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Original Research Article

Sexual Dimorphism from Mandibular Canine Index in Autopsied Bodies – A Pilot Study

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Forensic odontology,
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Abstract

Background: Teeth are pivotal in forensic identification due to their resilience and unique characteristics. This study investigates the sexual dimorphism of mandibular canines which is crucial for identifying decomposed or mutilated remains. **Materials and Methods:** Sixty autopsied individuals, aged 20 to 50 years, from a Mumbai tertiary center, were examined. Digital Vernier calipers measured mandibular inter-canine distance and mesiodistal crown width of canines. **Results:** A significant sexual dimorphism was found in inter-canine distance ($p = 0.036$) and mesiodistal crown width of canines (right: $p = 0.011$, left: $p = 0.001$). Males showed larger dimensions than females. The MCI achieved 76.66% accuracy in sex determination, with higher predictability for males (73.33%) than females (80%). Logistic regression models reached up to 90% accuracy, emphasizing the effectiveness of MCI in sex prediction. **Discussion:** Mandibular canines proved reliable for sex determination in forensic contexts, aligning with previous studies. Population-specific variations and limitations such as age-related changes highlight the need for cautious interpretation. **Conclusion:** This study preliminarily confirms mandibular canines as valuable tools in forensic sex determination. Future research should focus on expanding sample sizes and refining methodologies to further strengthen forensic odontology practices.

1. Introduction

Teeth are one of the strongest and toughest substances in the human body. Often, when a decomposed, charred, skeletonized, mutilated body is recovered, teeth become one of the most crucial pieces of evidence to help identify that person. Human dentition is also a good indicator of the life,

culture, food, and adaptation process of the past and present human populations through dental morphology, dental disease, dental modifications, and many more. The evolution of teeth transformed human canines into smaller and incisiform, losing their sexual and social function and are used

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primarily for tearing food. The evolution of the human canine is influenced by the biomechanical environment of the masticatory apparatus, making it an "exaptation" rather than a functional adaptation. The human canine has evolved from being a tool for sexual selection to a functional tooth adapted to the biomechanical demands of the masticatory apparatus. In modern humans, the canine's role is less about tearing food and more about fitting into the complex dynamics of the masticatory system. Understanding the evolutionary history of the canine can help inform dental practices and the treatment of dental anomalies.¹

In forensics, human canine teeth are of extreme significance. Owing to the morphology and position of canine in the oral cavity it shows least incidence of caries. It is referred to as cornerstone of mouth.² Various studies have been conducted in contemporary human populations, the permanent molar crowns are larger in males than females.³ Permanent canines begin mineralizing shortly after birth and require approximately 6 years to create enamel and 14 years to complete the root. It was seen that canines in males weighed more than of females. They concluded that although amounts of enamel were similar in males and females, the dentine present was more in males than females.^{4,5} Studies on odontometrics in relation to gender variances have found that canine with mandible have shown significant dimorphism amongst other teeth, being smaller in females than in males.^{4,6} In terms of age-related tooth extractions, the mandibular canines are one of the last teeth to be removed since they are less prone to caries damage and periodontal disease.

Mandibular canine index (MCI) is a fascinating little dental metric that has been used by forensic anthropologists and odontologists as a parameter for analysis of sex. Several research has been conducted taking into consideration the maxillary and the mandibular canine index. The inference drawn from the studies was mandible exhibits more sexual dimorphism than the maxilla. It is the ratio of the maximum mesiodistal width of the canine, and the inter-canine distance measured from tip to tip of canines. Due to their location in the jaw, canines are also better able to endure catastrophic damage like air disasters, storms, or conflagrations. These results suggest that the canines in mandible may be contemplated as crucial

for personal identity.⁷ Hence, mandibular canine index may be determined for the purposes of our study.

