The Maxillary and Mandibular Intercanine Distance as Gender Identification Method from Bitemark: A Rapid Review

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Abstract

The presence of physical evidence such as bite marks in criminal cases will be precious because, if properly analysed, it can prove someone's involvement in a crime. Through bite mark analysis, many information can be obtained, one of which is gender. Identifying gender from bite marks can be done through several methods, such as measuring intercanine distance. This study aims to examine how the comparison of maxillary and mandibular intercanine distance between males and females can be used to identify gender from the bite mark.

A rapid review was conducted in this research refers to the PRISMA framework. The search for articles conducted through PubMed, EBSCOhost, ScienceDirect, and SAGE Journals published in 2011-2021.

Articles are screened and assessed for eligibility. Seven articles fit all the criteria and obtained ten different samples. The data from articles were processed using a summary independent sample t-test to obtain a p-value. Seven out of ten samples showed that maxillary intercanine distance had a more significant p-value between males and females.

Maxillary and mandibular intercanine distance showed significant values between males and females in almost all intercanine distance data, but maxillary intercanine distance showed greater dimorphism in its use to identify gender from bite mark.

Review (J Int Dent Med Res 2023; 16(1): 417-422)

Keywords: Intercanine distance, gender identification, bite mark.

Received date: 09 October 2022 **Accept date:** 07 November 2022

Introduction

Identifying the age and gender of the teeth is a major subject of research in forensic odontology. Dental clues are increasingly being used, especially in solving criminal cases.[1] The two main components of forensic odontology include identifying human remains and analysing the bite marks.[2] Bite marks are patterned form of injury that is the physical result of biting or contacting human or animal teeth applied to the skin, food, or another inanimate substrate.[2–5] So far, bite marks have very characteristic of dental anatomy and each person has no identical teeth including dental arches.

Bite mark analysis can identify many information, one of which is gender identification. Identifying gender from the bite mark can be done through several methods, such as measuring the intercanine distance, and the distance between the cusps of contralateral canines in one arch.[6,7] However, there are still differences of opinion regarding the intercanine distance in the maxilla or mandible, which shows the more significant difference between males and females.

Bite marks, if properly analysed, can prove the involvement of certain people in a crime.[1,3] The main objective of bite mark case analysis is to relate the biter to the existing tooth pattern on an object or skin and determine whether it is related to the incident.[8] Hence, the presence of physical evidence such as bite marks in criminal cases is precious.

Several researchers have carried out gender identification using intercanine distance, and it can be concluded that intercanine distance can be used to identify gender.[8] The previous study by Rasidi et al.[9] explained that odontometric analysis based on the mandibular

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intercanine distance showed significant differences in differentiating gender. Another study by Cakici et al.[10] mentioned the maxillary intercanine distance would be more valuable than the mandibular intercanine distance in determining gender from the bite mark. Therefore, there are still differences of opinion regarding mandibular or maxillary intercanine distance which shows the greatest sexual dimorphism.

Bite mark analysis is very important and helpful in solving criminal cases. However, it is scanty to find the application of gender identification from bite marks in solving this case. Therefore, the authors studied this topic by conducting a rapid review. This study aims to examine how the comparison of maxillary and mandibular intercanine distance between gender can be used to identify gender from the bite mark.

Materials and methods

This research was conducted from October 2021-February 2022 through a rapid review. Simplification was done by analysing the literature with a single reviewer, using at least 2 or more databases, by limiting the year of publication, language, and study design.[11] The samples used in this study are data from articles or research from another researcher who measures intercanine distance to identify gender.

Search strategy

The search strategy uses the *Boolean Operators* 'AND' and 'OR' systematically. The search was conducted using the keywords intercanine distance, intercanine width, canine arch width, gender, and sex in databases including *PubMed, EBSCOhost, ScienceDirect,* and *SAGE Journals*.

Eligibility criteria

The researcher includes articles that use intercanine distance measurement as a gender determination method, have maxillary and mandibular intercanine distance data, classify data by gender, and measure intercanine distance from the cusp of the contralateral canine in one arch using a digital caliper. The article must be in English published in the last ten years (2011-2021) and available in full text. Research with subjects under 14 years old, who received orthodontic treatment, had dental malocclusion, malposition, canine anomaly, and non-human subjects were excluded.

