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Influence of gender and ethnicity on Bonwill's triangle and other morphometric parameters of mandible in a population of West Bardhaman district of West Bengal,India.

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Abstract

Aim of the study: Despite a number of studies on mandibular anthropometry, there is a dearth of parameters like goniognation lengths and Bonwill's triangular dimensions of mandibles from Eastern India. Earlier studies show intra-population differences in mandibular features. Gender determination has always been an integral part of biological profiling though reliability on population-specific morphometric data on mandibular dimensions is generally lacking.

Material and methods: A cross-sectional study was undertaken wherein the height, angle, bicondylar width, bigonial width, goniognation length and Bonwill's triangle of 110 mandibles of both genders were measured using Digital Vernier callipers and Mandibulometer. SPSS program was used for statistical analyses and results were interpreted. A p-value of <0.05% was considered significant.

Results: Results showed a statistically significant gender difference with respect to bigonial length, angle of mandible, height of mandible, goniognation length and Bonwill's triangular measurements.

Conclusions: Mandibular dimensions provide valid and reproducible scientific insight to gender identity and can be effectively used to determine gender in cases of natural calamities and accidents where the general parameters of gender identity might be

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absent or impossible to determine. Mandibular dimensions could also be effectively used to correct facial deformities with better accuracy.

Keywords: Facial Asymmetries; Goniognation length; Bonwill's triangle; Articulators

Introduction

The largest and strongest bone of the face, the mandible has several morphometric features[1,2] that serve in identification of sex[3], which is the first step towards age, stature and ethnicity determination [4,5,6].

Increase in natural calamities, accidents and violent crimes have resulted in increase in mutilated faces or unidentified bodies parts that pose a great challenge for forensic experts, plastic and maxillofacial surgeons [7]. Mandible is one of the most durable bones of skull, and mandibular remains from excavation sites is representative of the population and is of interest to anthropologists [8]. Features of the lower jaw is of interest to orthodontic and plastic surgeons due to more people wanting to correct dental and facial asymmetries [9,10]. Anaesthesiologists and ENT surgeons too need knowledge about mandibular parameters of a population for their procedures [11,12]. Skeletal characters vary between sex and race, so it is necessary to document sex and ethnicity based standards.

Modern occlusal concepts began with G. Bonwill's [13] works who described an equilateral triangle with sides 10cm formed by joining the middle condylar points and mid-incisal point on mandible. This is considered to be the ideal arch. Some investigators later agreed with Bonwill's theory[14], while some showed that sides of Bonwill's triangle were rarely equal and depended on ethnicity and sex[15,16,17]. This triangle helps to simulate the temporomandibular joint movements and gives the cusp angulations to construct complete dentures, articulators for reproducing mandibular movements, making of jaw prosthetics and is of anthropological interest too.

Mandible of different races and population are being studied around the world [18,19]. In India we find few studies from South[20] and North India[21] and Eastern India[22] as a whole, where researchers have measured very few parameters. There is dearth of data on parameters like goniognation length and dimensions of Bonwill's triangle of mandibles from Eastern India. Previous studies show that there is intra-population difference in mandibular features depending on region of residence and cultural practices.

The present study aims to explore, measure and document (sexual dimorphism) bi-condylar and bi-gonial width, angle of mandible, goniognation length, mandibular height and Bonwill's triangle of mandibles of the population of West Bardhaman district of West Bengal, and compare the same with data available.

Material and Methods:

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This cross-sectional study was conducted in Anatomy Department of IQ City Medical College and Hospital in Durgapur (West Bengal), from March 2021 to February 2022.

110 (74 male, 36 female) dry adult human mandibles were studied. Fractured, pathological or deformed bones were excluded. Digital vernier callipers (measuring range 0-150mm, Figure 1) and mandibulometer (measuring range 0-180 ^{o}, Figure 2) were used to measure:

Height of Mandible (at symphysis)– distance between infradentale and gnathion.

Angle of Mandible– Angle between lower and posterior borders of ramus.

Bicondylar width– Distance between the lateral poles of right and left mandibular condyles.

