122.3 | 122.8 | 0.46 | 0.08[NS] | 123.1 | 123.6 | 0.47 | 0.19[NS] |
| | S-Ar-Go | 137.8 | 137.6 | -0.29 | 0.89[NS] | 138.2 | 138 | 0.48 | 0.12[NS] |
| Linear Measurements (mm) | AND | 71.4 | 75.4 | 0.97 | 0.01 | 78.9 | 80.6 | 0.73 | 0.03 |
| | ALFH | 70.7 | 73.7 | 1.9 | <0.001 | 67.1 | 70.7 | 2.1 | <0.001 |
| | ATFH | 124.8 | 130.3 | 1.18 | <0.001 | 120.4 | 126.8 | 2.91 | <0.001 |
| | PTFH | 78.8 | 82.5 | 1.59 | <0.001 | 83.8 | 92.4 | 2.61 | <0.001 |
| | J-ratio | 0.63 | 0.67 | 2 | <0.001 | 0.70 | 0.73 | 3 | <0.001 |
| | MAXL | 51 | 53.9 | 0.9 | 0.003 | 52.2 | 56.6 | 1.4 | 0.03 |
| | MANDL | 117.5 | 118.6 | 0.98 | 0.002 | 121.2 | 122.5 | 1.2 | <0.001 |
| | M Ramus H | 55.5 | 62 | 1.58 | <0.001 | 57.2 | 68.2 | 2.84 | <0.001 |

Table 3: Right to Left Side Differences in MM Thickness Stratified by Classes

| Variables | Class I [N = 35] | | | Class III [N = 35] | | |
|---|---|---|---|---|---|---|
| | LT Side | RT Side | P(T-test) | LT Side | RT Side | P(T-test) |
| MM Thickness-Occlusion (mm) | 1.3 | 1.3 | 0.42[NS] | 1.46 | 1.46 | 0.29[NS] |
| MM Thickness-Rest(mm) | 1.09 | 1.09 | 0.45[NS] | 1.24 | 1.24 | 0.74[NS] |

Table 4: Effect of Occlusion Compared to Rest Stratified by Gender and Class

| Gender | Class I | | | | Class III | | | |
|---|---|---|---|---|---|---|---|---|
| | Rest | Occlusion | Cohen's d | P(T-test) | Rest | Occlusion | Cohen's d | P(T-test) |
| Female [N = 30] | 1.02 | 1.23 | 2.3 | <0.001 | 1.26 | 1.43 | 4 | <0.001 |
| Male [N = 40] | 1.11 | 1.3 | 2.7 | <0.001 | 1.22 | 1.49 | 4.5 | <0.001 |

Table 5: Effect of Gender on MM Thickness under Rest and Occlusion Conditions in Each Class

| Variable | Class I | | | | Class III | | | |
|---|---|---|---|---|---|---|---|---|
| | Female [N = 30] | Male [N = 40] | Cohen's d | P(T-test) | Female [N = 30] | Male [N = 40] | Cohen's d | P(T-test) |
| MM-Rest )mm( | 1.08 | 1.13 | 0.9 | 0.02 | 1.25 | 1.29 | 0.9 | 0.02 |
| MM-Occ )mm( | 1.29 | 1.36 | 1.3 | 0.01 | 1.39 | 1.45 | 1.2 | 0.03 |

Table 6: Effect of Skeletal Relationships on MM Thickness Stratified by Gender

| Variable | Female [N = 30] | | | | Male [N = 40] | | | |
|---|---|---|---|---|---|---|---|---|
| | Class I | Class III | Cohen's d | P(T-test) | Class I | Class III | Cohen's d | P(T-test) |
| MM-Rest )mm( | 1.07 | 1.26 | 2.2 | <0.001 | 1.11 | 1.22 | 2.1 | <0.001 |
| MM-Occ )mm( | 1.21 | 1.43 | 3.8 | <0.001 | 1.3 | 1.55 | 3.6 | <0.001 |

# DISCUSSION

**The difference between skeletal class I and class III relationships in selected measurements stratified by gender:**

From the results shown in table 1, we noticed that the mean value of SNA and SNB angles shown that the selection of subjects with class III skeletal relationship was built on the measurements of SNA and SNB angles. If we consider skeletal class I subjects as a control group and compare the result of SNA angle between skeletal class I and class III relationships show statistically non-significant difference (P>0.05), while the result of SNB angle between skeletal class I and class III relationships show statistically significant difference for both males and females (P<0.05), also the maxillary length (A-Ptm) for females and males in each class shown statistically non-significant differences (P>0.05), while the mandibular length (Cd-Gn) shows statistically significant difference for males and females in each class (P<0.05) that means the skeletal class III relationship in our study result from protruded mandible and normal length of the maxilla.

