Sex determination and odontometric dimensions – A study of a North Indian population

Określanie płci i wymiarów odontometrycznych – badanie populacji północnych Indii

Nandini Chitara[1], Kewal Krishan[2]

[1] **PhD Research Scholar, Department of Anthropology, Panjab University, Chandigarh, India**
e-mail: chitaranandini058@gmail.com
[2] **Professor and former Chair, Department of Anthropology, Panjab University, Chandigarh, India**
e-mail: gargkk@yahoo.com

Abstract
Sex determination is an indispensable parameter in identifying unknown deceased individuals. It can narrow down the chances of possible matches by 50%, providing a crucial lead in personal identification. In cases of commingled, decomposed, fragmented, charred and unidentifiable corpses, the importance of dental morphometrics cannot be overlooked due to the resistance of teeth to post-mortem degradation. Addressing this quality of teeth, a descriptive cross-sectional study was conducted in a North Indian population to evaluate sexual variations in dental dimensions and to identify the most sexually dimorphic dental dimension. The study included 207 participants (114 females and 93 males) in the age group of 21 to 45 years. Dental casts were prepared after obtaining informed consent from the participants and ethical clearance from the institute's ethical committee. Six odontometric dimensions, namely incisor-incisor distance, inter canine distance, combined width of central incisors, inter-premolar distance, inter-molar distance, and dental arch height of each participant were recorded on the dental casts using standard procedures. Analysis of the data elucidated the existence of statistically significant sexual dimorphism in the dental dimensions of the participants. The results of the discriminant function analysis show a sex determination accuracy of 68.1%, with a cross-validation accuracy of 65.2%. The study found the incisor-incisor distance to be the most sexually dimorphic trait, making it the best predictor of sex in the present population. The results of the present study may be helpful in sex determination and personal identification from dental remains in medico-legal and disaster victim identification cases.

Keywords
Forensics, Personal identification, Forensic odontology, Odontometrics, Discriminant function analysis, Sex determination

Abstract
Określanie płci jest niezbędnym parametrem w identyfikacji zmarłych o nieznanej tożsamości. Może zawęzić szanse możliwych dopasowań o 50%, zapewniając przewagę w identyfikacji osobniczej. W przypadku zmieszanych, rozłożonych, rozdrobnionych, zwęglonych i niezidentyfikowanych zwłok nie można pominąć znacznia morfometrii zębów ze względu na odporność zębów na degradację pośmiertną. Zajmując się jakością zębów, przeprowadzono opisowe badanie przekrojowe w populacji północnych Indii, aby ocenić różnice płciowe w wymiarach zębów i zidentyfikować najbardziej dymorficzny wymiar zębów. W badaniu wzięło udział 207 uczestników (114 kobiet i 93 mężczyzn) w grupie wiekowej od 21 do 45 lat. Odlewy dentystyczne przygotowano po uzyskaniu świadomej zgody uczestników i zgody etycznej od komisji etycznej instytutu. Sześć wymiarów odontometrycznych, tj. odległość siekacz-siekacz, odległość między kłami, łączna szerokość siekaczy centralnych, odległość między zębami przedtrzonowymi, odległość między zębami trzonowymi, wysokość łuku zębowego każdego uczestnika zostało odnotowanych na odlewach zębowych przy użyciu standardowych procedur. Analiza danych wyjaśniła istnienie statystycznie istotnego dymorfizmu płciowego w wymiarach zębowych uczestników. Wyniki analizy funkcji dyskryminacyjnej pokazują dokładność klasyfikacji płci na poziomie 68,1% i 65,2% jako dokładność walidacji krzyżowej. Badanie wykazało, że odległość siekacz-siekacz jest najbardziej dymorficzną cechą płciową, która może być wykorzystana jako najlepszy predyktor płci w ocenianej populacji. Wyniki niniejszego badania mogą być pomocne w szacowaniu płci i identyfikacji osobniczej na podstawie pozostałości zębowych w przypadkach medyczno-sądowych i identyfikacji ofiar katastrof.