Bi-gonial width– Distance between right and left angle angles of mandible.

Goniognation Length– Distance between angle of mandible (gonion) and gnathion (lowest point of mandible in anterior median plane).

Bonwill's Triangle– 3 sides (Figure 3)

- Distance between right mid-condylar point and mid-incisal point
- Distance between left mid-condylar point and mid-incisal point
- Distance between left and right mid-condylar points.

In case of angle of mandible and goniognation lengths, average of right and left sides was computed. SPSS was used for statistical analysis, p-value < 0.05 was considered statistically significant.

Results

Table1 shows:

Bi-condylar width: For male mandibles, mean is 11.26±0.58cm (SD) which is larger than female mandibles having mean 10.97±0.61cm .

Bi-gonial length: average for males was 9.28±0.72cm and that for females was 8.79±0.69cm.

Angle of Mandible: It was lesser in males (mean= 118±3.66 ^{o}) than in females (mean= 128±2.43 ^{o}) .

Height of mandible: Average for males and females were 2.73±0.59cm and 2.72±0.34cm, respectively.

Goniognation length: Average for males (8.23±0.47cm) is greater than females (7.73±0.39cm) .

Except bi-condylar width, all above parameters showed statistically significant gender difference.

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Bonwill's Triangle: Only 15% were equilateral in males and 38.8 % in females, rest of the triangles are isosceles in both genders (Figure 4). The mean length of the sides were less than 10cm and lesser for females (Table 2). Dimensions of Bonwill's triangles show strong positive correlation in both genders between mid-incisor to right condyle and mid-incisor to left condyle (Table 3).

Discussion

110 dry adult human mandibles were studied in Anatomy department of IQ City Medical College, West Bengal. 74 belonged to males, 36 to females . Deformed bones were excluded. Each bone was measured for 6 parameters, compared with earlier studies to utilise the information to identify sex and create a database of West Bardhaman district population of West Bengal.

Bi-condylar width: In this study mean value for male mandibles (11.26±0.58cm) was greater than in females (10.97±0.61cm), but not significant. In 207 mandibles studied by Jayakaran F et al [22] found a mean of 11.26±0.53cm in males and 10.77±0.53cm in females of Karnataka. Datta A et al[21] got a mean of 11.27±0.56cm in males and 10.75±0.77cm in females in Devangere, Karnataka. The gender differences were statistically significant . Similarly, Sreelekha et al[19] found highly significant gender differences for bi-condylar width for population of South India. Ongkana N et al[3] had similar results for Thai population , Bertsatos et al[29] for Greek population and Steyn et al[30]for South African whites. Kumar et al[27]studied mandibles from Morgantown (USA); values were 11.29±1.31cm and 7.27±1.69cm for males and females respectively. Unlike our findings, Ranganath V et al[23]found females had greater bicondylar width than males.

Bi-gonial length: The mean value in male mandibles was 9.28 ±0.72cm and 8.79±0.67cm in female mandibles in this study, with statistically significant gender difference. Mondal T et al[25] showed statistically significant sexual dimorphism in Bengali population, mean length being 9.56cm and 7.85cm in male and female mandibles respectively. Datta A et al[21] too recorded highly significant difference between male (9.57±0.52cm) and females (8.88±0.68cm) bi-gonial length. Jayakaran F et al[22] similarly concluded that mean length in males (9.38±0.54cm) was more than in females (8.71±0.48cm). Sreelekha et al[19] recorded a very highly significant gender difference ; mean bi-gonial length in males and females were (8.94±0.69cm) and (7.78±0.52cm), respectively. Study on Thai population by Ongkana et al[3] showed similar results (males: 9.68±0.77cm, females: 8.97± 0.59cm). Steyn et al[30] found bigonial width was the most dimorphic parameter in South African white mandibles (males: 9.96±0.55cm, females: 9.15±0.50cm). A study on Australian population by Leversha J et al[18] showed similar results. Kumar et al[27] too recorded a statistically significant difference between males (6.82±1.37cm) and females (6.62±1.77cm). Ranganath V et al[23]differed showing almost similar values for males (8.68±1.37cm) and females (8.62±0.72cm).

