Original Article

Determination of Sex by Cone-beam Computed Tomography Analysis of Mental Foramen in South Indian Population

TS Subash, BM Balaraj[1], C Hema[2]

From the Department of Dentistry, Mysore Medical College and Research Institute, [1]Department of Forensic Medicine, JSS Medical College and Hospital, Mysore, [2]Department of Oral Medicine and Radiology, Dentascan CBCT Centre, Bengaluru, Karnataka, India

Received: October, 2018.
Accepted: December, 2018.

ABSTRACT

Background: One of the most challenging tasks for forensic dentists and anthropologists has been identification and determination of sex of unknown human skeletal remains.
Aim: To determine sexual dimorphism by CBCT (3-D) analysis of mental foramen among the south Indian population.
Materials and Methods: Total of 116 CBCT images of subjects were analysed. Distance from the superior border of mental foramen to lower border of mandible (SLM) and the inferior border of mental foramen to lower border of mandible (ILM) were calculated by three examiners and recorded.
Statistical Analysis: Descriptive statistics, paired t-test and independent sample t-test were used for statistical comparisons.
Results: The mean distance of right SLM among male and female subjects were 17.07±1.64 and 14.92 ± 1.33 respectively. Similarly of the left side of male and female subjects were 13.30 ±1.52 and 11.73± 1. The mean distance of left ILM among male and female subjects were 13.44± 1.68 and 11.79 ± 1.21 respectively and on the left side of male and female subjects were 1.3 ± 1.52 and 11.73 ± 1.27. There was a statistically significant difference between sex and sides in terms of SLM and ILM (P = 0.0001).
Conclusion: Distances from mental foramen to the lower border of mandible demonstrates sexual dimorphism.

Key Words: *CBCT, mental foramen, Sex determination*

Introduction

Identification and determination of sex of unknown human skeletal remains especially in mass disasters, totally mutilated, putrefied, and skeletal remains have been one of the most challenging tasks for forensic dentistry and anthropologists.

There are certain skeletal remains which can guide forensic experts toward accurate identification; one such can be human mandible which is the strongest bone that persists in a well-preserved state longer than any human bone.[1] Therefore, the use of morphological features of the mandible is a common approach used by the anthropologists and forensic dentists in the determination of sex.[2]

There are needs for a systemic compilation of population-specific standards that are the need of the hour.[3,4] Among many anatomical landmarks in the human skull, the mental foramen is a stable landmark on the mandible.[5] It is a funnel-like opening, on the lateral surface of the mandible at the terminus of the mental canal, it lies near the apices of the premolars and transmits the mental nerves and vessels. The opening is directed outward, upward, and superiorly.[6] Previously, many studies have used radiographs as an indispensable tool in forensic anthropology and till date have very heavily relied on its usefulness. But with its share of drawbacks and inaccuracies, which does not enable a three-dimensional (3D) view leading to lots of guesswork with subsequent loss of myriad of information that is required for a near accurate predictions in forensic sciences.[3,5,7-9]

Now with technological advancement, we are in a better position to accurately identify the anatomical landmarks by 3D viewing and reconstruction of the entire facial contours which leads to near perfect measurements of landmarks which can be well-documented, preserved, reviewed, and shared with another anthropologist one such technological advancement is in the form of cone-beam computed tomography (CBCT).[10,11]

Skeletal characteristics vary by the population (ethnic/race), and there are meager data available on the same among the south Indian population. Hence, the purpose of this study was to determine the gender from the analysis of mental foramen on CBCT (3D) in the south Indian population.

Address for correspondence:
Dr. TS Subash, E-mail: tssubash@yahoo.com

Access this article online

Quick Response Code:

Website: www.ijofo.org

DOI: 10.4103/ijfo.ijfo_33_18

How to cite this article: Subash TS, Balaraj BM, Hema C. Determination of sex by cone-beam computed tomography analysis of mental foramen in South Indian Population. Int J Forensic Odontol 2019;4:21-6.

