Acta Scientific ANATOMY

Volume 1 Issue 5 June 2022

Research Article

Dental and Facial Parameters: Index for Posthumous Gender Determination

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Received: June 14,2022

Published: June 28, 2022

Abstract

Background: The dentition is a hard, chemically stable body tissue with extreme resistance to heat and corrosion. This property has made it a robust forensic tool even after many years of decay. This study aims to establish data using dental parameters as an index for posthumous gender determination. Ethical approval was given by the ethical committee, Faculty of Basic Medical Science, University Nigeria Enugu campus.

Materials and Methods: One hundred and thirty-two subjects 60 males and 72 females, were selected, and dental impressions were taken from their mandibular and maxillary arches with alginate. Dental cast were prepared with dental stone and measurements were taken directly from the casts. Measurements of the facial parameters and facial skin fold thickness were also taken with a digital vernier caliper and skinfold caliper, respectively.

Result: The descriptive statistics of the dental and facial parameters were established, and sexual dimorphism was established in most of the parameters ($P < 0.05$, $P < 0.01$). Bilateral asymmetry was also established in some of the parameters ($P < 0.05$, $P < 0.01$).

Conclusion: This study can be used to determine gender using the facial parameters, and maxillary and/or mandibular parameters.

Keywords: Dentition; Mandibular and Maxillary Arches; Gender Determination; Sexual Dimorphism

Introduction

The dentition is the hardest and chemically the most stable tissue in the body; it is an excellent material in living and non-living populations for forensic investigations [39,40], such as gender determination and age estimation. Canine tooth, most significantly, has been reported to have the highest degree of sexual dimorphism, rendering them highly valuable in individual or group identification [1-5,7,10,39,40]. Canine mesio-distal width, inter-canine width, and mandibular canine index have been proved highly valuable in human identification [9-13]. Jonathan., *et al.* [39] documented that the mandibular and maxillary inter-molar width can be used to determine gender correctly, especially if the canine is missing. The posthumous determination of gender with the application of soft tissues and organs and archeological osseous materials such as the bones has been reported to be unreliable and seldomly used [1,22,23]. This is as a result of their inability to resist chemical attack.

Ufuk., *et al*. [54] reported that proportional relationships emerge between the bizygomatic width and the width of the central incisor, the inter-canine distance and the inter-alar width which were observed mostly in women. They also reported that maxillary central incisor and canine dimensions of men were greater than those of women in the Turkish population studied, with the canines showing the greatest gender variation.

The goal of this study is to use dental parameters as an index for posthumous gender determination.

Materials and Methods

The instruments and materials for this study included: alginate, dental stone, dental tray, tape measure, and vernier caliper (digital sliding and skinfold).

Ethical clearance

The permission and approval for this study were obtained from the Faculty of Basic Medical Science Ethical Committee University of Nigeria Enugu Campus and were carried out according to the principles and guidelines prescribed for use.

Sample size

The sample size of this study was made up of 132 subjects with normal occlusion, with 60 males and 72 females, selected from students, staff, patients, and relatives visiting the Dental Clinic of Federal School of Dental Technology and Therapy, Trans-Ekulu, Enugu Nigeria. All participants were of Nigerian origin (Nigerian by birth), and their mean ages were 24.3 and 22.8 for males and females, respectively.

Selection criteria

The subjects used in this study were selected based on the following inclusion criteria: full set of dentition, normal facial symmetry, absence of dental caries and no history of orthodontic and prosthodontic treatment.

Procedure

The subjects were randomly selected, and written consent was obtained from them after explaining the procedure and the purpose of the study. Each subject was comfortably seated on the dental chair, and a height adjustment was made. Measurements of facial parameters were taken with a digital vernier caliper.

Maxillary and mandibular impressions were taken with alginate using universal precautions for infection control, and the procedures were performed in accordance with the manufacturer's instructions. The dental casts were prepared using dental stone, and measurements were taken directly on the dental casts after 24hours. A digital vernier caliper, giving two decimal points, was used for the measurements.

Dental parameters

The methods used for the measurement of the dental cast were in accordance with the one used by Eugenia., *et al*. [18] and Ling., *et al.* [37].

Figure 1: Picture of the measurement of first inter-molar width and second inter-molar width of the maxillary teeth.

