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The Morphometry of the Angle of Mandible and its Correlation with Age and Sex in the eThekwini Metropolitan Region: A Panoramic Study

Morfometría del Angulo de la Mandíbula y su Correlación con Edad y Sexo en la Región Metropolitana eThekwini: Un Estudio Panorámico

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SUMMARY: The angle of mandible is formed by the tangent line joining the posterior margin of the ramus and the base of the mandible. The angle of mandible has population-specific characteristics therefore; it is imperative to the field of forensic anthropology for age and sex determination. Literary reports regarding the use of the angle of mandible for age and sex determination vary, as some studies support it, while other studies have documented inefficiencies. Therefore, the aim of this investigation was to document the morphometry of the angle of mandible and to determine if a correlation between the angle of mandible, age and sex exists. Sixty four digital panoramic radiographs (n=128) of individuals between 16-30 years were morphometrically analysed using the Dicom Digital Imaging Software. The data was captured and analysed using the Statistical Package for Social Science (SPSS version 23.0). Despite females having a greater angle of mandible than males, no statistically significant correlation was found between the size of the angle of mandible and sex (p=0.088). The angle of mandible was observed to decrease with advancement of age, however only the 16-19 year age cohort displayed a statistically significant correlation with the size of the angle of mandible (p=0.006). Therefore, this study concluded that the angle of mandible may not be a useful indicator of sex, but may be a reliable indicator of age for individuals between 16-19 years in the eThekwini Metropolitan region.

KEY WORDS: Angle of mandible; Age; Sex; Mandible; Morphometry.

INTRODUCTION

The mandible is the second most durable bone of the body and is the most resilient in unfavourable conditions (Oettlé *et al*., 2009). The angle of mandible is formed by the tangent lines of the posterior border of the ramus and the base of the mandible (Drake *et al*., 2010; Leversha *et al*., 2016). It is an important landmark of the mandible and is commonly used in forensic science for age, race and sex identification (Upadhyay *et al*., 2012). However, controversy exists with regard to the use of the angle of mandible in forensic science, specifically in age and sex determination (Upadhyay *et al*.).

The literature revealed that the angle of mandible may be an accurate cephalometric tool for population-specific age and sex identification (Singh *et al*., 2015). Conversely, Oettlé *et al*. and Upadhyay *et al*. reported the angle of mandible to be an inefficient tool for the determination of age and sex, since there are countless factors that influence its development, viz. diet, dentition and population-specific characteristics.

Furthermore, the literature reviewed has documented that the size of the angle of mandible decreased from birth to adulthood and increased from adulthood to old age (Schuenke *et al*., 2004; Lipski *et al*., 2013). On the contrary, Leversha *et al*. reported a steady increase in the size of the angle of mandible with advancement in age.

In South Africa, the crime rate is continuously increasing (Crime Stats, 2017) with 17805 individuals

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murdered in 2015, consequently resulting in a large quantity of unidentified bodies recovered each year (Franklin *et al*., 2008a). The use of standard anthropological measurements of the angle of mandible may play a significant role in identifying unknown remains (Kitai *et al*., 2013). Furthermore, there are a few studies conducted on the angle of mandible and none of which were previously reported in the eThekwini Metropolitan region.

Therefore, the aim of this study was to determine the morphometry of the angle of mandible and its correlation with age and sex (if any) in the eThekwini Metropolitan region.

MATERIAL AND METHOD

Sixty-five digital panoramic radiographs of a South African Black population aged between 16-30 years were measured using the MicroDicom Digital Viewer (091-win-32). 34 males and 30 female radiographs were categorized into 3 intervals: 16-19 years old, 20-25 years old, and 26-30 years old. The radiographs were obtained from the Radiological data bank at Clinical Anatomy, University of KwaZulu-Natal (Westville campus). Ethical clearance was obtained (LMMSEC 002/16).

The selection criteria were:

Inclusion criteria

· Patients between the ages of 16-30 years that have no history of trauma, with a complete medical record and full dentition

Exclusion criteria

· Panoramic radiographs that are not clear, patients that had mandibular and facial surgery or fractures to the jaws, as well as patients with oligodentia, systematic diseases or metabolic bone diseases

Morphometric Analysis. The morphometric parameters utilized in this study were adapted from Leversha *et al*. and measured using the MicroDicom (091-win32) digital software:

· Ramus line (RL) was measured from the posterior border of the condylar process of the mandible, along the posterior margin of the ramus to the edge of the inferior margin of the ramus (Plate 1).
· Mandibular line (ML) was the line drawn anteriorly along the inferior margin of the body of the mandible through the gnathion, which is the middle point on the base of the mandible in the sagittal plane (Plate 1).
· Angle of mandible (GA) was measured at the intersection of the RL and ML (Plate 1).