Angle of mandible: We found that this angle was less in males (118±3.66^{o}) than in females (128±2.43^{o}), with was statistically highly significant. In Bengali population, Mondal T et al[25] found the values to be 121.25^{o} in males and 127.2^{o} in females on

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right side, 118.17° and 126.6° on left side in male and females respectively. Datta A et al[21]derived 126.6±6° and 139±72° for males and females respectively. Jayakaran F et al[22] too found mean mandibular angle in males (121.43°) was less than in females (124.19°). Sreelekha et al[19] also found significant difference between males (106±5.05°) and females (116.36±5.5°). Ranganath V et al[23] and Leversha J et al[18] showed similar results. A study on Lebanese population by Ayoub F et al[26] found no significant gender difference.

Height of Mandible: In this study, mean value in males was 2.73±0.59cm and in females was 2.72±0.34cm. Similar results were provided by Datta A et al[21] (males: 2.88±0.32cm, females: 2.28±0.38cm). Sreelekha et al[19] reported male and female values as 2.99±0.31cm and 2.83±0.28cm respectively. Kumar et al[27] recorded 2.17±0.88cm and 1.72±0.88cm for males and females respectively. Males had a higher value than females and were statistically significant as seen in our study. Unlike our findings, Ongkana[3] found no sex difference in mandibular height in Thai population (males: 2.83±0.61cm, females: 2.82±0.65cm).

Goniognation Length: Our study shows males have greater goniognation length (8.23±0.47cm) than females (7.73±0.39cm) and the difference is statistically significant. Ongkana[3] found significant gender difference between Thai males (8.32±0.52cm) and females (7.92±0.46cm). In South African whites, Styne M et al[30] showed similar significant gender differences (males: 7.68±0.57cm; females: 7.27±0.53cm). We could not find record of goniognation length for Indians.

Bonwill's Triangle: In our study, Bonwill's triangle is equilateral in only 15% males and 38.8% females. Majority are isosceles triangles, with the sides formed by midcondylar-incisal length being equal and statistically significant gender differences existed. All the sides were larger in males than females, although the difference for mid-bicondylar length was not significant. All sides were <10.16cm. Bonwill[13] measured 6000 skulls and 4000 living persons and deduced that the triangles were equilateral and named it after himself. He showed that the average side length was 4"(10.16cm). Ohm E et al[17] studied Norwagean population to show that all sides of the triangle were nearly equal, less than 10cm and sexually dimorphic. Shen Y W et al[28] showed in the Taiwanese population length of sides of Bonwill's triangle were consistent with Bonwill's theory but larger by 2mm. Lotric N et al[16] showed Yugoslav mandibles rarely had equilateral triangle, the mid-bicondylar breadth was lesser than 10cm and the other 2 sides recorded sexual dimorphism. Zivanovic S et al[15] found in East African Bantu-speaking males, the triangles were isosceles, but in females they were nearly equilateral; all sides were larger in males. Nikolopoulou F et al[14] showed the Greek population had equilateral Bonwill's triangle, the sides of which were greater in males with a mean of 10.1cm. Such studies on Bonwill's triangle are scanty in India. Gullapalli A et al[24] studied 100 mandibles in South India and found only 20% males and 40% females had equilateral triangle, and sides were larger in males, which was similar to our study. We could not find any study regarding this from Eastern or other regions of India.

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Conclusion

Sex determination has always been an integral part in biological profiling. The mandible has dimorphic traits which can be successfully applied for sex determination. But reliability lies on population-specific morphometric data.

Applying an average Bonwill's triangle values for making articulators and prosthetics for all races has resulted in errors in full mouth reconstruction. Our study provides a reference database for Bonwill's triangle of West Bardhaman district population.

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Table 1: Dimensions of male (N=74) and female (N=36) mandibles. Significance level set at p<0.05 with 95% confidence interval. SD=Standard deviation.
*denotes significant p-values.