Keywords
kryminalistyka, identyfikacja osobnicza, odontologia sądowa, odontometria, analiza funkcji dyskryminacyjnych, określanie płci

Introduction and background

Sex, age and ethnicity are considered primary pillars in the field of anthropology for population studies, evolutionary studies and personal identification [1]. Specifically, sex determination is the foremost potential step in identifying an unknown individual in forensic, medico-legal cases and disaster victim identification. In living individuals, sex is determined by their biological appearance and genetic makeup. However, in unidentified decomposed, putrefied, fragmented corpses and skeletal remains, it is difficult to estimate the sex of the deceased as the opinion is based solely on fragmentary remains. In these situations, identification becomes a challenging task for forensic anthropologists and investigative teams. Therefore, forensic experts seek other scientific and reliable evidence and methods for identifying the unknown deceased. Teeth, because of their hard compositional aspects (enamel, dentin and cementum), resist environmental disturbances, fire, and chemical degradation [2]. This nature of teeth allows them to retain their structural and anatomical features in decomposing, putrefying, charred, fragmented and mutilated corpses. Therefore, the morphological, morphometric and molecular features of teeth can be utilized for personal identification in compromised dead bodies.

The reliability of dental evidence for personal identification is established by INTERPOL, which identifies forensic odontology as a primary identifier and main specialty in disaster victim identification [3]. The pivotal role of odontometrics in establishing the sex of an individual has been explored by various researchers in the past. Macaluso [4], Thapar et al. [5], Narang et al. [6], Sravya et al. [7], Satish et al. [8], and Gopinath et al. [9] elucidated the dental dimensions for sex determination in South African, and various Indian population groups, respectively. These studies found a significant to highly significant association of dental measurements with sex. Gouveia et al. [10] conducted a unique study on burned remains and achieved an accuracy of more than 80% for sex determination using odontometrics. Researchers have explored a variety of dental dimensions with respect to sex determination, however, the literature lacks the identification of the best and most reliable dental parameter for sex determination.

Aim of the work

Addressing this research gap, the present study is an attempt to classify sex on the basis of dental dimensions with the help of discriminant function analysis. The study also seeks to identify the best odontometric predictor of sex in a North-Indian population and its application in medico-legal cases, personal identification and disaster victim identification.

Material and methods

Study Area and Study Population

The present research is a cross-sectional study conducted in the state of Haryana in North India. A total of 207 healthy participants were included in the study, comprising 114 females and 93 males. Almost all teeth are usually erupted in the oral cavity at the age of 21 years and after the age of 45 years, attrition and other natural changes occurring in the teeth proceed at a higher pace and are visibly marked [11,12]. Therefore, the participants were selected in the age group of 21 to 45 years with no dental diseases, no restorative work, and no orthodontic treatment. The present work is part of an ongoing Ph.D. research study in the Department of Anthropology, Panjab University, Chandigarh, India. Informed written consent was obtained from the subjects after explaining the nature and purpose of the study to them. Moreover, the study has been ethically approved by Panjab University Institutional Ethical Committee, Chandigarh vide approval number: PUIEC 230602-I-114 dated 9th June 2023.

Data Collection and Evaluation

The primary data collection for the present study included general and demographic details, as well as the preparation of dental casts from the participants. All the participants belonged to the ***Jingar*** endogamous group (a genetically homogenous population), a native population of the Karnal region in Haryana state, North India. The demographic details included the name, sex, age and address of the participants. For the preparation of dental casts, an impression tray was used to obtain the dental impression with Neoalgin alginate impression material. The prepared dental impression was then poured with dental stone (Kalabhai Kalstone plaster class III) material. The poured cast was dried at room temperature (37° C) until completely dry and then carefully removed to prevent any breakage.

Six odontometric dimensions, namely incisor-incisor distance, inter canine distance, combined width of central incisors, inter-premolar distance, inter-molar distance, and dental arch height were measured on the dental cast of each participant. Dental measurements were obtained following the standard procedures prescribed by Zorba et al. [13] and Moreno- Gómez [14]. A standard sliding caliper was used for measuring dental dimensions in the laboratory. The description and illustration of the obtained odontometric dimensions are presented in Table I and Figure 1, respectively.