Figure 1: Cone beam computed tomography

Figure 2: Kodak 9500 - cone beam computed tomography

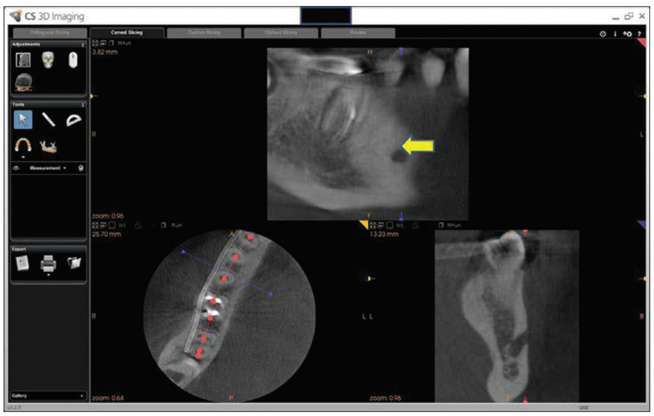

Figure 3: Arrow pointing to superior aspect of mental foramen in Modified Sagittal view. This is where the mouse is initially clicked after selecting the distance measurement tool

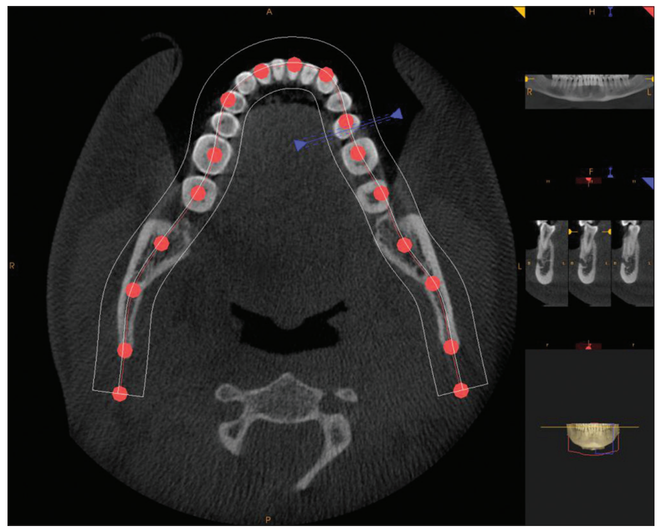

Figure 4: Reformated

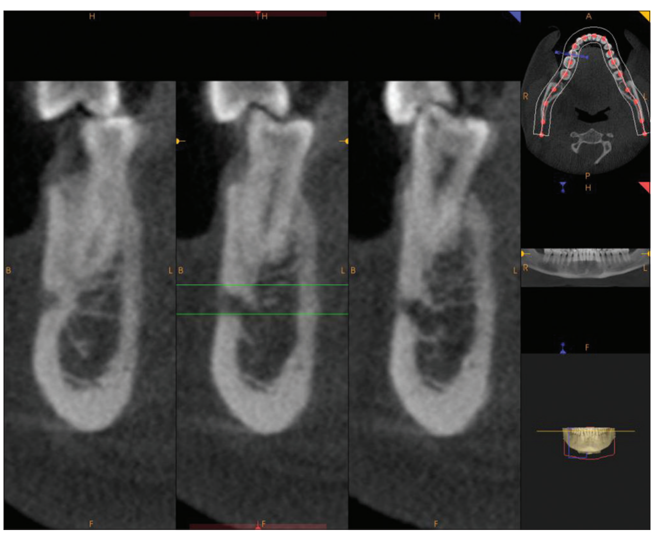

Figure 5: Tangent Marking - Upper border and lower border

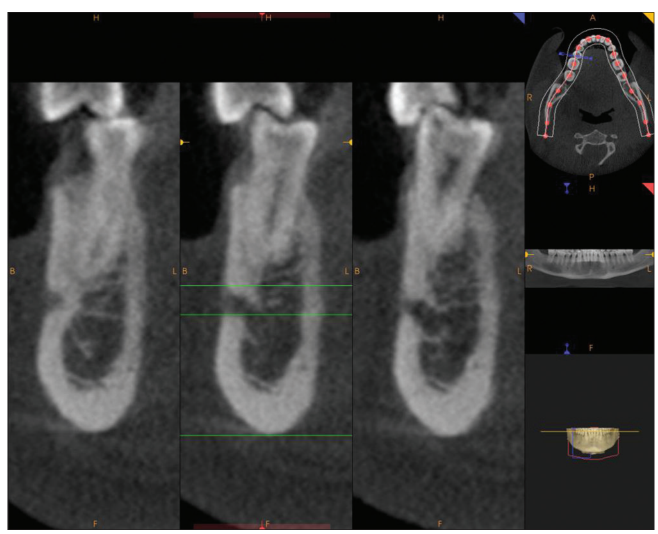

Figure 6: Tangent Marking - base of mandible

Materials and Methodology

A retrospective research on 115 south Indian population of both sexes using CBCT (Kodak 9500 Series) was undertaken in the department of forensic odontology, JSS Dental College, Mysore and at Denta scan CBCT Centre, Bangalore from August 2013 and March 2014 by three examiners (Endodontist, Oral radiologist, Orthodontist) with CS-3D software of 200 micron resolution. The adjusted scan parameters were 90Kvp, 10 - 42 mA depends on the size of the patients. The exposure time was 12sec [Figures 1 and 2].

All the three examiners were blinded so that to reduce the inter-observer bias that could result from selection, reforming or identifying anatomical specific site landmarking undertaken on the CBCT slices. The inclusion criteria comprised the subjects more than 18 years whose skeletal growth had been completed and only high-quality imaging's with the correct position and identifiable features were selected with known patient's age, sex and origin. (1^{st} generation of parentage was considered). The exclusion criteria were the subjects with pathologic lesions in the mandible.

A total of 150 CBCT were screened out of which only 116 were selected for the analysis which satisfied the inclusion criteria. (66 males & 49 females) Multiplanar reformatted images were created from the data set and the transverse section was utilized for identification. Following identification of foramina, 3 transverse section were obtained of each right and left side, now the best slice amongst the 3 sections was identified in concurrence with 3 observers, [Figures 3 and 4] and a tangent was drawn from the superior and inferior border of mental foramen respectively using the ruler software (Cs=3D) [Figures 5 and 6]. Now perpendiculars were drawn from these 2 tangents to the lowermost of the mandible (maximum parabolic curvature) and distances were noted both on right and left side simultaneously [Figures 7 and 8].