	Male		Female		
Parameters	**Range**	**Mean ± SD**	**Range**	**Mean ± SD**	**Significance Level (p-value)**
Bi-condylar Width (in cm)	9.93-12.37	11.26 ±0.58	10.6-11.85	10.97 ±0.61	0.682
Bi-gonial length (in cm)	8.1-10.85	9.28 ±0.72	7.52-9.65	8.79 ±0.67	0.001*
Angle of mandible (in degrees)	107-126	118 ±3.66	121-133	128 ±2.43	<0.0001 *
Height of mandible (in cm)	1.26-3.95	2.73 ±0.59	2.02-3.45	2.72 ±0.34	0.001 *
Gonio-gnation length (in cm)	7.18-9.31	8.23 ±0.47	7.73-8.73	7.73 ±0.39	0.015 *

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Table 2: Dimensions of Bonwill's triangle in male (N=74) and female (N=36) mandibles. Significance level set at p<0.05 with 95% confidence interval. SD=Standard deviation. *denotes significant p-values.

Variable	Male Mean ± SD	Female Mean ± SD	Significance level (P – Value)
Mid Right condyle to Incisal length (in cm)	9.89 ± 0.45	9.67 ± 0.64	0.002*
Mid Left condyle to Incisal length (in cm)	9.76 ± 0.52	9.65 ± 0.61	0.001*
Mid bi-condylar length (in cm)	9.48 ± 0.46	9.34 ± 0.57	0.749

Table 3: Correlation coefficient between dimensions of Bonwill's triangles in male (N=74) and female (N=36) mandibles.

Variable	Male (r)	Female (r)	Implication
Mid incisor to Right condyle vs. Mid incisor to Left condyle	0.81	0.98	Strong Positive Correlation for both male & female
Mid incisor to Right condyle vs. Bi-condylar midpoint	0.66	0.60	Moderate Positive Correlation for both male & female
Mid incisor to Left condyle vs. Bi-condylar midpoint	0.78	0.57	Moderate Positive Correlation for both male & female

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Figure 1: Measurement of Bi-condylar width using Digital Vernier Callipers.

Figure 2: Measurement of Angle of Mandible using Mandibulometer

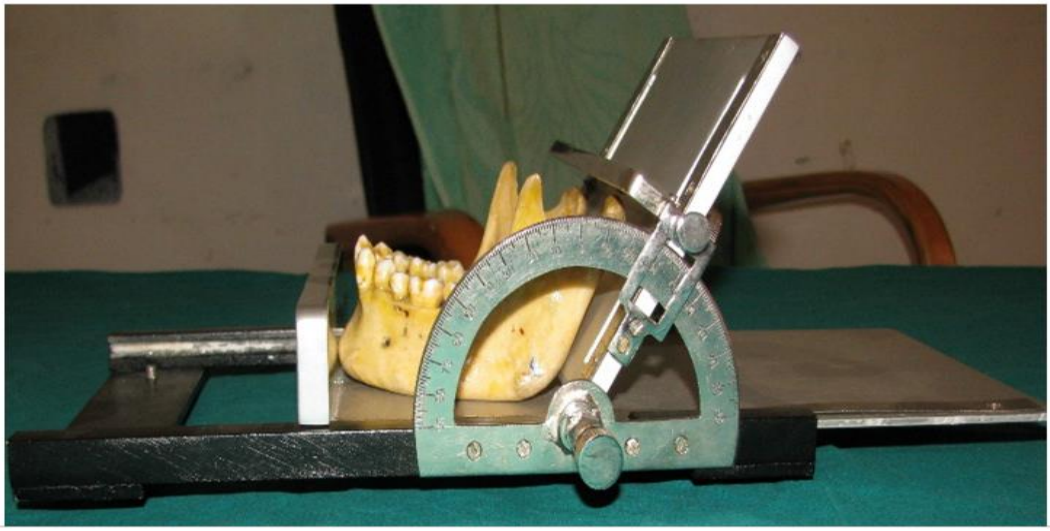

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Figure 3: Schematic diagram showing Bonwill's triangle; A - Right mid-condylar point, B- Left mid-condylar point , C - mid-incisal point .