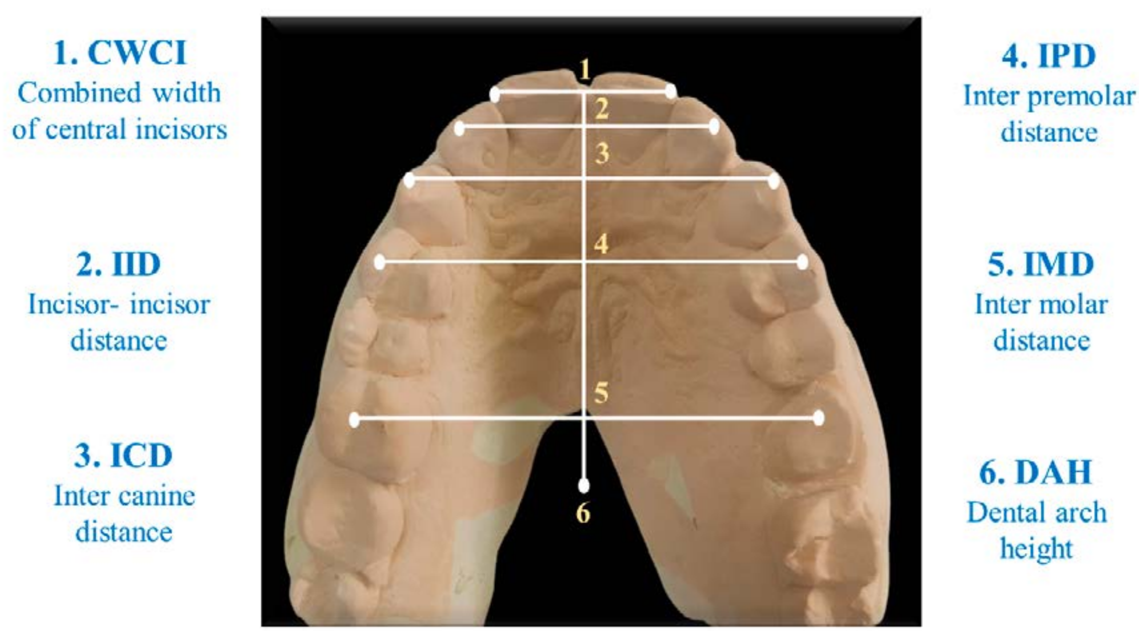

Fig. 1. Various maxillary dental dimensions included in the present study

Table I. Various dental measurements utilized in the present study [13,14]

Dental dimension	Abbreviation used	Description
Incisor-Incisor distance	IID	The distance measured from the maxillary right to the maxillary left lateral incisors. It is measured using a sliding caliper from the center point on the incisal surface of the lateral incisors.
Inter Canine distance	ICD	The distance measured from the cusp tip of the maxillary right canine to the cusp tip of the maxillary left canine. It is recorded with the help of a sliding caliper.
Combined Width of Central Incisors	CWCI	The combined distance of mesio-distal width of two maxillary central incisors, measured with a sliding caliper.
Inter-Premolar Distance	IPD	The distance measured from the cusp tip on the occlusal surface of the right first premolar to the cusp tip of the left first premolar. It is measured with the help of a sliding caliper.
Inter-Molar Distance	IMD	The distance measured from the buccal groove (on the occlusal surface) of the right maxillary first molar to the buccal groove of the maxillary left first molar. It is also recorded with the help of a sliding caliper.
Dental Arch Height	DAH	The distance measured from the occlusal plane of the maxillary first molar to the palatal contour.

Hypothesis Formulation

Through the null hypothesis (H0), it was assumed that "no statistically significant differences exist in the dental dimensions with respect to the sex of the individuals in the test population".

Statistical Analysis

The collected data was entered into the Microsoft Excel software program. Pre-screening and verification of the data were conducted in Microsoft Excel to identify and correct any typological or other errors. Descriptive and inferential analyses of the data were conducted using IBM SPSS (Statistical Product and Service Solution) software version 20.0. The normality of the data was accessed using both descriptive and graphical tests. Mean= Mode= Median, Normal Q-Q plots, and Stem and Leaf test were utilized as presumptive measures, whereas Shapiro-Wilk and Kolmogorov- Smirnov tests were employed as confirmatory normality measures. All approaches confirmed that the data was not normally distributed. Therefore, a non-parametric test, the Mann-Whitney U test (which compares the means of the variables without assuming the normal distribution of the parameters), was applied to the data for inference of sexual dimorphism in dental measurements. Further, discriminant function analysis was applied to assess the group membership based on sexual dimorphism in the variables. The significance level of the test was determined by the p-value with $p<0.05$ considered significant.