The data so obtained were noted, tabulated & subjected to statistical analysis with Statistical Package for Social Science (SPSS) (version 20, SPSS Inc., Chicago, IL).

Results

From 115 CBCT images, 66 and 49 images belonged to men and women, respectively. The mean age of the patients was 36.31 ± 13.87 [Table 1]. Mental foramen was present in both the sides of all the images and the mean diameter of mental foramen was 3.4 ± 1.07 on the right side and 3.01 ± 1.0 on the left side.

The mean distance from the superior border of mental foramen to the inferior border of mandible (SLM) on the right side for males was 17.07 ± 1.64 mm and for females was 14.92 ± 1.33. Mean SLM on the left side of males was 16.63 ± 1.45 mm and in females was found to be 14.41 ± 1.39. The results of paired *t*-test showed statistically significant differences in SLM distance between the right and left sides (P = 0.07) [Table 2]. There were statistically significant differences between genders in SLM (P = 0.001), and SLM distances were greater in men than in women [Table 3].

Table 1: Mean age and sex distribution

	n	Mean age±SD
Males	66	34.97±13.63
Females	49	38.02±14.19

SD: Standard deviation

Table 2: Paired mean differences of left- and right-sided distance between superior border of mental foramen to the lower border of mandible and distance between inferior border of mental foramen to the lower border of mandible among males and females

	Paired differences mean	*t*	*P*
Males			
Pair 1			
Right SLM - left SLM	0.44	2.80	0.007
Pair 2			
Right ILM - left ILM	0.14	1.03	0.306
Females			
Pair 1			
Right SLM - left SLM	0.51	3.01	0.004
Pair 2			
Right ILM - left ILM	0.06	0.56	0.577

*Statistical significance at >0.05. *t*: Paired *t*-test value, SLM: Distance between superior border of mental foramen to the lower border of mandible, ILM: Distance between inferior border of mental foramen to the lower border of mandible