Study selection

The articles were selected using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, as shown in Figure 1.

The first selection is made by screening the years of publication. After saving results in Research Information Systems (RIS) format, the researcher then exported them to Mendeley for duplicate selection. Screening of titles and abstracts was carried out, and the remaining articles were screened based on inclusion criteria by reading the full text. Included articles are processed for data extraction.

Risk of bias assessment

Risk of bias assessment in included articles carried out using Joanna Briggs Institute (JBI) Critical Appraisal Tool for cross-sectional studies. Articles are assessed using four assessment criteria, namely 'yes,' 'no,' 'unclear,' and 'not applicable,' based on the questions formulated in the assessment tool. There are three criteria for the article: low bias with 7-8 yes, moderate bias with 4-6 yes, and high bias with 1-3 yes.[12] Three assessors carried out a risk of bias assessment.

Statistical analysis

The statistical test was performed on IBM SPSS Statistics software using the summary independent-samples t-test with $p<0.05$. Males and females intercanine distance data in one sample were compared for each arch. Through this test, a *p*-value was obtained, which was then compared between the maxilla and mandible to determine which arch showed a higher significance value.

Results

In the search for articles in the database, 1362 articles matched the keywords. Then researcher carried out screening and selection through PRISMA and got seven articles included in the review. Full results can be seen in Figure 1.

The characteristics of the seven articles are shown in Table 1. Three articles were obtained from PubMed and two articles each from ScienceDirect and EBSCOhost based on database sources. Then based on country, five articles came from India, while the other two came from South Africa and Turkey, respectively. A total of 2 articles were published each in 2014 and 2017, and 1 article each was published in

2011, 2012, and 2016.

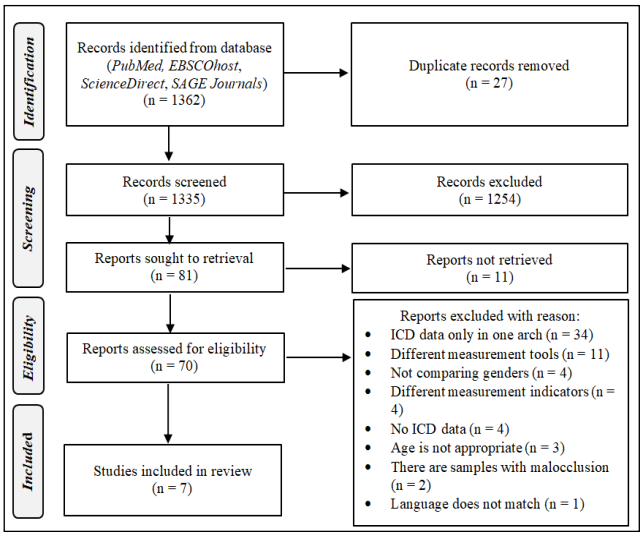

Figure 1. Study selection results using PRISMA framework.

No	Author	Database sources	Country/area	Study design
1	Paramkusam, G., et al. (2017)[33]	PubMed	India	Cross-sectional
2	Khandelwal, S., et al. (2011)[34]	EBSCOhost	North India	Cross-sectional
3	Reinprecht, S., et al. (2016)[19]	PubMed	Gauteng, South Africa	Cross-sectional
4	Bakkannavar, S. M., et al. (2014)[35]	ScienceDirect	South India	Cross-sectional
5	Cakici, B., et al. (2017)[10]	ScienceDirect	Turkey	Cross-sectional
6	Prasad, M., et al. (2014)[27]	PubMed	South India	Cross-sectional
7	Khera, A. M., et al. (2012)[28]	EBSCOhost	India	Cross-sectional

Table 1. Study characteristics of seven articles used in the review.

The risk of bias assessment in seven articles found five articles with low bias and two articles with moderate bias results. Full results can be seen in Table 2.

The extracted data are intercanine distance data measured on a dental model or intraoral using a digital caliper. All of the intercanine distance data in included articles found a greater value in males than in females. The average intercanine distance data collected from included articles can be used as a reference to identify gender from the bite mark and adjust it according to the alleged perpetrator's ethnicity. The samples used in this study were aged between 15-75 years, without malocclusion, malposition, or canine anomalies, and had never received orthodontic treatment. The maxillary and mandibular intercanine distance data, and the number of samples can be seen in Table 3.