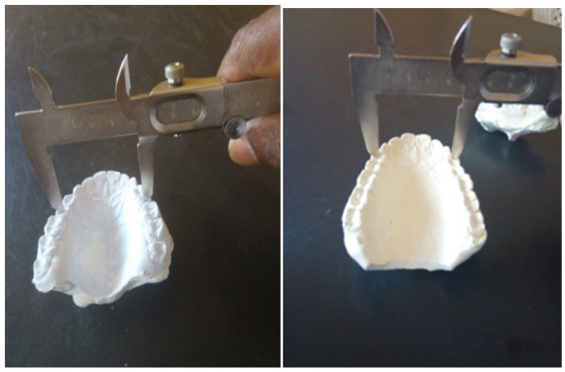

Figure 2: Picture of the measurement of first inter-premolar width and second inter-premolar width of the maxillary teeth.

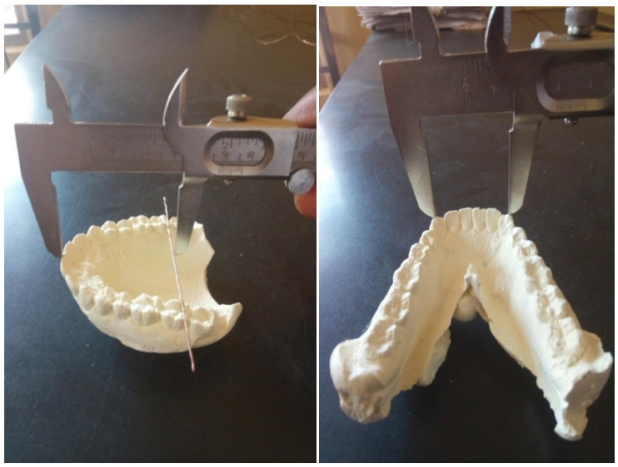

Figure 3: Picture of the measurement of the total dental arch of maxillary teeth and inter-canine width of the mandibular teeth.

Figure 4

Facial parameters

Facial landmarks were measured by one investigator with a digital vernier caliper, and values were rounded off to 0.1cm. The measurement of facial landmarks was done according to the method established by [42-46] and [41]. The table below shows the parameters taken from each of the subjects.

Statistical analysis

Descriptive statistics which included the means, median, mode and standard deviation were calculated for each measurement and T-test was also used for comparison between males and females. Statistical significance is noted at $P < 0.05$.

Results

In this study, arithmetic means were calculated for both facial and dental parameters for male and female subjects. Student t-test was used to compare the means of the facial and dental measurements.

Discussion

One of the key steps in human identification is comparing the known features of antemortem information with the recovered features from the postmortem information. Gender determination is a critical aspect in postmortem profiling and is especially useful in

Variables	Male	Female	P-value (T-test analysis)
Total canthal distance	10.19 ± 0.42	10.04 ± 0.49	0.68
Right canthal distance	3.31 ± 0.28	3.50 ± 0.29	0.00
Left canthal distance	3.43 ± 0.27	3.50 ± 0.29	0.14
Outer-inner canthal distance	6.85 ± 0.33	6.61 ± 0.31	0.00
Lip length	5.33 ± 0.43	4.89 ± 0.38	0.00
Lip width	2.25 ± 0.47	2.19 ± 0.29	0.42
Philtrum distance	1.19 ± 0.20	1.18 ± 0.19	0.78
Nasal height	1.38 ± 0.22	1.32 ± 0.17	0.05

Nasal length	5.42 ± 0.50	5.19 ± 0.40	0.01
Nasal breadth	4.25 ± 0.34	3.95 ± 0.27	0.00
Nasal root height	2.01 ± 0.28	1.74 ± 0.26	0.00
Nasal root width	3.31 ± 0.34	3.02 ± 0.29	0.00
Ear height	5.63 ± 0.40	5.44 ± 0.36	0.01
Ear breadth	3.11 ± 0.44	2.69 ± 0.42	0.00
Eye-ear distance	7.97 ± 0.44	7.30 ± 0.46	0.00
Bitragion chin arc	31.80 ± 1.06	30.34 ± 1.16	0.00
Bitragion coronal arc	38.05 ± 1.39	38.28 ± 1.12	0.36
Bitragion sub-nasal arc	29.83 ± 1.15	28.83 ± 1.11	0.00
Bitragion frontal arc	32.38 ± 1.14	31.41 ± 1.42	0.00

Table 1: Distribution of some demographic parameters, facial and head and neck, Parameter distributed based on gender.