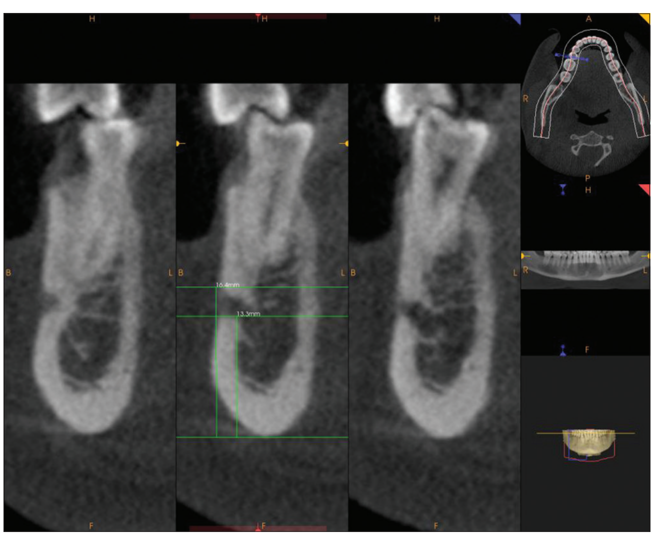

Figure 7: Tangent Markings - to lower border - 1

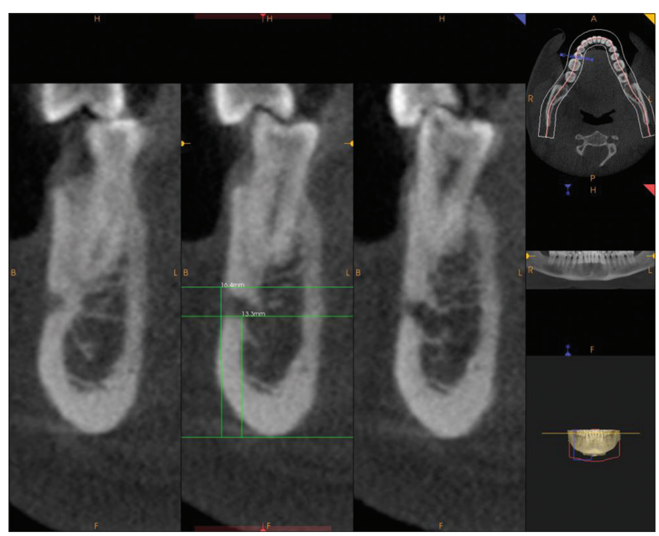

Figure 8: Tangent Markings - to lower border - 2

Table 3: Right- and left-sided distance between superior border of mental foramen to the lower border of mandible mean difference in males and females

Side	Gender	*n*	Mean±SD	95% CI for mean		*t*	Significance (two-tailed)
				Lower bound	Upper bound		
Right	Male	66	17.08±1.65	16.67	17.48	7.51	0.0001*
	Female	49	14.92±1.33	14.54	15.31		
	Total	115	16.16±1.85	15.82	16.50		
Left	Male	66	16.63±1.46	16.28	16.99	8.21	0.0001*
	Female	49	14.42±1.39	14.02	14.82		
	Total	115	15.69±1.80	15.36	16.02		

*Statistical significance at >0.05. SLM: Distance between superior border of mental foramen to the lower border of mandible, *n*: Sample, SD: Standard deviation, *t*: Independent sample *t*-test value, CI: Confidence interval

Table 4: Right- and left-sided distance between inferior border of mental foramen to the lower border of mandible mean difference in males and females

Side	Gender	*n*	Mean±SD	95% CI for mean		*t*	Significance (two-tailed)
				Lower bound	Upper bound		
Right	Male	66	13.44±1.68	13.03	13.73	5.81	0.0001*
	Female	49	11.80±1.22	11.45	12.21		
	Total	115	12.74±1.70	12.43	13.02		
Left	Male	66	13.30±1.53	12.93	13.68	5.81	0.0001*
	Female	49	11.74±1.28	11.37	12.11		
	Total	115	12.64±1.62	12.34	12.94		

*Statistical significance at >0.05. ILM: Distance between inferior border of mental foramen to the lower border of mandible, *n*: Sample, SD: Standard deviation, *t*: Independent sample *t*-test value, CI: Confidence interval

The mean distance from the Superior border of mental foramen to lower border of mandible (SLM); the inferior border of mental foramen to lower border of mandible (ILM) in the right side for males was 13.44 ± 1.68 mm and for females was 11.79 ± 1.21 mm. Mean ILM on the left side of males was 13.3 ± 1.52 mm and in females was found to be 11.73 ± 1.27 mm. The results of paired *t*-test showed no statistically significant differences in ILM distance between the right and left sides (P = 0.306) [Table 2]. There were statistically significant differences between genders in ILM (P = 0.000), and ILM distances were greater in men than in women [Table 4].