Results

The descriptive statistics of the data (minimum, maximum, mean, median, mode, standard deviation) are shown in Table II. Further, the Shapiro-Wilk and the Kolmogorov- Smirnov tests confirmed, at a 95% confidence level, that the data is not normally distributed. The statistics and significance levels of the Shapiro-Wilk and the Kolmogorov- Smirnov tests are shown in Table III ($p<0.05$ indicated that the data is not normally distributed). Because all the variables were not normally distributed, the Mann-Whitney U test was employed to assess sexual variations in dental dimensions. Table IV signifies the test statistics of the Mann-Whitney U test along with their significance values.

In the assessment of sexual dimorphism, it was observed that males exhibit higher values of dental measurements as compared to their female counterparts. The mean rank of each test dimension was higher in males than in females (Table IV). The $p<0.05$ for all parameters indicated that the null hypothesis should be rejected, concluding that statistically significant differences exist in the dental dimensions with respect to the sex of the individuals in the test population. Statistically highly significant ($p<0.01$) sex differences in mean rank were recorded in incisor-incisor distance, followed by inter molar distance and inter premolar distance. The least mean rank difference was observed in combined width of central incisors (Table IV).

Further, group membership of parameters was assessed through discriminant function analysis. Based on the variables (IID, ICD, CWCI, IPD, IMD, DHA), a discriminant function model (DFM) was generated. The developed DFM is as follows:

$$Y = -23.04 + IID \times 2.830 + ICD \times -0.467 + CWCI \times -0.408 + IPD \times 0.837 + IMD \times 1.962 + DAH \times 1.065$$

where: Y = Discriminant score, IID= Incisor-incisor distance, ICD= Inter canine distance, CWCI= Combined width of central incisors, IPD= Inter-premolar distance, IMD= Inter-molar distance, DAH= Dental arch height.

Table II. Descriptive statistics of the data for presumptive normality assessment

Variable	Sex and sample size	Minimum (cm)	Maximum (cm)	Mean (cm)	Median (cm)	Mode (cm)	Standard deviation (cm)
IID	Female (114)	2.60	3.50	2.96	3.00	3.00	0.181
	Male (93)	2.60	3.50	3.07	3.10	3.00	0.182
ICD	Female (114)	2.80	4.30	3.55	3.50	3.40	0.283
	Male (93)	3.10	4.20	3.67	3.60	3.40	0.278
CWCI	Female (114)	1.30	2.40	1.83	1.80	1.80	0.199
	Male (93)	1.60	2.40	1.88	1.80	1.80	0.160
IPD	Female (114)	3.10	4.20	3.59	3.60	3.40	0.245
	Male (93)	3.20	4.20	3.72	3.70	3.70	0.214
IMD	Female (114)	4.10	5.40	4.75	4.75	4.70	0.272
	Male (93)	4.00	5.50	4.91	5.00	5.00	0.295
DAH	Female (114)	3.30	5.10	4.08	4.00	4.00	0.415
	Male (93)	3.50	5.10	4.23	4.20	4.00	0.372

where: IID= Incisor-incisor distance, ICD = Inter canine distance, CWCI = Combined width of central incisors, IPD = Inter-premolar distance, IMD = Inter-molar distance, DAH = Dental arch height.

Table III. Test statistics of confirmatory normality assessment tests: the Shapiro-Wilk and the Kolmogorov- Smirnov test

Variable	Shapiro-Wilk test	p-value	Kolmogorov- Smirnov test	p-value
IID	0.965	0.000	0.156	0.000
ICD	0.979	0.003	0.099	0.000
CWCI	0.943	0.000	0.208	0.000
IPD	0.973	0.001	0.129	0.000
IMD	0.976	0.002	0.128	0.000
DAH	0.979	0.003	0.112	0.000

where: IID = Incisor-incisor distance, ICD = Inter canine distance, CWCI = Combined width of central incisors, IPD = Inter-premolar distance, IMD = Inter-molar distance, DAH = Dental arch height, p<0.05 = normal distribution

Table IV. Test statistics of the Mann-Whitney U test with the mean ranks of the variables for both sexes