Questions	Author							
	Paramkusam, G, et al. (2017)	Khandelwal, S., et al. (2011)	Reinprecht, S., et al. (2016)	Bakkannavar, S. M., et al. (2014)	Cakici, B., et al. (2017)	Prasad, M., et al. (2014)	Khera, A. M., et al. (2012)	Paramkusam, G, et al. (2017)
1. Were the criteria for inclusion in the sample clearly defined?	Yes	Yes	No	Yes	No	Yes	Yes	Yes
2. Were the study subjects and the setting described in detail?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Was the exposure measured in a valid and reliable way?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Were objective, standard criteria used for measurement of the condition?	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
5. Were confounding factors identified?	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
6. Were strategies to deal with confounding factors stated?	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
7. Were the outcomes measured in a valid and reliable way?	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
8. Was appropriate statistical analysis used?	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Results	Low	Low	Low	Moderate	Moderate	Low	Low	Low

Table 2. Risk of bias assessment results using the JBI Critical Appraisal Tool for cross-sectional studies.

No	Sample size		Arch*	ICD* ± SD (mm)		*P*-value	Sig.**
	Males	Females		Males	Females		
1[33]	60	60	Mx	34,4	32,7	0,014***	S
			Md	25,9	23,7	0,000***	S
2[34]	20	20	Mx	34,49±0,93	33,54±1,47	0,035	S
			Md	24,30±1,60	23,23±1,72	0,049	S
3[19]	1306	1772	Mx	36,33±2,49	35,12±2,33	0,000	S
	1340	1812	Md	28,02±2,24	27,34±2,13	0,000	S
4[19]	65	74	Mx	35,74±2,58	34,45±2,32	0,002	S
	67	78	Md	27.58±2,20	26,81±2,40	0,047	S
5[19]	59	59	Mx	34,60±2,17	34,27±2,36	0,431	
	61	58	Md	26,77±2,54	26,73±2,01	0,924	
6[19]	330	365	Mx	34,79±2.62	33,44±2,13	0,000	S
	361	390	Md	26,65±2,14	25,69±1,93	0,000	S
7[35]	250	250	Mx	34,17±1,68	33,47±1,22	0,000	S
			Md	25,25±1,32	24,75±1,08	0,001	S
8[10]	100	100	Mx	35,34±0,03	33,29±0,03	0,000	S
			Md	26,78±0,02	25,40±0,03	0,000	S
9[27]	40	40	Mx	32,66±1,10	31,77±1,20	0,001	S
			Md	23,82±1,00	23,65±1,20	0,493	
10[28]	15	15	Mx	35,31±1,60	34,40±1,83	0,158	
			Md	25,31±1,69	25,70±1,67	0,530	

*Mx=maxillary; Md=mandibular; ICD=intercanine distance; **Significance; S=significant; ***The *p*-value is already known from the article source.

Table 3. Summary independent sample t-test results of maxillary and mandibular ICD between gender.

Table 3 shows the statistical analysis results on the ten samples used in this study. Almost all samples showed significant values ($p<0.05$), except for the maxillary intercanine distance at samples numbers 5 and 10 and the mandibular intercanine distance at samples numbers 5, 9, and 10. Seven samples showed a smaller *p*-value in the maxillary intercanine distance than the mandibular intercanine distance, namely in samples number 2, 4, 5, 6, 7, 9, and 10. One sample showed a smaller *p*-value at the mandibular intercanine distance, namely in sample number 1. Sample numbers 3 and 8 showed an equally significant value between the maxillary and mandibular intercanine distance.