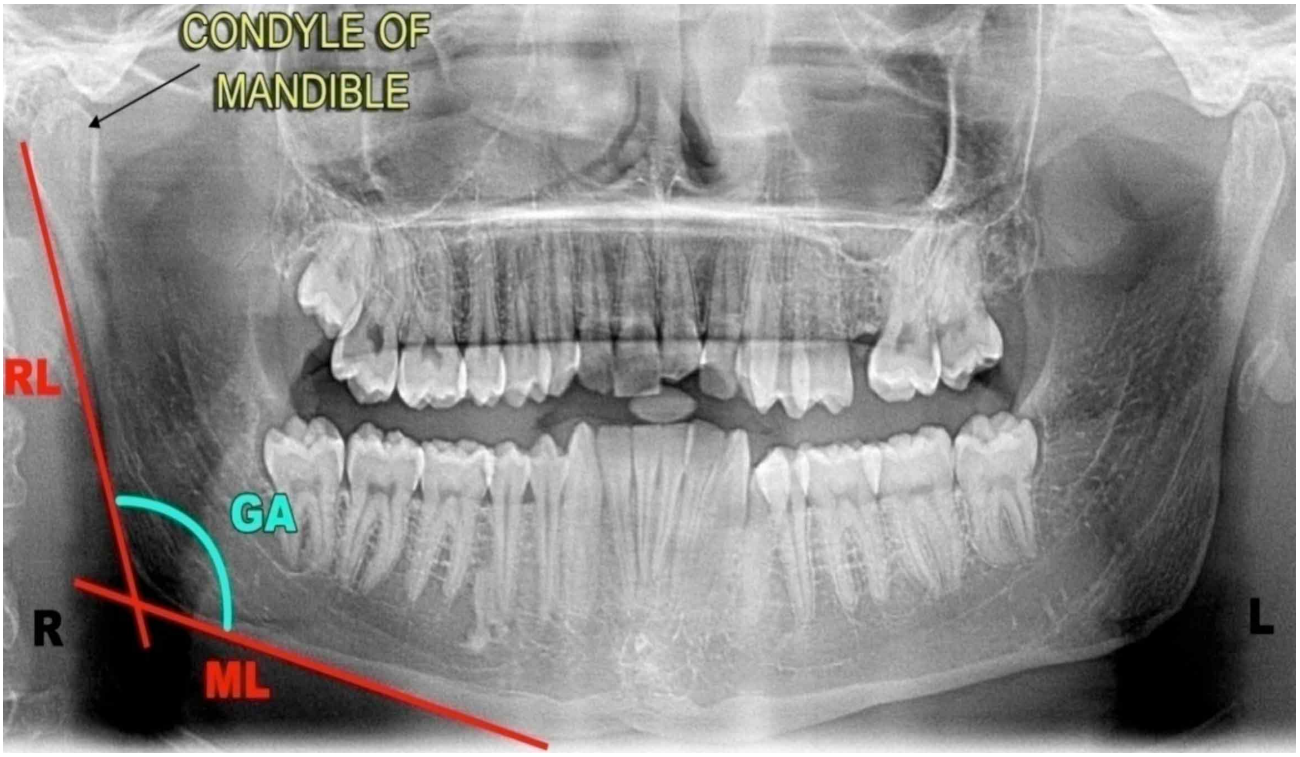

Fig. 1. Measurements of the angle of mandible on a panoramic radiograph x-ray of the mandible. Key: RL: Ramus line, ML: Mandibular line; GA: Angle of mandible; R: Right; L: Left

Statistical Analysis. The data was captured and analyzed using the Statistical Package for Social Sciences (SPSS version 23.0) software. The Pearson Product Moment Correlation Coefficient Test was used to determine if a correlation exists between the angle of mandible and age, as well as the angle of mandible and sex. The Intra-Class Correlation Coefficient test was then employed to assess the inter-observer reliability (Cicchetti *et al*., 1994). A p-value of less than 0.05 was considered to be statistically significant.

RESULTS

Angle of mandible versus age. The size of the angle of mandible decreased with advancement in age from 121.63º to 120.57º (Table I). No statistical significance was observed between the size of the angle of mandible and age (p=0.487).

Age: 16-19 years. In the 16-19 year age cohort, the angle of mandible was slightly greater in females, with a mean angle of 121.81°, while in males it was recorded to be 121.37°. A statistically significant relationship between size of angle of mandible and the 16-19 year age cohort was recorded (p<0.006) (Table I).