Variable	Sex	Sample Size	Mean Rank	Mann-Whitney U test	p-value
IID	Male	93	123.91	3449.500	0.000
	Female	114	87.76		
ICD	Male	93	117.53	4043.000	0.003
	Female	114	92.96		
CWCI	Male	93	114.60	4315.000	0.019
	Female	114	95.35		
IPD	Male	93	122.94	3540.000	0.000
	Female	114	88.55		
IMD	Male	93	123.45	3492.000	0.000
	Female	114	88.13		
DAH	Male	93	116.00	4185.000	0.009
	Female	114	94.21		

where: IID = Incisor-incisor distance, ICD = Inter canine distance, CWCI = Combined width of central incisors, IPD = Inter-premolar distance, IMD = Inter-molar distance, DAH = Dental arch height, significant level is defined as p<0.05

The explanatory power defines the ability of a variable to effectively explain or predict the parameter/ subject matter/dependent variable to which it pertains. It was observed that incisor-incisor distance has the most explanatory power with a coefficient of function 0.752 (0.752 ×100 = 75.2%, i.e., 75.2% predictive power for sex), followed by inter molar distance, inter premolar distance, inter canine distance and dental arch height. The combined width of central incisors was found to have the least explanatory power with a coefficient of function 0.336 (0.0336 ×100 = 3.36%, i.e., 3.36% predictive power for sex) (Table V).

Table V. Correlation between discriminating variables and standardized canonical discriminant functions

Variable	Function
	1
IID	0.752
IMD	0.708
IPD	0.664
ICD	0.541
DAH	0.441
CWCI	0.336

where: IID = Incisor-incisor distance, ICD = Inter canine distance, CWCI = Combined width of central incisors, IPD = Inter-premolar distance, IMD = Inter-molar distance, DAH = Dental arch height

Moreover, the group centroids were recorded as 0.453 for males and – 0.369 for females. Therefore, it indicates the probability of a male if an individual's discriminant score from the discriminant function model falls between 0 to 0.453. Whereas, it indicates the possibility of a female if individual's discriminant score falls between 0 and -0.369.

Further, it was found that 68.1% of original group cases were correctly classified. Moreover, utilizing leave-one-out classification the developed DFM was cross-validated, and an accuracy of 65.2% was observed in cross-validation. The accuracy of the results signifies that the model is moderately good.

The canonical coefficient, Wilks' Lambda, and the Eigen value for the discriminant function are defined in Table VI. It was found that the canonical correlation for the developed DFM is 0.380, indicating that the model is moderately good. The Eigen value of 0.169 and the Wilks' Lambda value of 0.856 further support that the model is moderately good.

Table VI. Statistics of discriminant function analysis

Function	Eigen value	Canonical correlation	Wilk' Lambda	Df	Sig.
1	0.169	0.380	0.856	6	0.000

Discussion

Sex determination plays a vital role in personal identification, especially in forensic examinations. Estimating the sex of an individual is the primary step followed by forensic anthropologists and forensic pathologists when establishing the identity of the unknown. When commingled remains, fragmented, and decomposed corpses are brought for forensic examination, sex determination becomes a challenging assignment. The resistant compositional aspects of teeth fascinate researchers for identifying individuals from dental remains. Previous studies have highlighted the significance of dental dimensions in estimating the sex of individuals [4-9]. Zorba et al. [13] found statistically significant differences in dental dimensions between sexes, with dental measurements significantly larger in males in a Greek population. Similar results were observed by Filipovic et al. [15] in a Siberian population, with canines being the most sexually dimorphic teeth. Filipovic et al. [15] also supported the finding that the dimensions of maxillary canines are the most sexually dimorphic dental trait.

The present study also found that dental dimensions were statistically significantly higher in males compared to their female counterparts, with incisor-incisor distance being the most sexually dimorphic dimension.

