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RESEARCH ARTICLE

ANALYSIS OF VARIOUS MEASUREMENTS OF RADIOGRAPHS OF MANDIBLE AS AN INDICATOR FOR SEX DETERMINATION

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ABSTRACT

Objectives: The present study was conducted to observe various mandibular measurements using digital panoramic radiography, which can be used for sex determination. The study was done among the Maharashtran population with a sample size of 500 out of which 250 were males and 250 were females of age group 20-50yrs.

Method: The parameters considered for the study were **mandibular angle, distance between mental foramen** and basal border of the mandible, distance between mental foramen and alveolar border of the mandible, mental foramen breadth**,** mental foramen height, length of the mandibular body, maximum length of the mandible, height of the mandibular body, maximum ramus breadth, minimum ramus breadth, maximum ramus height, length of the condyle, breadth of the condyle, distance between the centre of mental foramen and mental tubercle, distance between the centre of foramen mentale and gonion, bigonial width.

Result: Out of these 16 variables 9 variables were highly significant for sex determination which were, **distance between mental foramen** and basal border of the mandible, Length of the mandibular body, Maximum length of the mandible, Length of the mandibular body, Maximum and Minimum ramus breadth, Maximum height of ramus and bigonial width were highly significant and variables, distance between the centre of mental foramen and mental tubercle were significant in determining the sex of the mandible.

Conclusion: This research showed that variables length of body of mandible, maximum length of mandible, height of body of mandible, maximum and minimum breadth of ramus, height of ramus and bigonial width exhibit highest degree of sexual dimorphism.

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INTRODUCTION

The identification of sex from human skeletal is of great importance in forensic medicine, especially in criminal investigations as well as in the recognition of missing persons and performing experiments for recreating the lives of ancient populations. Recognition of humans using specific features of teeth and jaws has been used since Roman times, because humans show distinct features in jaw and teeth dimensions and morphology of both adults and children. When only bones of head or broken parts jaws are available for sex determination, forensic scientists may use techniques that are based on the measurement of various bone parameters and examination of cranial osteological traits like shape of the glabella, size of the mastoid process, orbital form, frontal profile, shape of the occipital protuberance or size of the foramen magnum (Vodanovic *et al*., 2006). Presence of a dense layer of compact bone in mandible makes it very durable and well preserved than many other bones hence important role in identification of sex from human remains (Annamalai *et al*., 2012). Radiography can play an important role in forensic odontology, this may take the precise form of comparison between antemortem and postmortem radiographs. Comparable radiographs are an essential factor to confirm the identification in a mass disaster. These are usually in the form of bitewing radiographs, but may also include other intraoral techniques such as periapical and occlusal views. The frontal sinus view taken for sinus complaints are very useful as it is an established fact that the frontal sinus is a unique feature of every individual. Consequently it is necessary for the forensic

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odontologist to be familiar with the relevant maxillofacial views as well as the radiographic techniques, both intraoral and extraoral radiography may have to be carried out in the field or at the scene of autopsy. The morphological marks are more subjective and sex determination depends on the skills of the investigator, so visual method of sex determination by skull are mostly to be incorrect when performed by an inexperienced worker (Karjodkar FR 2014). Identified structures can be further classified into two i.e males and females by Discriminant function analysis (Vodanovic *et al*., 2006). Numerous studies have clearly demonstrated that skeletal characteristics vary by population and that there is a need for population specific standards for sex determination. The present study is an attempt to derive a discriminant function to determine sex by using mandible measurements.

Aim

To analyze various measurements of radiographs of mandible on orthopantomogram as an indicator for sex determination.

Objectives

(1) To carry out various measurements of mandible on orthopantomogram.
(2) To compare the various measurements of mandible on orthopantomogram in males and females patients.
(3) To determine the utility of orthopantomogram as an indicator for sex determination.