2. Material and Methods

A total of 60 autopsied bodies, distributed from 20 to 50 years of age between males and females were included for study. The ethical approval has been obtained by Institutional Ethics Committee at authors institution with vide approval number IEC(II)/OUT/918/2022. The work was done in tertiary center, Mumbai. Digital caliper was used for taking measurements which were as follows-

- Mesiodistal crown width of left mandibular canine
- Mesiodistal crown width of right mandibular canine.
- Mandibular inter-canine distance.

Samples with mal-aligned, absence of anterior teeth, crowding, decay, and restorative treatment were excluded from the study. The present study ventured to record the measurements in deceased subjects unlike most of studies which have taken living subjects into consideration. In the deceased to open the oral cavity for examination, it involves multiple examiners for reflecting lower lip, recording & noting measurements. Each autopsied body was examined by two competent personnel to overcome inter-observer error.

The ratio of the maximum mesiodistal (MD) width of the canine and the inter-canine distance (ICD) is referred to as mandibular canine index.

Mandibular canine index (MCI) =

$$\frac{\text{Mesiodistal crown width of mandibular canine}}{\text{Inter-canine distance.}}$$

Computation of sexual dimorphism: It have been done as per formula specified by Garn et al.³ Standard MCI was used for differentiating male & female. It was calculated by method given by Rao et al.¹⁰ The data was analyzed using the statistical analysis package of IBM SPSS 26.0. It is used to find out differences between male & female for various parameters, unpaired t-test was used. A logistic regression analysis is done to predict outcome variables. The MCI, Standard MCI estimation was done on an MS Excel spreadsheet.

3. Observation and Results

The study investigated the sexual dimorphism in mandibular canines among 60 autopsied individuals (30 males, 30 females), aged 20 to 50 years. The descriptive statistics of the mandibular canine parameters and the Mandibular Canine Index (MCI)

are shown in **table 1**. Significant differences were observed in inter-canine distance and mesiodistal crown width between males and females. Males exhibited larger dimensions in all measured parameters. Specifically, the mean inter-canine distance was 27.196 mm in males and 26.117 mm in females, with a significant p-value of 0.036.

Table 1: The descriptive statistics of the mandibular canine parameters and the Mandibular Canine Index (MCI).

Parameters	Sex	Mean	SD	t-stat	P value
Inter-canine Distance	Male	27.196	1.955	2.149	0.036
	Female	26.117	1.931		
Right Canine MD	Male	6.216	0.462	2.642	0.011
	Female	5.874	0.537		
Left canine MD	Male	6.223	0.458	3.483	0.001
	Female	5.774	0.537		
Right MCI	Male	0.228	0.020	4.217	0.000
	Female	0.205	0.022		
Left MCI	Male	0.230	0.018	-1.113	0.270
	Female	0.235	0.021		

Table 2: Percentage of sexual dimorphism calculated using the formula provided by Garn et al.

Sexual Dimorphism	Percentage (%)
Right Canine	5.82
Left Canine	7.77

Table 3: Sex predictability using the Standard Mandibular Canine Index (MCI = 0.217).

Gender	Number of Cases	Cases Correctly Identified	Accuracy (%)
Male	30	22	73.33
Female	30	24	80.00
Total	60	46	76.66

Table 4: Shows the sex predictability by logistic regression analysis.

Gender	Predicted Model	Percentage Correct
Male	28	93.3
Female	26	86.7
Total	90	90

The mesiodistal width of the right canine was 6.216 mm in males and 5.874 mm in females ($p = 0.011$), while the left canine showed 6.223 mm in males and 5.774 mm in females ($p = 0.001$). The right Mandibular Canine Index (MCI) was higher in males (0.228) compared to females (0.205), with a p-value of 0. The left MCI did not show a significant difference between sexes. Sexual dimorphism was more pronounced in the left canine (7.77%) compared to the right canine (5.82%) **table 2**. The MCI demonstrated a 76.66% accuracy in sex

determination, with 73.33% predictability for males and 80% for females **table 3**. Logistic regression models incorporating multiple odontometric parameters achieved up to 90% accuracy in predicting sex **table 4**, highlighting the robustness of combining different measurements for higher accuracy. The binary logistic regression equation obtained after statistical analysis (**table 5**) for predicting sex (λ) is $\lambda = 20.35 - 9.251 \times \text{Left Canine Width} + 162.785 \times \text{Left CI} + 5.436 \times \text{Right Canine Width} - 157.506 \times \text{Right CI}$.