Discussion

Based on the intercanine distance data obtained in this study, almost all the maxillary and mandibular intercanine distance data showed significant differences between males and females. These results prove the existence of sexual dimorphism at the intercanine distance in which almost all samples showed a greater value in males than females. This result is in line with other studies by Adamek et. Al; Smitha et. al; Al-Khatib et. al; Ayoub et. al[7,13–15] which found differences in the dimensions of teeth and dental arch between males and females. The difference in the size of a dental arch between the gender is caused by several factors such as genetic, environmental, cultural, and food sources or eating habits in specific populations.[16,17] The values of odontometric parameters, including the observed higher intercanine distance in males, can also be attributed to other factors such as the more prominent appearances in males than females.[17,18] However, based on the study by Reinprecth et. al[19] the prominent differences between males and females can only be seen between the gender of the same ethnicity.

The relationship between dental arch width and shape has also been investigated. It has been observed that the size of the intercanine distance increases with differences in the mandibular arch shape from square, ovoid, and tapered.[20,21] Based on research by Olmez et al.[22] on the population of Turkey, males have a relatively larger dental arch, and the dental arch shape tends to be tapered. Meanwhile, the dental arch in females is smaller than in males, and the arch shape tends to be more ovoid.[22] However, the dental arch shape is not always the same for all ethnicities. Each racial group may have a different dental arch shape in males and females.[23] Although there are differences in the dimensions of dental arches between different ethnicities or races, in each ethnicity, it is still found that intercanine distance is greater in males than females. So, it can be agreed that males have a larger dental arch than females.

This study found that the maxillary intercanine distance was better because it showed a greater significance value between males and females in 7 out of 10 intercanine distance samples. Meanwhile, the mandibular intercanine distance only showed a greater significance value in 1 sample, while the other two samples showed an equal significance value between the maxilla and mandible. Therefore, it can be concluded that the maxillary intercanine distance can give better results for gender identification from bite marks than the mandibular intercanine distance. The results of this study are quite contrary to the results of the study by Harshita et. al[24], which state that the mandibular canine has the best dimorphism and the most significant difference between males and females. Even so, the mandibular intercanine distance based on the results of this study can still be used to identify gender because it shows a significant value. A recent study[16,25] mentioned that the most dimorphic tooth was the mandibular canine both from the mesiodistal mandibular canine measurement and the mandibular intercanine distance. However, a study by Bano and Babu[26] have a different opinion which is in line with the articles included in this study[19,27,28] that there is no significant difference in the mean of the mandibular intercanine distance between males and females.

The higher significance value of the maxillary intercanine distance obtained in this study could be caused by several factors, such as the dental arch changes process. The previous study by Brudi and Moyers[29] explained there are several essential points when studying the dental arch changes; the width of the dental arch involves a significantly different direction of vertical alveolar growth in the maxillary and mandibular arches, and the growth of the alveolar process with a slight increase in bone width, especially in the mandibular arch. The growth of the maxillary alveolar process diverges when teeth erupt, whereas the growth of the mandibular alveolar process is more parallel.[29,30] These changes have significant clinical implications as when the increase in intercanine distance is compared between males and females, it will be seen that a greater increase is evident in males, especially in the maxilla as compared to the mandible. This is sufficient to explain why the maxillary intercanine distance was much more significant than that of the mandible in this study.

Besides the dental arch change process, the results in this study can also be related to the dental arch shape. Dental arches in males tend to be larger than in females, and each has a different dental arch shape.[22] The previous study by Rehman et al.[20] in three different dental arch

shapes, namely square, ovoid, and tapered, found significant differences in those shapes, which means that the dental arch shape can affect the dental arch width. Based on a study by De Castro et al.[23] on a population of Brazilian children, the dental arch shape itself was different between the maxilla and mandible in one individual. Another study by Owais et al.[23] also agrees with this opinion where he found that the most common dental arch shape in the maxilla is ovoid, while the most common dental arch shape in the mandible is square. The difference in the dental arch shape between the arches in one individual certainly affects the intercanine distance in both the maxilla and mandible.

Based on the explanation above, it can be concluded that a higher significance value at the maxillary intercanine distance is acceptable. The maxillary intercanine distance was found to have a significant difference between gender and this difference was large enough to determine gender. Therefore, the maxillary intercanine distance would be beneficial in identifying gender from the bite mark. Apart from bite marks, the intercanine distance can also help identify the gender of the disaster victims, along with other methods and parameters.[6,24] Other methods that can be used in conjunction with bite mark analysis to determine the gender of the disaster victim are such as DNA analysis and identification of the pelvis and skull, but the determination of the sex from the skull is not reliable until well after puberty.[31,32]

The articles included in this study were limited to articles that measured the intercanine distance using a digital caliper. According to a recent study[15], there is a minimal difference of about 0.02–0.2 mm measurements using a caliper and three-dimensional or image-based analysis. Further research can be carried out by including all types of measurements such as three-dimensional measurements and image-based digital measurements. Moreover, researchers have not been able to get an absolute value of intercanine distance that can be used as a guide in identifying the gender from bite marks due to limited data.