MATERIALS AND METHODS

Source of data

The study will be conducted with a sample size of 500 will be conducted using orthopantomograms of age matched males and females of Maharashtran population in the age group between 20 and 50 years. Ideal orthopantomograms of completely dentate patients will be selected for the study. Pathological, fractured mandible, developmental disturbances of the mandible, deformed and edentulous mandibles were excluded from the study. Digital Panoramic Radiographs will be used for the study which was stored in the system. Radiographs will be taken using Planmeca machine and the software used is Romexis software. Mandibular measurements were measured in millimeters (mm) by carried out using mouse driven method (by moving the mouse and drawing lines using chosen points on radiograph)at exposure parameters 70KV, 10mA, 18sec.

Method of data collection

The following parameters were measured in mm using mouse-driven method (by moving the mouse and drawing lines using chosen points on the digital panoramic radiograph):

1. ***Mandibular Angle (Man A)*: *angle formed by inferior border of the corpus and the posterior border of the ramus.***
2. ***Distance between mental foramen*** and basal border of the mandible (MF-BaB).
3. Distance between mental foramen and alveolar border of the mandible (MF-AlB).
4. Mental foramen breadth (MF-Br): distance between mesial and distal border of the mental foramen.
5. Mental foramen height (MF-H): distance between the alveolar and basal border of the mental foramen.
6. Length of the mandibular body (ManBo-L): distance between gnathion (the most basal point of the symphyisis) and gonion (point on the gonional perimetrum which crosses the bisectrix of the angle defined by the tangents to the posterior margin of the ramus and the basal border).
7. Maximum length of the mandible (Max-L-Man): distance between gnation and condyle (medial point of the condyloid process taken at the point of contact of the articular surface with the neck condyle at its posterior side).
8. Height of the mandibular body (ManBo-H): direct direct distance from the alveolar process to the inferior border of the mandible perpendicular to the base at the level of the mental foramen.
9. Maximum ramus breadth (Max-R-Br): distance between the most anterior point on the mandibular ramus and a line connecting the most posterior point on the condyle and the angle of the jaw.
10. Minimum ramus breadth (Min-R-Br): the smallest breadth of the mandibular ramus measured perpendicularly to the height of the ramus.
11. Maximum ramus height (Max-R-H): direct distance from the highest point on the mandibular condyle to gonion.
12. Length of the condyle (Con-L): distance between the most lateral and the most medial point of the mandibular condyle.
13. Breadth of the condyle (Con-Br): distance between the most anterior and most posterior point of the mandibular condyle.
14. Distance between the centre of mental foramen and mental tubercle (MF-MT).
15. Distance between the centre of foramen mentale and gonion (MF-Go).
16. Bigonial width (Go-Go): distance between right and left gonion.

RESULTS

Table 1 Denotes sexual dimorphism and descriptive statistics of the mandible in the analyzed sample.

Out of these 16 variables 9 variables were highly significant for sex determination which were, MF-BaB, ManBo-L, Max-L-Man, ManBo-H, Max-R-Br, Min-R-Br, Max-R-H, MF-Go,Go-Go and variables MF-Br and MF-MT were significant.

Table 2 shows within-group correlation matrix for the analyzed variables. Strong, positive correlations are present between the variable Con-L and Con-Br and between ManBo-L and Go-Go

Table 3 shows Eigenvalue, canonical correlation, Wilks' Lambda, Chi-square and significance level for the derived discriminant function. The results were highly significant ($p<0.001$).