Variables	Male	Female	P-value (T-test analysis)
Height	1.73 ± 0.08	1.63 ± 0.08	0.00
Weight	66.43 ± 7.93	60.32 ± 10.41	0.00
Facial width	11.95 ± 0.59	11.97 ± 0.74	0.85
Facial height	12.69 ± 0.60	11.77 ± 0.59	0.00
Upper facial height	5.43 ± 0.51	5.27 ± 0.69	0.14
Lower facial height	7.26 ± 0.48	6.61 ± 0.49	0.00
Skull height	10.18 ± 1.06	9.53 ± 1.04	0.00
Bigonial width	10.41 ± 0.59	9.95 ± 0.54	0.00
Head length	19.41 ± 0.67	19.00 ± 0.63	0.00
Head width	15.76 ± 0.56	15.18 ± 0.61	0.00
Head height	11.68 ± 0.71	11.08 ± 0.71	0.00
Head circumference	56.92 ± 1.29	57.07 ± 1.49	0.52
Neck circumference	37.05 ± 1.83	33.45 ± 1.89	0.00
Zygomatic skinfold thickness	1.43 ± 0.42	1.70 ± 0.39	0.00

Table 2: Descriptive statistics of the Orbital, Oral, Nasal and Auricular parameters distributed based on gender.

Variables	Male	Female	P-value (T-test analysis)
Lateral inter-incisor width	2.56 ± 0.33	2.58 ± 0.14	0.74
Inter-canine width	3.79 ± 0.27	3.68 ± 0.22	0.01
First inter-premolar width	4.08 ± 0.29	3.96 ± 0.24	0.01
Second inter-premolar width	4.53 ± 0.34	4.39 ± 0.26	0.00
First inter-molar width	5.08 ± 0.32	4.90 ± 0.28	0.00
Second inter-molar width	5.57 ± 0.34	5.32 ± 0.25	0.00
Anterior segment length	1.39 ± 0.21	1.43 ± 0.17	0.39
Posterior segment length	3.06 ± 0.33	3.06 ± 0.24	0.93
Maxillary depth	2.06 ± 0.36	2.05 ± 0.22	0.93
Total dental arch length	4.44 ± 0.41	4.46 ± 0.30	0.64
Lateral incisor perimeter	3.12 ± 0.27	3.09 ± 0.21	0.45
Canine perimeter	4.90 ± 0.34	4.89 ± 0.29	0.82
First premolar perimeter	6.79 ± 0.43	6.71 ± 0.33	0.20
Second premolar perimeter	8.34 ± 0.48	8.23 ± 0.39	0.16
First molar perimeter	10.46 ± 0.77	10.57 ± 0.37	0.28
Second molar perimeter	12.63 ± 0.68	12.68 ± 0.41	0.60

Table 3: A descriptive statistics of maxillary dental parameters distributed based on gender.

Variables	Male	Female	P-value (T-test analysis)
Lateral inter-incisor width	1.74 ± 0.22	1.64 ± 0.13	0.06
Inter-canine width	2.83 ± 0.29	2.86 ± 0.23	0.58
First inter-premolar width	3.38 ± 0.29	3.35 ± 0.23	0.41
Second inter -premolar width	3.95 ± 0.30	3.83 ± 0.26	0.02
First inter-molar width	4.45 ± 0.26	4.28 ± 0.26	0.00
Second inter-molar width	4.95 ± 0.32	4.76 ± 0.26	0.00
Anterior segment length	1.05 ± 0.14	1.01 ± 0.14	0.16
Posterior segment length	2.96 ± 0.25	3.02 ± 0.25	0.12
Total dental arch length	3.99 ± 0.27	3.98 ± 0.32	0.82
Lateral incisor perimeter	2.05 ± 0.21	2.05 ± 0.15	0.87
Canine perimeter	3.65 ± 0.27	3.64 ± 0.26	0.75
First premolar perimeter	5.44 ± 0.38	5.39 ± 0.34	0.54
Second premolar perimeter	7.06 ± 0.42	7.04 ± 0.38	0.75
First molar perimeter	9.46 ± 0.55	9.42 ± 0.44	0.65
Second molar perimeter	11.82 ± 0.59	11.68 ± 0.48	0.15

Table 4: A descriptive statistics of mandibular dental parameters distributed based on gender.

the identification of skeletal remains [26-32,39]. It is one of the essential steps employed in human identification [2,17-21].

This study was oriented to use dental and facial parameters to determine gender in a Nigerian population. This study showed several of these parameters that showed sexual dimorphism. The need to have accurate landmarks and anthropometric ratios to facilitate and enhance human identity has grown in demand with astronomical increases in crime and late detection of these victims of murder, alongside also is the increase in cases of mass disasters and several other factors that lead to dismembering and disfiguring and mutilation of the victims [22,34-38]. Common in forensic analysis is the recovery of partial remains like a fragmented skull, jaws, and other bones of the body [6,16,17,31]. The dentition is one of the most recovered skeletal remains, strong and chemically stable and can resist a variety of antemortem and postmortem attacks and insults, and perhaps, most suitable for forensic investigation [8,31,36].