Conclusions

In conclusion, based on the results of this study, both arches showed significant values between males and females in almost all intercanine distance data. However, in this study, the maxillary intercanine distance was found to have a more significant difference than the mandibular intercanine distance between males and females. The maxillary intercanine distance showed greater sexual dimorphism and could be used to identify gender from the bite marks better.

Acknowledgements

This paper and the research behind it would not have been possible without the exceptional support and contribution of all of the authors. The authors disclosed receipt of the following financial support for the publication of this article by Universitas Padjadjaran.

Declaration of Interest

The authors report there are no conflicts of interest to declare.

References

1. Sunil MK, Vidya MA, Garg S, Kohli S. Role of bitemarks in personal identification. Journal of PEARLDENT. 2016;7(4):8–14.
2. David TJ, Lewis JM. Forensic Odontology Principles and Practice. London: Elsevier; 2018:3, 178.
3. Krittika R, Don KR. Bite marks-a brief review. Drug Invention Today. 2019;11(2):349–53.
4. Taylor JA, Kieser JA. Forensic Odontology: Principles and Practice. London: Wiley Blackwell; 2016:228-9.
5. Malinda Y, Zakiawati D. Acquaintance of bite mark identification procedures in forensic odontology. Vol. 27, Padjadjaran Journal of Dentistry. 2015;27(3):166–71.
6. Hartomo BT, Adrianto AWD, Anas AN, Basman RS, Auerkari EI. The use of human intercanine and intermolar for determining sex on natural disaster. In: AIP Conference Proceedings. American Institute of Physics Inc.; 2019;2092(1):040020.
7. Adamek A, Minch L, Kawala B. Intercanine width – review of the literature. Dent Med Probl. 2015;52(3):336–40.
8. Rai B, Kaur J. Evidence-Based Forensic Dentistry. Copenhagen: Springer; 2013:87-107.
9. Rasidi MQZBM, Sukumaran G. Study of intercanine distance of mandibular permanent canine in gender identification among Chennai population. Indian Journal of Forensic Medicine and Toxicology. 2019;13(4):235–9.
10. Cakici B, Aka PS, Sevim, EA, Arıcı G. Comparison of bimaxillary permanent canine arch width in terms of human sex identification for metric analysis of bite marks. Journal of Anthropology Reports. 2017;2(1):2–4.
11. Tricco AC, Langlois E, Straus SE. Rapid Review to Strengthen Health Policy and Systems: A Practical Guide. 2017:23-34.
12. Mecenas P, da Rosa Moreira Bastos RT, Rosário Vallinoto AC, Normando D. Effects of temperature and humidity on the spread of COVID-19: A systematic review. PLoS One. 2020;15(9):1–21.
13. Singh S, Saraf BG, Indushekhar KR, Sheoran N. Estimation of the intercanine width, intermolar width, arch length, and arch perimeter and its comparison in 12–17-year-old children of faridabad. Int J Clin Pediatr Dent. 2021;14(3):369–75.
14. Smitha S, Nagar P, Abinaya R, Janani J. Comparing the arch forms between mongoloid race and dravidian race in 11-14-