Table 1. Sexual dimorphism and descriptive statistics of the mandible in the analyzed sample

	Sex	N	Mean	Std. Deviation	index	f	P value
Man A	Male	250	134.980	12.2826	98.9691	-1.329	.185
	female	249	136.386	11.3260			
MF-BaB	1	250	12.08	1.658	113.2146	9.811	.000
	2	249	10.67	1.549			
MF-AlB	1	250	14.75	2.747	104.1667	2.603	.010
	2	249	14.16	2.270			
MF-Br	1	250	3.36	.749	104.3478	1.986	.048
	2	249	3.22	.771			
MF-H	1	250	2.68	.678	99.62825	-.113	.910
	2	249	2.69	.652			
ManBo-L	1	250	64.93	6.640	104.3555	4.655	.000
	2	249	62.22	6.348			
pMax-L-Man	1	250	125.40	7.664	105.7068	7.828	.000
	2	249	118.63	11.314			
ManB0-H	1	250	30.15	3.453	107.6017	7.780	.000
	2	249	28.02	2.594			
Max-R-Br	1	250	34.07	3.188	103.8087	4.385	.000
	2	249	32.82	3.193			
Min-R-Br	1	250	28.79	2.944	106.3146	6.287	.000
	2	249	27.08	3.108			
Max-R-H	1	250	54.08	7.117	108.2033	7.353	.000
	2	249	49.98	5.199			
Con-L	1	250	9.64	1.445	104.7826	3.531	.000
	2	249	9.20	1.358			
Con-Br	1	250	9.67	1.480	104.9946	3.582	.000
	2	249	9.21	1.382			
MF-MT	1	250	27.47	3.468	102.9996	2.370	.018
	2	249	26.67	4.098			
MF-Go	1	250	45.29	8.107	105.892	3.991	.000
	2	249	42.77	5.783			
Go-Go	1	250	149.32	13.165	103.1073	3.730	.000
	2	249	144.82	13.759			

Table 2. The within-group correlation matrix for the analyzed variables

	Man A	MF-BaB	MF-AlB	MF-Br	MF-H	Man Bo-L	Max-L-Man	Man B0-H	Max-R-Br	Min-R-Br	Max-R-H	Con-L	Con-Br	MF-MT	MF-Go	Go-Go
Man A	1.000	-.077	.022	.011	-.081	.118	.031	-.006	.032	.004	.131	.030	.043	.007	.128	.001
MF-BaB	-.077	1.000	-.048	-.133	-.117	.182	.233	.364	.177	.232	.245	.111	.132	.006	.122	.214
MF-AlB	.022	-.048	1.000	.148	-.026	.232	.232	.788	.104	.160	.233	.008	.025	.174	.090	.282
MF-Br	.011	-.133	.148	1.000	.352	.180	.091	.114	.084	.014	.054	.165	.158	.127	.175	.280
MF-H	-.081	-.117	-.026	.352	1.000	.050	.031	.035	-.016	-.015	-.030	.107	.104	.052	.049	.152
ManBo-L	.118	.182	.232	.180	.050	1.000	.410	.279	.376	.435	.410	.226	.253	.447	.587	.792
Max-L-Man	.031	.233	.232	.091	.031	.410	1.000	.359	.418	.362	.235	.213	.227	.380	.213	.399
ManB0-H	-.006	.364	.788	.114	.035	.279	.359	1.000	.213	.253	.279	.079	.106	.223	.133	.334
Max-R-Br	.032	.177	.104	.084	-.016	.376	.418	.213	1.000	.733	.298	.219	.240	.165	.304	.338
Min-R-Br	.004	.232	.160	.014	-.015	.435	.362	.253	.733	1.000	.309	.281	.286	.183	.329	.395
Max-R-H	.131	.245	.233	.054	-.030	.410	.235	.279	.298	.309	1.000	.132	.163	.092	.293	.406
Con-L	.030	.111	.008	.165	.107	.226	.213	.079	.219	.281	.132	1.000	.969	.180	.163	.249
Con-Br	.043	.132	.025	.158	.104	.253	.227	.106	.240	.286	.163	.969	1.000	.159	.189	.297
MF-MT	.007	.006	.174	.127	.052	.447	.380	.223	.165	.183	.092	.180	.159	1.000	.026	.413
MF-Go	.128	.122	.090	.175	.049	.587	.213	.133	.304	.329	.293	.163	.189	.026	1.000	.517
Go-Go	.001	.214	.282	.280	.152	.792	.399	.334	.338	.395	.406	.249	.297	.413	.517	1.000