4. Discussion

Teeth are often used for identification purposes in forensic investigations and other scenarios where identifying individuals is crucial. In mass disasters, such as plane crashes or natural disasters, identifying victims can be challenging due to physical trauma. Teeth are often one of the most durable elements of the body, capable of withstanding harsh environments. Determining sex of the deceased narrows the search to great extent. Research studies have shown potential use of Mandibular Canine Index (MCI) in sex determination from teeth. The research into variation of tooth size and other distances among teeth in the mouth cavity is known as odontometrics. It is simple, dependable, low-cost, and straightforward to measure. Studies with respect to stature estimation have also been conducted taking into consideration the inter-molar, inter-premolar and inter-canine distance.⁹

In humans, one area where sexual dimorphism can be observed is in the dentition, including the mandibular canines. The process of amelogenesis is sex linked and hence the formation of teeth is influenced by enamel & dentine development. It occurs for higher duration of time in males leading to larger teeth size in both permanent and temporary teeth.^{9,10} As represented in **Table 1**, all odontometrics like canine width & inter-canine distance were larger in males than females. Similar findings are seen in studies conducted by Patel et al, Rao et al, Soundarya et al Magar et al and Baheti MJ et al.^{6,8,11, 12,13} However, in research by Boaz et al they have done study on South Indian population, 100 subjects comprising of 50 male & 50 females, it was concluded that females are having larger mandibular canine width than male.^{14,15}

From statistics observations mentioned in **table 1**, all parameters, inter-canine distance, right & left canine mesiodistal width, right MCI are significant while left MCI is not significant. Various investigators studied canines for greater degree of

sexual dimorphism than other teeth. Canines have also shown a prominent level of resistance to postmortem examination. Regarding sexual dimorphism, left canine showed sexual dimorphism 7.77% compared to right canine 5.82%. It was estimated using the Garn et al. formula.³ Similar findings where the left canine had the most sexual

dimorphism than the right was found in several studies,^{7,10, 12,16-19} while study done by Barmate et al showed opposite results.¹⁵ While Kumavat et al²⁰ found that right & left canine had showed 5.53%, 5.42%, respectively. Also, N Vishwakarma et al found right canine having maximum dimorphism 12.51% than left 10.15%.²¹

Table 5: The variables used in the logistic regression analysis

Variables in equation	B	S.E.	Wald	df	Sig.	Exp(B)
Left Canine Width	-9.251	3.522	6.901	1	.009	.000
Left CI	162.785	76.636	4.512	1	.034	4.972E+70
Right Canine Width	5.436	2.876	3.573	1	0.59	229.499
Right CI	-157.506	68.055	5.357	1	.021	.000
Constant	20.350	7.800	6.808	1	.009	688669418.471

The mandibular canine index (MCI) was formulated in the 1980s by Rao et al. It is based on the increased differences in sexuality shown by canines with mandibles. MCI is statistically higher in males compared to females about canine dimorphism. In our study, left MCI is greater in females. Male & female were distinguished by use of standard MCI. It was calculated by method given by Rao et al.⁸ The present study shows sex predictability from standard MCI is 76.66%. It is like other studies which have showed results between 75-80 %. Kumavat et al have done study on Maharashtra population and found 79.66% accuracy.²⁰ Bakkannawar SM et al²² and Paramkusam et al⁷ have shown 75% & 78.3% sex prediction through MCI in South Indian population. Patel RA et al⁶ and Gandhi N et al¹⁷ have met 78.75% & 79.03% accuracy in their study. Magar et al observed that sex determination accuracy by MCI index was 83.8% in males and 87.2% in females in North Saudi Sakaka population.¹² R Iqbal et al²³ have done study on Uyghur population and found 77% sexpredictability. In a study conducted by Narang et al on North Indian population, the results showed that MCI could predict sex determination as 68% in males and 67.6% in females.²⁴