In this study, the mean statistical result of dental parameters obtained indicated sexual dimorphism with higher values in males than females. The gender difference in the dimensions of maxillary inter-canine width, first and second inter-premolar width, first and second inter premolar width and mandibular second inter-premolar width, first and second intermolar width were found to be statistically significant. Hussein., *et al.* [30], in line with this study, reported that mandibular inter-canine width was greater in males than in females. Inter-canine width and mandibular canine index have also been used to evaluate sex in the past and are supported by many scientists [40,41]. Contrary to these reports, Daniel., *et al.* [39], in their study, did report no sexual difference. However, they suggested that inter-molar arch width may be helpful in gender determination and human identification.

Hashim and Murshid [27] reported that only the canines in both jaws exhibited a significant sexual difference while the other teeth did not. AL-Rifaiy., *et al.* [5], noted that, the mean values for left and right maxillary and mandibular canine mesio-distal width were less in females than in males in line with our report, but reported no statistically significant differences. Mehreen., *et al.* [38] studied the lower canines using the ratio between the maximum crown width and canine arch width. They reported that the mandibular canine index was significantly higher in males than females in Punjab Province of Pakistan. They suggested that differences between canines and other dental measurements in both sexes may be due to the influence of the Y chromosome, which affects the size of teeth by controlling the thickness of dentine.

In contrast, the X chromosome is considered to be responsible only for the thickness of enamel [26,33]. The gender difference in dental parameters noted in this study has been attributed to the males' possession of larger tooth crowns in contemporary human populations [10,29,34]. This may be due to a more extended period of amelogenesis for both deciduous and permanent dentitions in males [10,29,36]. This study is also in agreement with the reports of Daniel., *et al*. [39], which noted no significant differences in the mean mandibular inter canine arch width in males and females.

The mean statistical result of facial parameters obtained in this study indicated sexual dimorphism with higher values in males than females. Oladipo., *et al.* [46-50] reported nasal heights of Ogoni males and females as 3.99cm and 3.91cm respectively in Nigeria. Akpa., *et al.* [3] reported nasal height of Igbos as 6.31cm and 6.04 for males and females respectively. Osunwoke., *et al*. [52] reported Menton-Nasion distance in males was 113.62 ± 9.44mm, and 109.05 ± 6.58mm in females. Zygoma-Zygoma 124.63 ± 5.78mm in males and 122.28 ± 6.39mm in females, Subnasal-Subnasal 43.05 ± 3.83 in males and 39.93 ± 3.96mm in females, Ala-Ala 41.14 ± 3.30mm in males and 37.34 ± 3.50mm in females, Lip width 26.67 ± 4.11 in males and 25.59 ± 3.03mm in females, Menton-Subnasal 65.97 ± 5.91mm in males and 60.35 ± 5.71mm in females. They concluded that Bini males had significantly higher values than Bini females in all the facial parameters measured. Oladipo., *et al.* [46-50] reported male Ibibios mean facial height as 11.14 ± 0.77cm, nasal height as 4.15 ± 0.34cm, and oro-facial height as 6.99 ± 0.59cm and their females mean facial height as 10.55 ± 0.74cm, nasal height as 3.93 ± 0.35cm, and oro-facial height as 6.63 ± 0.60cm. In line with the findings of this study, they concluded that the males had significantly higher values than the females in all the facial parameters measured.

Didia., *et al*. [19] reported male adult Nigerians' facial height as 12.28 ± 3.39cm, nasal height as 4.50 ± 1.23cm and oro-facial height as 6.90 ± 1.89cm while female facial height as 11.77 ± 3.5cm, nasal height as 4.48 ± 1.3cm, and oro-facial height as 6.32 ± 1.91cm. Olotu., *et al.* [51] reported males' adult Igbos facial height as 12.55 ± 2.11cm and nasal height as 4.87 ± 0.84cm while females facial height as 11.9 ± 1.92cm and nasal height as 4.40cm ± 0.76cm. The results indicated sexual dimorphism with higher values of all parameters in males compared to females. Obaje., *et al.* [45] reported that there is a statistically significant difference between the males and females in two ethnic groups (Idoma and Igede) with respect to their head length, head width, bizygomatic distance, upper facial height, lower facial height, facial height, nose length and skull height.

Conclusion

In conclusion, the maxillary and mandibular intercanine, first and second inter-premolar and inter-molar arch widths were found to have the highest t-value in males compared to females, making them a useful measurement to determine gender. Our measures in craniofacial parameters create a standard for gender determination and human identification since most of the parameters in the head and face were found to have high t-value in males as compared to females.

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