Table 3. Eigenvalue, canonical correlation, Wilks' Lambda, Chi-square and significance level for the derived discriminant function

Function	Eigenvalue	Wilks' Lambda	Chi-square	df	Sig.
1	.371[a]	.729	154.305	16	.000

Table 4. Standardized and unstandardized discriminant function coefficients, structure matrix and sectioning points

Variables	Standardized Coeffcients	Structure matrix	Unstandardized coefficients
Man A	-.145	.722	-.012
MF-BaB	.409	.576	.255
MF-AlB	-.300	.573	-.119
MF-Br	.239	.541	.314
MF-H	-.031	.463	-.047
ManBo-L	.078	.343	.012
Max-L-Man	.364	.323	.038
ManB0-H	.471	.294	.154
Max-R-Br	-.272	.275	-.085
Min-R-Br	.314	.264	.104
Max-R-H	.379	.260	.061
Con-L	.118	.192	.084
Con-Br	-.068	.175	-.047
MF-MT	.041	.146	.011
MF-Go	.155	-.098	.022
Go-Go	-.448	-.008	-.033
CONSTANT			-10.207
Sectioning point			-0.609

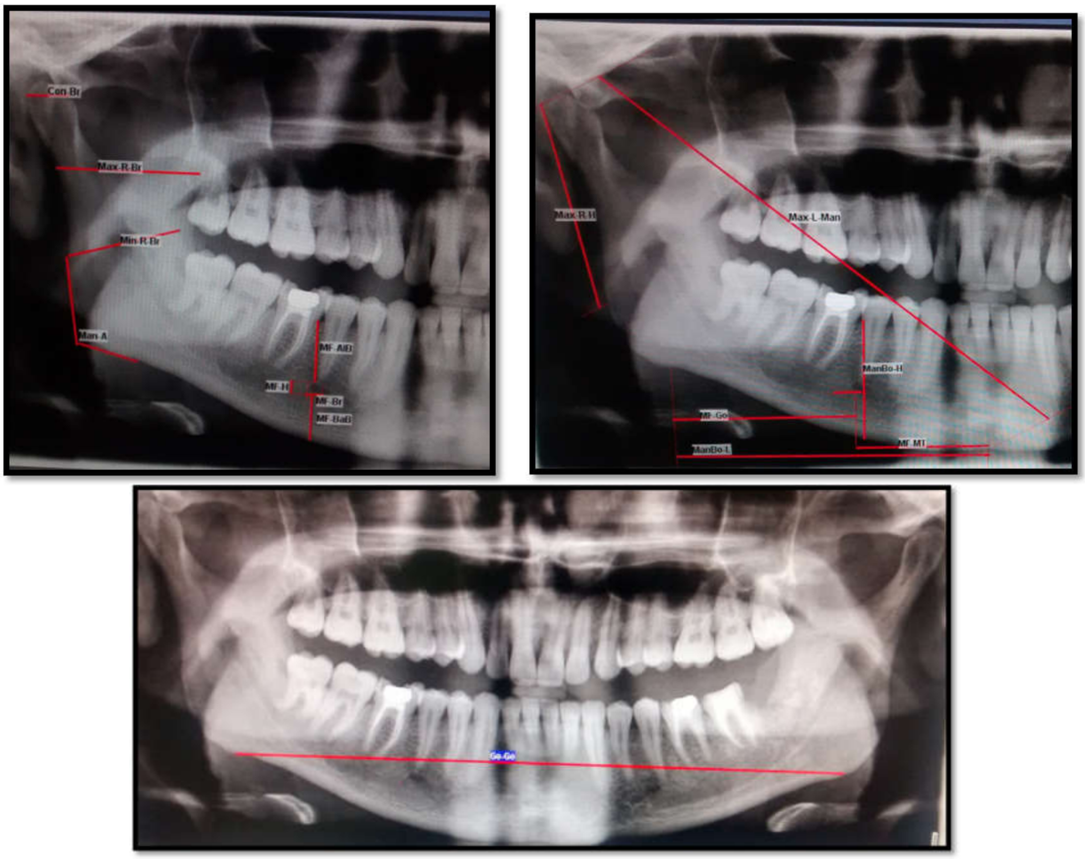

Figure 1. Mandibular measurements on OPG

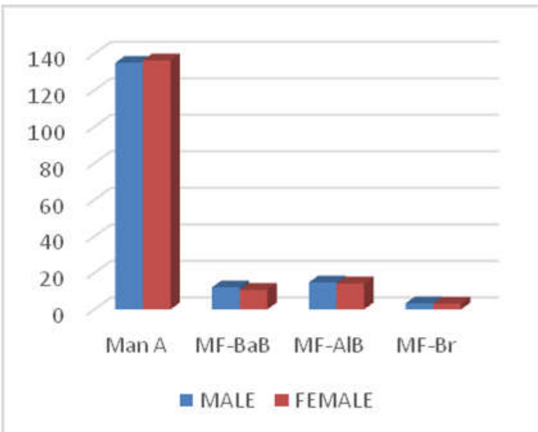

Figure 2

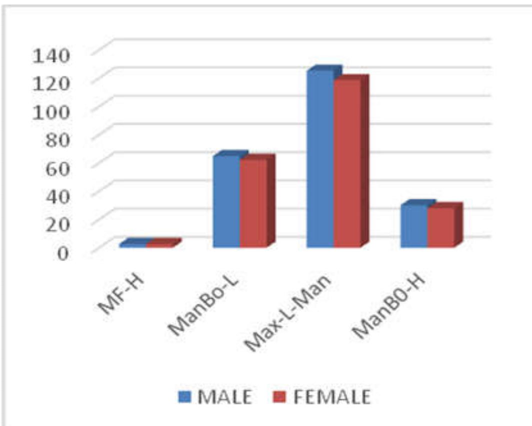

Figure 3

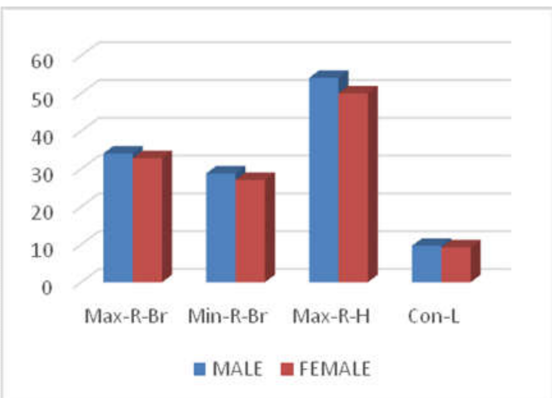

Figure 4

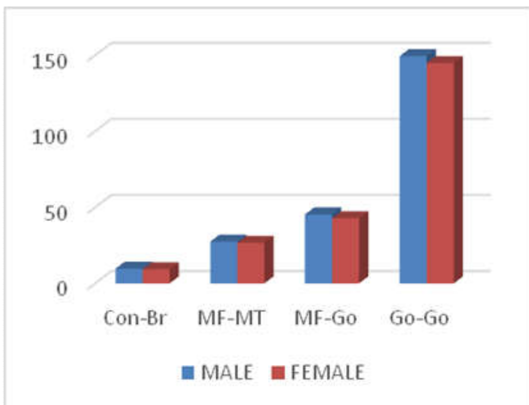

Figure 5

Figures 2,3,4,5. Sexual dimorphism and descriptive statistics of the mandible of parameters ManA, MF-BaB, mF-AlB, MF-Br, MF-H, ManBo-L, Max-L-Man, ManBo-H, Max-R-Br, Min-R-Br, Max-R-H,Con-L, Con-Br, MF-MT, MF-Go and Go-Go