Age: 20-25 years. In the 20-25 year age cohort, the size of the angle of mandible was 122.23° and 119.92° in females and males, respectively. No statistical significant difference was recorded between this age cohort and the size of angle of mandible (p=0.096) (Table I).

Age: 26-30. The mean angle of mandible measured 123.16° and 117.70° in females and males, respectively. No statistically significant relationship between the size of the angle of mandible and 26-30 age cohort was recorded (p=0.194) (Table I).

Table I. Mean angle of mandible for males and females between 16-30 years of age (in °).

Sex	Age Cohort (years)		
	16-19	20-25	26-30
Mean male angle of mandible	121.81	119.92	117.71
Mean female angle of mandible	121.37	122.23	123.16
Both	121.63	120.87	120.57
Value(angle of mandible v/s age)	*p=0.006*	*p=0.096*	*p=0.194*

Table II: Mean angle of mandible for males and females (in°).

Patients	Total sample size	Mean age (years)	Mean angle of mandible with SD (in º)
Males	34	22.85	119.65± 7.88
Females	30	23.75	122.40 ± 4.52

Angle of mandible versus sex. The mean angle of mandible in males and females measured 120.94º. Females reported a greater angle of mandible than males, with a mean angle of mandible of 122.40º and 119.65º, respectively (Table II). Despite these differences, no statistically significant difference was noted between the size of angle of mandible and sex (p=0.088).

Reliability and validity. A second observer morphometrically analyzed 12 random digital panoramic radiographs using the MicroDicom (091-win32) digital software. The Intra-Class Correlation Coefficient test was then employed to assess the inter-observer reliability. A 0.989 significance for the mean angle of mandible between both observers was found, which donates excellent agreement (max=1) (Cicchetti *et al*.). These findings are in agreement to Oettlé *et al*. who reported an Intra-Class Correlation Coefficient of 0.944.

DISCUSSION

Angle of the mandible and age. In the present study, the mean angle the mandible was 121.03º, which correlated closely with the Lebanese, South African White, Jordanian and Australian population groups (Table III). However, the Indian population group reported the largest angle of mandible with a mean angle of 130.50º (Table III). Furthermore, despite differences in the size of the angle of mandible in the different age cohorts, no correlation between the size of the angle of mandible and age were observed in this study (p=0.487). These results were in accordance with Oettlé *et al*. who investigated the South African Black population in the Tshwane metropolitan region. However, it differed from the study conducted by Leversha *et al*., who reported a statistical significance between age and the size of angle of mandible. However, when the size of the angle of mandible was correlated to each age cohorts, this study observed a statistically significant correlation between the 16-19 year age cohort and age (p<0.006). However, the present study was the first to document such a correlation. The aforementioned differences could be due to dietary differences, as well as local population-specific

differences, however this was out of the scope of this study (Franklin *et al*., 2008b). Furthermore, these differences may be due to the sample size of this study.

This study also noted a trend between the size of the angle of mandible and age viz. the size of the angle of mandible decreased with advancement of age. This concurred with the findings of Upadhyay *et al*. in an Indian population. However, Al-Shamout *et al*. (2012) and Leversha *et al*. reported conflicting results, as they reported that the size of the angle of mandible increased with advancement of age in Jordanian and Australian populations, respectively.

Possible reasons for these differences may be due to craniometrical differences, which may have resulted from the evolutionary processes in different continents therefore this may contribute to population-specific differences (Oettlé *et al*.). Furthermore, genetic variation, climate, dietary habits and nutrition may also contribute to population-specific differences (Poongodi *et al*., 2015). South Africa is a multi-racial country, therefore the sub-population groups within South Africa may have their own oestometric standards. This may account for the discrepancy that arises when the current study was compared to other South African literature (Franklin *et al*., 2008b).

Angle of the mandible and sex. In the present study, the female angle of mandible was observed to be greater than male. However, Ayoub *et al*. (2009) and Gamba *et al*. (2016) reported that males had a greater angle of mandible than their counterparts in Lebanese and Brazilian populations, respectively (Table IV). This study reported no statistically significant correlation between the angle of mandible and sex. This finding concurred with Oettlé *et al*. who conducted a study on the Black South African population in a Tshwane metropolitan area, as well as Al-Shamout *et al*. in a Jordanian population. However, Huumonen *et al*. (2010), in a Finnish population and Leversha *et al*. in an Australian population reported a significant correlation between the size of the angle of mandible and sex. These sex differences may be due to genetic variation, as the male mandible persists in growth after puberty in comparison to females (Franklin *et al*., 2008b). Furthermore, masseter force may also play a role in genetic differentiation, as males have a greater masseter force which reduces the size of the angle of mandible, thus resulting in a smaller angle of mandible in males than females (Ayoub *et al*.).