Discussion

The mandible is the strongest bone in the human body, especially in the head region,[1] development of mandible begins well at the 3rd month of intrauterine life as a small horse-shoe bend and tends to grow up to circumpubertal growth (girls 11–12 years and boys 16–18 years). These changes can happen up to third decade of life, because these changes are the result of aging or maturational process rather than growth and some changes imply a decrease rather than increase in dimensions and are more pronounced in females because they begin and completed their active growth and development period earlier than men, also begin aging earlier and display more significant changes in the third decade of life.[12]

Mental foramen is an important landmark located on each side of the buccal cortex of the mandibular bone and lies near the apices of the premolars and has shown to be located precisely at the same level on most humans, except at times few variations varying from the mesial root of mandibular first molar up to canine.[6] The opening of the mental foramen is directed outward, upward, and posteriorly viewed from inside out, transmitting the mental vessels and nerve.[6]

There is a considerable debate regarding the normal position of mental foramen in different population and major amount of studies are based on the panoramic radiographic images (2D) which is a curved plane tomographic radiographic technique used to depict the body of the mandible, the maxilla, and the lower half of the maxillary sinuses on a single image, the ability to view the entire body of the mandible allows more accurate location of mental foramen in both horizontal and vertical dimension on panoramic radiographs.[13] Although it is written in anatomy textbook that mental foramina are centered vertically in the mandible in patients with complete dentitions, the analysis of vertical positions of mental foramina on panoramic radiographs shows that they are frequently positioned lower than expected. Although the vertical angulation of panoramic radiography may be one reason for this discrepancy, there may be more significant reasons that contribute to the lower position of the mental foramina. The radiographic mental foramina may actually represent a section of the mental canal and not the foramen itself.[9,14] But with advances in digitalization and introduction of 3D imaging like CBCT, where we can obtain the transverse section of up to 3-mm, we have decided to utilize this advancement to avoid the pitfalls of panoramic radiographs.[10,11]

Most of the researches proven that,[13,15,16] despite alveolar bone resorption above the mental foramen the distance from the foramen to the inferior border of the mandible (basal bone) remains relatively constant or static throughout life, therefore can be accounted or considered as a stable landmark on the mandible. Hence, based on these proven works of literature, it was considered and decided in our research to measure the distance from the superior and the inferior border of the mental foramen to the lowermost borders (maximum parabolic curvature) of the mandible on both the sides between sexes.

The present research utilized CBCT (Kodak 9500-3D imaging) where it sections right through the mental foramen, and we obtain a 1:1 ratio to reduce the errors that commonly occur in panoramic radiographs such as magnification of 15%–20%, −50° angulation, and the object has to be within the focal trough. Accurate reproducible vertical and horizontal angulations and bone density and direction of mental foramen,[9,14] all play an important role leading to radiograph artifacts which at times could lead to significant errors in the precise prediction of location, size, and shape of the mental foramen.[9,14]

The confidence interval range shows that SLM values in males on both sides (R − 17.07 and L − 16.63) were higher compared to the females (R − 14.92 and L − 14.41), and for ILM, males exhibited higher values (R − 13.44 and L − 13.30) compared to females (R − 11.79 and L − 11.70). These results are in accordance with worldwide researches of a variety of ethnic groups.[3,5,17-19]

These results clearly suggest that if a distance of above 16.33 mm (SLM) and 13.30 mm (ILM) is obtained the gender is male in 99% of the cases. Similarly, distances of below 14.41 mm (SLM) and 11.70 mm (ILM) are obtained, and then, the gender is female in 99% of the cases, and this is in accordance with study with Mahima *et al*.[5]

All the above findings are suggestive of obtaining separate values for the right and left SLM for both the sexes, which in case of ILM is not necessary as the individuals showed that the values were almost similar with nonsignificant differences, and this applies for both male and female groups. Therefore, the distance from any of the sides of ILM can be used as a representative for gender discrimination and is in agreement with Vodanović *et al*., who found that the mean value of ILM of both the sides is equal to each other; any side can be used to determine sexual dimorphism.[20] SLM values show statistical differences between left and right sides among both the sexes, these results are in partial agreement with the studies of Agthong *et al*.,[14] who have found differences in several measurements, suggestive that both gender and side should be considered when applying the anatomical variation data to an individual subject.[14]

It is evident from the results that we are not in agreement with the findings of some researches[3,5,19] due to various reasons such as population variations and radiographic techniques[7-9] where the mental foramen is more likely to be the image of the portion of the mental canal likely.[9]

As observed in this study, we found it difficult to identify the superior border of the mental foramen which is generally in continuation with the body of the mandible, could be also one of the key attributes to the variation in the results seen above.