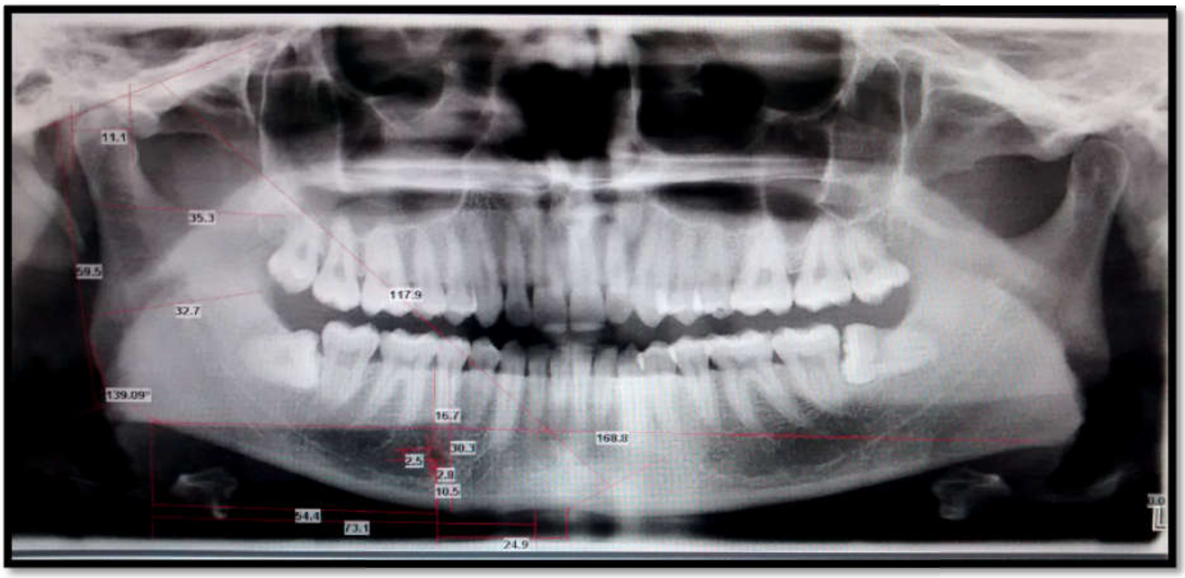

Figure 6. Mandibular measurements in OPG of a male patient

Figure 7. Mandibular measurements in OPG of a female patient

Sectioning points, standardized and unstandardized coefficients and structure matrix for all the variables are present in Table 4. Standardized discriminant function coefficients indicate relative importance of each variable in predicting the gender. Height of body of mandible (ManBo-H) makes the greatest contribution and bigonial (Go-Go) width contributes least. Unstandardized discrimination function coefficients are used to construct the actual prediction equation in order to calculate the discriminant scores. If the result is below the sectioning point, the person is female, and if over the sectioning point, the person is male.

DISCUSSION

In the present study 16 variables were analyzed in age matched individuals for sex determination those were ***mandibular angle (Man A), distance between mental foramen*** and basal border of the mandible (MF-BaB), distance between mental foramen and alveolar border of the mandible (MF-AlB), mental foramen breadth (MF-Br)**,** mental foramen height (MF-H), length of the mandibular body (ManBo-L),maximum length of the mandible (Max-L-Man), height of the mandibular body (ManBo-H),maximum ramus breadth (Max-R-Br), minimum ramus breadth (Min-R-Br), maximum ramus height (Max-R-H), length of the condyle (Con-L), breadth of the condyle (Con-Br), distance between the centre of mental foramen and mental tubercle (MF-MT),distance between the centre of foramen mentale and gonion (MF-Go), bigonial width (Go-Go).Out of these 16 variables 9 variables were highly significant for sex determination which were, MF-BaB, ManBo-L, Max-L-Man, ManBo-H, Max-R-Br, Min-R-Br, Max-R-H, MF-Go, Go-Go and variables MF-Br and MF-MT were significant. In a similar study conducted by Vodanovic *et al*. (2006) variables Man-A, MF-AlB, ManBo-L, Max-L-Man, ManBo-H, Max-R-Br, Min-R-Br, Max-R-H and Go-Go exhibit statistically significant sexual dimorphism. Rosas *et al*. found that the mental foramen area does not sexual differences in humans, but ramus height , gonion and coronoid processes present a high degree of sexual dimorphism (Vodanovic *et al*., 2006).