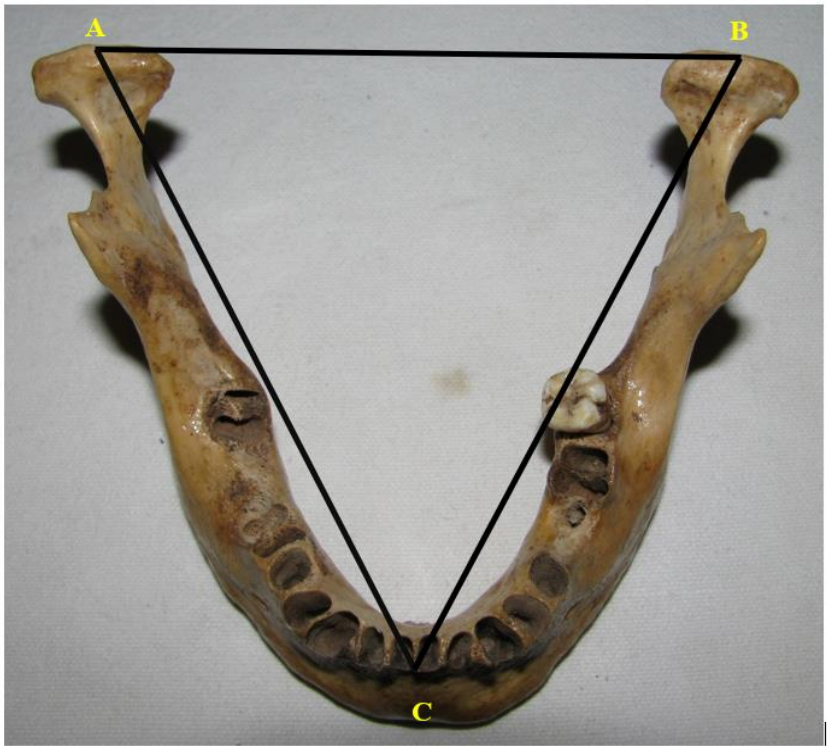
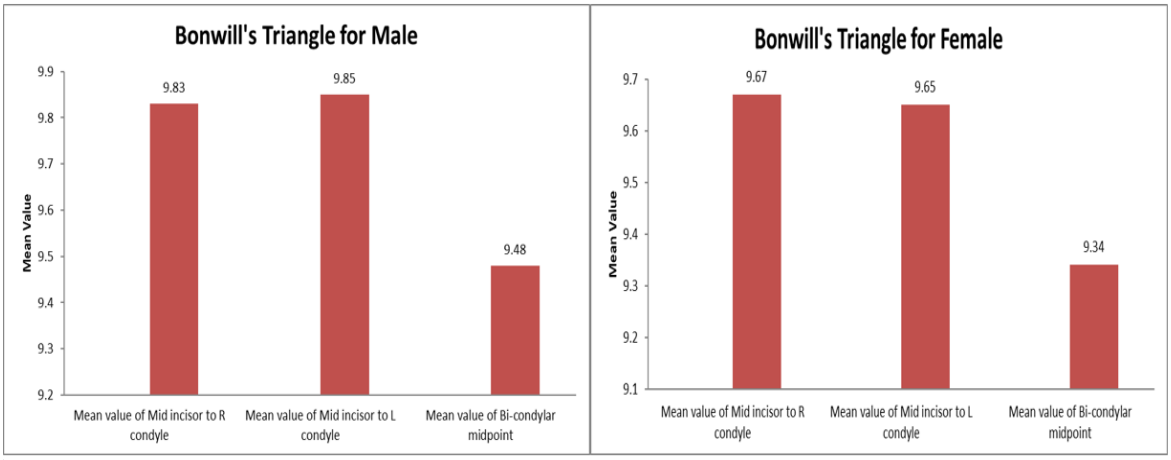


Figure 4: Dimensions of Bonwill's Triangle was isosceles for both male and female mandibles.



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