Conclusion

The distance from mental foramen to the lower border of the mandible shows clear sexual dimorphism and bilateral measurement of SLM and ILM in both sexes can be used as an effective tool for gender discrimination.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Hu KS, Koh KS, Han SH, Shin KJ, Kim HJ. Sex determination using nonmetric characteristics of the mandible in Koreans. J Forensic Sci 2006;51:1376-82.
2. Sweet D. Why a dentist for identification? Dent Clin North Am 2001;45:237-51.
3. Chandra A, Singh A, Badni M, Jaiswal R, Agnihotri A. Determination of sex by radiographic analysis of mental foramen in North Indian population. J Forensic Dent Sci 2013;5:52-5.
4. Steyn M, Işcan MY. Sexual dimorphism in the crania and mandibles of South African whites. Forensic Sci Int 1998;98:9-16.
5. Mahima V, Patil K, Srikanth H. Mental foramen for gender determination: A panoramic radiographic study. Medico Legal Update 2009;9:33-5.
6. Haghanifar S, Rokouei M. Radiographic evaluation of the mental foramen in a selected Iranian population. Indian J Dent Res 2009;20:150-2.
7. Phillips JL, Weller RN, Kulild JC. The mental foramen: 3. Size and position on panoramic radiographs. J Endod 1992;18:383-6.
8. Yosue T, Brooks SL. The appearance of mental foramina on panoramic radiographs. I. Evaluation of patients. Oral Surg Oral Med Oral Pathol 1989;68:360-4.
9. Yosue T, Brooks SL. The appearance of mental foramina on panoramic and periapical radiographs. II. Experimental evaluation. Oral Surg Oral Med Oral Pathol 1989;68:488-92.
10. Miles DA. Atlas of Cone Beam Imaging for Dental Applications, Quintessence publishers. Batavia; 2008.
11. Zöller JE, Neugebauer J. Cone-beam Volumetric Imaging in Dental, Oral and Maxillofacial Medicine: Fundamentals, Diagnostics, and Treatment Planning: Germany; Quintessence; 2008.
12. Akgül AA, Toygar TU. Natural craniofacial changes in the third decade of life: A longitudinal study. Am J Orthod Dentofacial Orthop 2002;122:512-22.
13. Güler AU, Sumer M, Sumer P, Biçer I. The evaluation of vertical heights of maxillary and mandibular bones and the location of anatomic landmarks in panoramic radiographs of edentulous patients for implant dentistry. J Oral Rehabil 2005;32:741-6.
14. Agthong S, Huanmanop T, Chentanez V. Anatomical variations of the supraorbital, infraorbital, and mental foramina related to gender and side. J Oral Maxillofac Surg 2005;63:800-4.
15. Lindh C, Petersson A, Klinge B. Measurements of distances related to the mandibular canal in radiographs. Clin Oral Implants Res 1995;6:96-103.
16. Wical KE, Swoope CC. Studies of residual ridge resorption. I.

Use of panoramic radiographs for evaluation and classification of mandibular resorption. J Prosthet Dent 1974;32:7-12.
17. Amorim MM, Borini CB, de Castro Lopes SLP, Haiter-Neto F, Caria PHF. Morphological Description of Mandibular Canal in Panoramic Radiographs of Brazilian Subjects: Association Between Anatomic Characteristic and Clinical Procedures. International Journal of Morphology 2009;27:1243-47.
18. Ćatović A, Bergman V, Ćatić A, Seifert D, Poljak-Guberina R. Influence of sex, age and presence of functional units on optical density and bone height of the mandible in the elderly. Acta Stomatol Croat 2002;36:327-8.
19. Thomas C, Madsen D, Moses J, Peace J, Singham D, Whittle T. A radiological survey of the edentulous mandible relevant to forensic dentistry. In journal of dental research 2003;82:73.
20. Vodanović M, Dumančić J, Demo Ž, Mihelić D. Determination of sex by discriminant function analysis of mandibles from two Croatian archaeological sites. Acta Stomatol Croat 2006;40:263-77.