The effect of Jarabak ratio (Cohen's d test) in females was (4) and males was (5) shown a highly significant differences between class I and class III skeletal relationships because the posterior total facial height and anterior total facial height were statistically significant difference and had a strong effect (P<0.001).

**Gender effect on selected measurements stratified by class:**

From the results shown, all the linear measurements were significantly higher in males than females in each class. The craniofacial skeleton of males is larger in all linear dimensions than females[15]. This finding may be attributed to the fact that maturation is attained earlier in females than males with a longer growth period in males. Males had consistently larger values for linear dimensional variables, including anterior and posterior facial heights, mandibular length, and ramus height[16].

The angular measurements showed non-significant differences between males and females in each class.

**Right to left side differences in masseter muscle thickness in each class:**

The masseter muscle thickness was scanned for both sides under rest and occlusion conditions in class I and class III skeletal relationships showed statistically insignificant differences (P>0.05), this was because we excluded abnormal habits, bruxism, clinching, also subject sample are free from cross bite and crowding, and all subjects asked about chewing on bilateral sides, right and left, to exclude masseter muscle hypertrophy on chewing side.

**Effect of occlusion compared to rest stratified by gender and class:**

The masseter muscle thickness increased under occlusion compared to rest conditions among males and females, this explained by ***Huxley's sliding filament theory in 1954***, the key principle behind muscle contraction is the overlapping of the actin and myosin filaments. Sarcomeres represented the basic unit controlling changes in muscle length, within the sarcomere, myosin (thick filaments) slides along actin (thin filaments) to contract the muscle fiber in a process that requires ATP[3].

**Effect of gender on masseter muscle thickness under rest and occlusion conditions in each class:**

The masseter muscle thickness under rest and occlusion conditions among males much thicker compared to that for female, this was related to a large variation in masseter muscle thickness among individuals, during both relaxation and contraction conditions due to the fact that there are differences in the fiber-type and fiber-size composition of the masseter muscle. Various factors have been proposed to account for inter-individual variation in fiber-type composition of skeletal muscle. Some of these factors relate with the level of physical activity, genetic factors, and an influence of sex hormones[3]. Although the fiber profile of an individual muscle results from the influence of multiple factors as mentioned above, one of the most important factors contributing to the sex difference in masseter muscle fiber-type composition may be male and female sex hormones. In female masseter muscle, type I (slow-twitch) fibers constituted a larger percentage of cross-sectional area and number than in males. Whereas in the male masseter muscle, the cross-sectional area and number of type II (fast-twitch) fibers were larger than in the female masseter muscle[17]. Other factors which may be attributed to inter-individual variation are the racial, ethnic differences, and different dietary habits[2,3].

**Effect of skeletal relationships on masseter muscle thickness stratified by gender:**

The masseter muscle thickness increased in class III skeletal compared to class I skeletal relationships in both rest and occlusion conditions among males and females, this was because the effects of muscle thickness on bone morphology can be explained by ***Wolff's law***[3,4,5,18].This law states that "the internal structure and the shape of the bone are closely related to the bone's function and it also defines a relationship between the bone's shape and muscle function", so the thickness of masseter muscle affected by ramus height due to its attachment[2,5].

The mean ramus height among females with class III skeletal relationship was (57.2mm) compared to females with class I skeletal relationship (55.6mm) and the ramus height among males with class III skeletal relationship was (64.2mm) compared to males with class I skeletal relationship (62mm), we noticed that the ramus height in class III was higher than the ramus height in class I skeletal relationship. According to ***Wolff's law*** the muscle affected by ramus height, so that the thickness of masseter muscle will increase with increased ramus height[5].

Furthermore, the orientation of the masseter muscle fibers in Class III patients compared to the controls was found to be in a more forward direction, forming an obtuse angle with the Frankfort horizontal plane[19,20]. It has been suggested that the more upright the direction of the masseter muscle fibers (as in subjects with class III skeletal relationship) in relation to the Frankfort horizontal or functional occlusal planes, the greater the occlusal forces[19].

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