Fabian and Mpembeni (2002) conducted a study to study the mandible of known age and gender and to determine sexual dimorphic features. Heights were measured at the level of mental foramen and symphesyeal height at level of symphysis menti, bicondylar distance, and height of ramus, width and lenth of condylar process out of which height of ramus, height of basal bone and height of body of mandible were statistically significant in sex determination.

Rai (2007) conducted a study on 103 orthopantomograms of edentulous patients, aged (55-76 years). Different parameters such as; height of mandibular body, distance between lower mandible border to superior margin of mental foramina, distance between the superior margin of mental foramina to crest of the alveolar ridge and from the lower border to crest of alveolar ridge. Out of these parameters the distance between the superior margin of mental foramina to crest of the alveolar ridge showed significance in sex determination.

Kalinowski and Różyło-Kalinowska (2011) had done a study consisting of 877 digital panoramic radiographs of patients aged 20 to 95 years which included 467 females and 410 males in order to determine normal ranges of panoramic radiomorphometric parameters and examine the influence of gender and age on them.Parameters such as mandibular height (H) and distance between inferior margin of mental foramen and inferior mandibular cortex (h), were used for calculation of panoramic radiomorphometric indices. In males the mean values were significantly greater for mandibular height. Both the parameters were statistically significant.

Raghda AL-Shamout *et al*. (2012) examined a total of 209 (103 males and 106 females) dentate subjects aged 11 and 69yrs using digital panoramic radiography to investigate the influence of age and gender differences using three mandibular parameters gonial angle, ramus height and bigonial width in dentate Jordanian subjects. Out of which bigonial width and gonial were statistically significant to determine the sex.

Vinay *et al*. (2013) evaluated 250 human dry mandible for sex determination. Parameters like bigonial breadth, Bicondylar breadth and Mandibular length were measured using Mandibulometer and Vernier caliper. The mandibular length, bigonial breadth and bicondylar breadth showed significant statistical gender difference.

Thakur *et al*. (2014) conducted a study using Orthopantomographs of 102 Dentulous patients of age group of less than 25 years, 25-50 years and above 50 years for sex determination. The following measurements were done digitally 1) The height of mandibular body 2) The distance between the superior margins of the mental foramen to the inferior border of the mandible on the right side. 3) The distance between the inferior margins of the mental foramen to the inferior border of the mandible on the right side. 4) The distance between the superior margin of the mental foramen to the alveolar crest on the right side. Out of these four measurements only height of the mandible showed statistic significance for sex determination.

Conclusion

This research showed that variables length of body of mandible, maximum length of mandible, height of body of mandible, maximum and minimum breadth of ramus, height of ramus and bigonial width exhibit highest degree of sexual dimorphism. These gender specific mandibular features make the sex identification possible and reliable in cases with damaged and partially preserved lower jaws. Many visible sex traits are absent in infancy and childhood, developing fully in puberty, apparently by hormonal changes. Size and specific muscular relief emerge as the most diagnostic sex-related characters. Distinctive female specimens included small size and smooth muscle attachments, while male specimens are larger, with strong muscle attachments. It is well known that permanent use of a part of a body for occupational purposes produces some bone changes like the specific size and relief of muscle attachments. Different cultures exhibit different patterns of occupational stress hence population-specific standards must be developed for sex determination. The present study revealed that the sex of the human mandible can be assessed by using radiographic methods.

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