Variation in biological characteristics is a norm of human life and can be attributed to genetic, developmental and environmental factors. The reason behind males having larger dental dimensions can be attributed to genetic and developmental factors of teeth in both sexes. Regarding genetic factors, in humans, *AMELX* and *AMELY* are the two amelogenin genes responsible for the formation of enamel [16]. Because the *AMELX* gene is X-linked and females have two copies of the X chromosome, only one gene remains active due to the process of dosage compensation [17]. However, in males, both *AMELX* and *AMELY* (Y chromosome-linked) remain active, leading to the formation of a higher amount of enamel, greater enamel thickness, and thus larger dental dimensions in males. Regarding developmental factors, Moss et al. [18] suggest that the process of amelogenesis (the formation of enamel) takes a longer period in males, allowing them to develop thicker enamel, and thus larger dental dimensions. The larger dimensions of teeth in males may also be attributed to the generally larger body dimensions of males compared to females.

The results of the present study are supported by various previous studies [6,13,15]. However, identifying IID as the most sexually dimorphic dental dimension is a novel outcome of the present study.

However, a study conducted by Kaushal et al. [19] evaluated the mesiodistal width of maxillary central incisors with respect to sexual dimorphism in the North Indian population finding 3.84% dimorphism in right upper incisors and 4.52% dimorphism in left upper incisors. The results of this study were statistically insignificant and are contradictory to the present study, where 75.5% sexual dimorphism was found in IID (p<0.05).

Various other past studies have also identified other dental dimensions as the most sexually dimorphic traits. For instance, Fernands et al. [20] identified maxillary first molars in Brazilian participants, Narang et al. [6] identified mandibular first molars in a North Indian population, and Soundarya et al. [21] found maxillary canines and mandibular first molars to be the most sexually dimorphic traits in a South Indian population.

The variations in dental dimensions among different ethnic groups can be attributed to the environmental factors of their respective niches. Dunn and Dobzhansky [22] explained that all human beings have evolved from a single species. However, migration led humans to inhabit different environmental conditions. The variations in environmental exposure and dietary habits (due to variations in available food) have led to the evolution of variations in dentition among various ethnic groups living in different environmental conditions [23]. Therefore, it is emphasized that the results of the present study should be used with caution when applied to other populations around the world. Population diversity and variations exist globally, and the results of the present study may not be applicable to other populations.

The results of the present study may help in medico-legal cases and play a supportive role in identification. However, the accuracy and reliability of skull and pelvic bones in sex determination cannot be overlooked. Skull and pelvic bones are crucial for sex determination in skeletonized bodies. Sex determination by teeth is recommended in cases where other skeletal elements are missing or to support findings from the skull and pelvic bones.

Conclusion

The present study concludes that statistically significant sexual variations occur in the dental measurements in a North Indian population. The discriminant function analysis showed a sex determination accuracy of 68.1%, with a cross-validation accuracy of 65.2%. The study identified the incisor-incisor distance as the most sexually dimorphic trait, making it the best predictor of sex in the present population. Therefore, this study can be used as a method of sex determination in unidentified, compromised dead bodies and disaster victim identification in the absence of other skeletal remains.

Acknowledgements
The principal author (NC) is thankful to the University Grants Commission for funding the Ph.D. in the form of a research fellowship. This study is part of the ongoing PhD Project of the NC in the Department of Anthropology, Panjab University, Chandigarh, India. KK is supported by the UGC Centre of Advanced Study in Anthropology (CAS II), awarded to the Department of Anthropology, Panjab University, Chandigarh, India.

Ethical approval
The present study is part of Ph.D. research work in Department of Anthropology, Panjab University, Chandigarh, India. The ethical approval of the study was obtained from the Panjab University Institutional Ethical Committee vide approval number: PUIEC 230602-I-114 dated 09.06.2023. The consent of each participant was also obtained before data collection.

Declaration of Conflicting Interests
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding
The author(s) received no financial support for the research, authorship, and/or publication of this article.