However, it's important to note several caveats and limitations regarding the mandibular canine index. Population variation plays a significant role as the index varies among different populations, meaning that what might be indicative of sex in one population may not be applicable to another. Secondly, individual variation is a factor since mandibular canine indices for males and females overlap significantly, which lowers the accuracy of sex detection. Additionally, age can

affect the size and shape of teeth, potentially affecting the mandibular canine index over time. Lastly, ancestry and genetics can also influence tooth morphology, further complicating the use of this method for sex determination.

A.B. Acharya et al²⁵ discovered a sex predictability of 50.74%. Furthermore, AM Silva et al²⁶ have done investigation on the Portuguese people & stated that MCI had 54.2% accuracy. As stated, for a variety of reasons, our findings do not correspond to this research. A.B. Acharya et al²⁵ performed logistic regression analysis of their data on right canine MD, inter-canine width & MCI. Sex estimation accuracy was found 65.7%, 61.8% and 50.2%, respectively. Similarly, in a study conducted by Atreya et al in Nepalese population, it was found that MCI has poor sex predictability (57.5 to 62.5%). It concluded that sex determination should be done using other methods and that MCI should be cautiously used in Nepalese population.²⁷ Coberly in her study exhibited that 37% of males and 44% of females were sorted correctly using the standard MCI, for a 40% overall accuracy.²⁸ Various mandibular parameters have been used over years for determining the sex. The measurement of antegonial depth from radiographical examination has proved to be significant in determining the sex.²⁹ The morphometric parameters of bicondylar breadth, bimental breadth, bigonial breadth, coronoid breadth and height, maximum and minimum ramus breadth and height can also to taken into consideration for determining sex.³⁰

The present study examined four models for sex predictability using logistic regression analysis (LRA). The first model analyzed only the right canine index and achieved 75% accuracy. The second

model is made up of right canine index and left canine width. It shows the same 75% sex predictability. The third one considered the right canine index, left canine breadth, and left canine index. Sex accuracy has improved to 86.7%. The fourth model, which considered four variables: left canine breadth, right canine breadth, right canine index & left canine index demonstrated a greater 90% sex prediction. As a result, we chose the fourth and final model for the highest sex correctness using LRA. We can say that LRA can be used for sex estimation, but we will need more sample size around 100-125 for good result statistical point of view.

Limitation of study

This study has been done on dead individuals in our institute. Therefore, sample size was limited according to number of autopsies, age group and sex. Medico legal expert must exercise caution while using this method for estimating sex.

5. Conclusion

This study underscores the significance of mandibular canines in forensic odontology, particularly for sex determination in unidentified bodies. Our findings affirm that male mandibular canines show larger dimensions compared to females, with significant differences in inter-canine distance and mesiodistal crown width. The study's use of the Mandibular Canine Index (MCI) proved a sex predictability accuracy of 76.66%, aligning with prior research findings. Logistic regression analysis further enhanced sex predictability to 90% when incorporating multiple Odontometrics parameters, showing the robust potential of combining various measurements for higher accuracy.

However, several limitations call for consideration. The variability of the mandibular canine index across different populations highlights the need for population-specific standards. Additionally, individual variation, age-related changes, and genetic factors can influence tooth morphology, affecting the accuracy of sex determination. Future research should focus on expanding the sample size and including diverse populations to refine the predictive models and enhance the reliability of odontometric methods in forensic applications. In conclusion, the mandibular canine index, coupled with logistic regression analysis, can be used as preliminary valuable tool in forensic science for sex determination. However, it is not solely reliable and can be used in addition to

other indices for sex determination.

The study's method and findings contribute to the broader understanding of dental dimorphism and its practical applications in forensic investigations. Further research with increased sample size and refinement of these techniques will continue to improve their accuracy and reliability, ultimately aiding in the identification of unknown individuals in various forensic scenarios.

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