year-old children. Int J Clin Pediatr Dent. 2020;13(S-1):S26–8.
15. Al-Khatib A, Rajion ZA, Masudi SM, Hassan R, Anderson PJ, Townsend GC. Tooth size and dental arch dimensions: A stereophotogrammetric study in Southeast Asian Malays. Orthod Craniofac Res. 2011;14(4):243–53.
16. Ayoub F, Shamseddine L, Rifai M, et al. Mandibular canine dimorphism in establishing sex identity in the lebanese population. Int J Dent. 2014;2014:12–5.
17. Grewal DS, Khangura RK, Sircar K, Tyagi KK, Kaur G, David S. Morphometric analysis of odontometric parameters for gender determination. Journal of Clinical and Diagnostic Research. 2017;11(8):9–13.
18. Dung TM, Ngoc VTN, Hiep NH, et al. Evaluation of dental arch dimensions in 12 year-old Vietnamese children - A cross-sectional study of 4565 subjects. Sci Rep. 2019;9(3101):1-7.
19. Reinprecht S, van Staden PJ, Jordaan J, Bernitz H. An analysis of dental intercanine distance for use in court cases involving bite marks. Int J Legal Med. 2017 Mar 1;131(2):459–64.
20. Rehman SA, Rizwan S, Faisal SS, Hussain SS. Association between intercanine width and mandibular dental arch forms. J Coll Physicians Surg Pak. 2021;30(4):478–80.
21. Ferro R, Pasini M, Fortin A, Arrighi A, Carli E, Giuca MR. Evaluation of maxillary and mandibular arch forms in an Italian adolescents sample with normocclusion. Eur J Paediatr Dent. 2017;18(3):193–8.
22. Augustin I, Hidayat B, Oscandar F. Identification of gender based on bite markusingimage processing with method gray level co-occurrence matrix (glcm) and classification with support vector machine (svm). e-Proceeding of Engineering. 2018;5(3):4835–42.
23. Owais AI, Abu Alhaija ES, Oweis RR, Al-Khateeb SN. Maxillary and mandibular arch forms in the primary dentition stage. Oral Health Dent Manag. 2014;13(2):330–5.
24. Harshitha K, Mohamed S, Uppala D, Manjusha C, Sreedevi K. Evaluation and correlation of tooth morphometrics in the maxillary arch for sex identification. Oral & Maxillofacial Pathology Journal. 2019;10(2):57–60.
25. Patel RA, Chaudhary AR, Dudhia BB, Macwan ZS, Patel PS, Jani YV. Mandibular canine index: A study for gender determination in Gandhinagar population. J Forensic Dent Sci. 2017;9(3):135–43.
26. Bano AM, Babu KY. Comparison of intercanine and intermolar width of the maxilla as an aid in gender determination: A preliminary study. Drug Invention Today. 2018;10(3):3149–52.
27. Prasad M, Kannampallil ST, Talapaneni AK, George SA, Shetty SK. Evaluation of arch width variations among different skeletal patterns in South Indian population. J Nat Sci Biol Med. 2013;4(1):94–102.
28. Khera AK, Singh GK, Sharma VP, Singh A. Relationship between dental arch dimensions and vertical facial morphology in class I subjects. Journal of Indian Orthodontic Society. 2012;46(4):316–24.
29. Sangwan S, Chawla HS, Goyal A, Gauba K, Mohanty U. Progressive changes in arch width from primary to early mixed dentition period: A longitudinal study. Journal of Indian Society of Pedodontics and Preventive Dentistry. 2011;29(1):14–9.
30. Zafarmand AH, Mina M, Zafarmand M. Maxillary arch dimension changes of 3 - 5 years old Filipino children. Novelty in Biomedicine. 2014;2(4):126–30.
31. Uthman AT, Alomar A, Almukhtar A, et al. Accuracy of sphenoidal sinus morphometry in forensic identification using cone beam computed tomography. J Int Dent Med Res. 2021;14(4):1485–91.
32. Hartomo BT, Auerkari EI. Oral microbiome in forensic odontology to identify bioterrorism attack. J Int Dent Med Res. 2019 Aug;12(2):744–7.
33. Paramkusam G, Nadendla LK, Devulapalli RV, Pokala A. Morphometric analysis of canine in gender determination: revisited in India. Indian J Dent Res. 2014;25(4):425–9.
34. Khandelwal S, Sharma K, Rahman F, Tipu SR. A study of dimorphism of mandibular and maxillary canine teeth in establishing sex identity. Indian Journal of Stomatology. 2011;2(1):1–5.
35. Bakkannavar SM, Manjunath S, Nayak VC, Pradeep Kumar G. Canine index – A tool for sex determination. Egypt J Forensic Sci. 2015;5(4):157–61.