References | Piśmiennictwo

1. Krishan K, Kanchan T, Garg AK. Dental evidence in forensic identification: An overview, methodology and present status. Open Dent J 2015; 9: 250-256.
2. Mohammed F, Fairozekhan AT, Bhat S, et al. Forensic Odontology. StatPearls Publishing, Treasure Island – Florida 2019.
3. INTERPOL. Disaster Victim Identification Guide. 2018. Available at: https://www.interpol.int/en/How-we-work/Forensics/Disaster-Victim-Identification-DVI. Accessed on: March 12, 2024.
4. Macaluso PJ. Investigation on the utility of permanent maxillary molar cusp areas for sex estimation. Forensic Sci Med Pathol 2011; 7: 233-247.
5. Thapar R, Angadi PV, Hallikerimath S, et al. Sex assessment using odontometry and cranial anthropometry: Evaluation in an Indian sample. Forensic Sci Med Pathol 2011; 8: 94-100.
6. Narang RS, Manchanda AS, Malhotra R, et al. Sex determination by mandibular canine index and molar odontometrics: A comparative study. Indian J Oral Sci 2015; 5: 16-20.
7. Sravya T, Dumpala RK, Guttikonda VR, et al. Mesiodistal odontometrics as a distinguishing trait: A comparative preliminary study. J Forensic Dent Sci 2016; 8: 99.
8. Satish BN, Moolrajani C, Basnaker M, et al. Dental sex dimorphism: Using odontometrics and digital jaw radiography. J Forensic Dent Sci 2017; 9: 43.
9. Gopinath T, Ganesh S, Subramani VN. Role of facial index and odontometric parameters in the establishment of stature and gender of individuals. J Pharm Bioallied Sci 2021; 13: S1068-S1073.
10. Gouveia MF, Santos IO, Santos AL, et al. Sample-specific odontometric sex estimation: A method with potential application to burned remains. Science & Justice 2017; 57(4): 262-269.
11. Liu B, Zhang M, Chen Y, et al. Tooth wear in aging people: An investigation of the prevalence and the influential factors of incisal/occlusal tooth wear in northwest China. BMC Oral Health 2014; 14: 65.
12. Chan AKY, Tsang YC, Lai EH-H, et al. Tooth Wear in Older Adults: A review of clinical studies. Geriatrics 2024; 9(1):12.
13. Zorba E, Moraitis K, Manolis SK. Sexual dimorphism in permanent teeth of modern Greeks. Forensic Sci Int 2011; 210(1-3): 74-81.
14. Moreno-Gómez F. Sexual dimorphism in human teeth from dental morphology and dimensions: A dental anthropology viewpoint. In: Moriyama H. Sexual Dimorphism. InTech, London – UK 2013; 97-125.
15. Filipovic G, Kanjevac T, Cetenovic B, et al. Sexual dimorphism in the dimensions of teeth in a Serbian Population. Coll Antropol 2016; 40(1): 23-28.

16. Hu JC, Chan HC, Simmer SG, et al. Amelogenesis imperfecta in two families with defined AMELX deletions in ARHGAP6. PloS one 2012; 7(12): e52052.
17. Brockdorff N, Turner BM. Dosage compensation in mammals. Cold Spring Harb Perspect Boil 2015; 7(3): a019406.
18. Moss ML, Chase PS, Flower RI Jr. Comparative odontometry of the permanent post canine dentition of American whites and Negroes. Am J Phys Anthropol 1967; 27: 125-42.
19. Kaushal S, Patnaik VV, Agnihotri G, et al. Maxillary central incisor morphometry in North Indians a dimorphic study. J Punjab Acad Forensic Med Toxicol 2005; 5: 13-7.
20. Fernandes LC, Veloso CV, Oliveira JD, et al. Odontometric analysis of molars for sex determination. Braz J Oral Sci 2016; 15: 35-8.
21. Soundarya N, Jain VK, Shetty S, et al. Sexual dimorphism using permanent maxillary and mandibular incisors, canines and molars: An odontometric analysis. J Oral Maxillofac Pathol 2021; 25(1): 183-188.
22. Dunn LC, Dobzhansky T. Heredity, race, and society. Penguine Books 1946.
23. Sanin C, Savara BS. An analysis of permanent mesiodistal crown size. Am J Orthod 1971; 59: 488-500.

Date:
date of submission | data nadesłania: **29.06.2024**
acceptance date | data akceptacji: **13.08.2024**

Corresponding author:
Dr. Kewal Krishan, Ph.D., FRAI
Professor and former Chair,
Department of Anthropology,
(UGC Centre of Advanced Study)
Panjab University, Sector-14,
Chandigarh, India
E-mail: gargkk@yahoo.com; kewalkrishan@pu.ac.in
+919876048205 (Mobile)

ORCID:
Nandini Chitara: 0000-0002-1903-9592
Kewal Krishan: 0000-0001-5321-0958