In addition, this study observed that the angle of mandible was 119.65º in males. This concurred with the South African study conducted by Oettlé *et al*., who found a mean angle of mandible of 118.75º. However, Upadhyay *et al*. reported a mean angle in males of 132.0º in the Indian population group, which was 12.35º greater than the present study. In this study, the size of the angle of mandible in females was 122.40º, this concurred with the White South African population, who had mean angle of mandible of 122.48º (Oettlé *et al*.). However, Upadhyay *et al*. reported a greater mean angle of mandible than the current study of 129.0º for females in an Indian population (Table IV).

A possible explanation for this occurrence may be due to

Table III. Mean angle of mandible of different population groups (in °).

Author	Year	Population	Age (years)	Mean GA
Ayoub *et al.*	2009	Lebanese	17-26	121.38
Oettlé *et al.*	2009	South African White	M = 38-91 F= 21-97	120.13
Oettlé *et al.*	2009	South African Black	M= 23-98 F= 24-80	120.64
Shahabi *et al.*	2009	Iranian	15-30	124.17
Al-Shamout	2012	Jordanian	20-29	123.04
Upadhyay *et al.*	2012	Indian	17-35	130.50
Leversha *et al.*	2016	Australian	18-29	123.24
Current study	2016	South African Black	16-30	121.03

Table IV. Angle of mandibles of males and female of different population groups (in°).

Author	Year	Population	Age (years)	Male	Female
De Villiers	1968	South African Black	-	120.60	125.00
Ayoub *et al.*	2009	Lebanese	17-26	121.76	121.00
Shahabi *et al.*	2009	Iranian	15-30	123.68	124.39
Oettlé *et al.*	2009	South African Black	M=23-98 F=24-80	120.11	121.17
Oettlé *et al.*	2009	South African White	M=38-91 F=21-97	118.25	122.00
Upadhyay *et al.*	2012	Indian	17-35	132.00	129.00
Al-Shamout *et al.*	2012	Jordanian	20-29	123.23	122.84
Leversha *et al.*	2016	Australian	18-29	121.53	124.94
Current study	2016	South African	16-30	119.65	122.40

population-specific differences regarding the morphometric analysis of the angle of mandible (Poongodi *et al*.). In addition, different climate, nutrition and labour division may also contribute to population-specific differences regarding the size of angle of mandible (Poongodi *et al*.). This study recommends that future studies should include a larger sample size with a wider age range and to compare the size of the angle of mandible between the sub-population groups of South Africa.

CONCLUSION

The angle of mandible was found to decrease as age increased. A statistically significant correlation was only observed between the size of the angle of mandible and the 16-19 year age cohort ($p<0.006$). Although, other studies reported a significant difference between sex and the size of the angle of mandible, no statistically significant correlation between the afore-mentioned parameters was found in this study. Thus, the angle of mandible maybe an insufficient tool for sex identification in forensic science but may be useful in identifying human remains in the 16-19 year age cohort in the eThekwini Metropolitan region.

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RESUMEN. El ángulo de la mandíbula está formado por la línea tangente que une el margen posterior de la rama y la base de la mandíbula. El ángulo de la mandíbula tiene características específicas según la población; es imperativo en el área de la antropología forense para la determinación de la edad y género. Los informes literarios sobre el uso del ángulo de la mandíbula para la determinación de edad y género varían, según algunos estudios que lo apoyan, mientras que otros estudios han documentado ineficiencias. El objetivo de esta investigación fue documentar la morfometría del ángulo de la mandíbula y determinar si existe una correlación entre el ángulo de la mandíbula, la edad y el sexo. Se analizaron 64 radiografías panorámicas digitales (n = 128) de individuos entre 16-30 años morfométricamente utilizando el software Dicom Digital Imaging. Los datos fueron capturados y analizados utilizando el Paquete Estadístico para Ciencias Sociales (SPSS versión 23.0). A pesar de que las mujeres tenían un ángulo de la mandíbula mayor que los hombres, no se encontró una correlación estadísticamente significativa entre el tamaño del ángulo de la mandíbula y el sexo ($p = 0,088$). Se observó que el ángulo de la mandíbula disminuyó con el avance de la edad, y solamente la cohorte de edades de 16-19 años mostró una correlación estadísticamente significativa con el tamaño del ángulo de la mandíbula ($p = 0,006$). Por lo tanto, este estudio concluyó que el ángulo de la mandíbula puede no ser un indicador útil de sexo, pero puede ser un indicador confiable de edad para individuos entre 16-19 años en la región metropolitana de eThekwini.

PALABRAS CLAVE: Ángula de la mandíbula; Edad; Sexo; Mandíbula; Morfometría.

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