Acta Scientiarum
http://periodicos.uem.br/ojs/acta
ISSN on-line: 1807-8648
Doi: 10.4025/actascihealthsci.v43i1.54202

Sexual dimorphism applying the mandibular canine index in a Brazilian sample: a pilot study

Luciana Vigorito Magalhães[1], Bruna Saud Borges[1], Paulo Henrique Viana Pinto[1], Caroline Paula Alves[2] and Ricardo Henrique Alves da Silva[3*]

[1]Programa de Pós-graduação em Patologia e Medicina Legal, Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo, Ribeirão Preto, São Paulo, Brazil. [2]Departamento de Estomatologia, Saúde Coletiva e Odontologia Legal, Especialização em Odontologia Legal, Faculdade de Odontologia de Ribeirão Preto, Universidade de São Paulo, Ribeirão Preto, São Paulo, Brazil. [3]Departamento de Estomatologia, Saúde Coletiva e Odontologia Legal, Faculdade de Odontologia de Ribeirão Preto, Universidade de São Paulo, Av. do Café, s/n, 14040-904, Ribeirão Preto, São Paulo, Brazil. *Author for correspondence. E-mail: ricardohenrique@usp.br

ABSTRACT. This research study aimed at applying the morphometric quantification of the canine index for sexual dimorphism in a Brazilian sample. This was an observational study and the convenience sample consisted of 90 adult participants (45 male subjects and 45 female subjects), aging from 18 to 35 years. With the aid of a digital caliper, the intraoral mesiodistal measurement of the permanent mandibular right canine (MD43) and the intercanine distance (IC) were taken by three examiners. The measurements were applied to the mandibular canine index formula to estimate sex based on the morphometric features of human canines. The applicability of this approach for sexual dimorphism was assessed based on the mandibular canine index (MCI) calculated by the formula. The MCI was higher in male than in female subjects. In the total sample, the MCI overall mean accuracy rate for sexual dimorphism was 52.22%. In male subjects, the MCI was able to properly differentiate sex in 82.22% of the sample, while in female subjects the accuracy rate decreased to 22.22%. These results call the attention to the careful use of MCI especially for Forensic Anthropology. In particular, the accuracy of the method was close to the random of a sample that contained both sexes. Thus, the MCI should not be used as the only tool for sexual dimorphism.

Keywords: forensic anthropology; forensic dentistry; odontometry; tooth.

Received on June 10, 2020.
Accepted on October 5, 2020

Introduction

Sexual dimorphism is an important part of the human identification process (Khangura, Sircar, Singh, & Rastogi, 2011; Costa, Lima, & Rabello, 2012; Paramkusam, Nadendla, Devulapalli, & Pokala, 2014; Shireen et al., 2014; Peckmann, Meek, Dilkie, & Mussett, 2015; Akkoç, Arslan, & Kök, 2017; Capitaneanu, Willems, Jacobs, Fieuws, & Thevissen, 2017). In practice, it narrows the list of possible victims by clustering deceased bodies based on sex (Acharya & Mainali, 2009; Costa et al., 2012; Angadi, Hemani, Prabhu, & Acharya, 2013; Joseph, Harish, Rajeesh Mohammed, & Vinod Kumar, 2013; Srivastava et al., 2014; Aggarwal, Gorea, Gorea, & Gorea, 2016; Akkoç et al., 2017). This process is especially important in complex forensic cases such as those involving charred, putrefied and mutilated bodies, as well as skeletal remains (Vijayan, Jayarajan, & Jaleel, 2019). In general, sexual dimorphism is established based on the morphological features of the pelvic bones. However, in challenging situations, these bones may be missing or fragmented, making the human teeth potential source for providing sexual information (Acharya & Mainali, 2009; Capitaneanu et al., 2017; Vijayan et al., 2019).

The main advantage of teeth, when compared to bones, is their hardness and enamel protection to extreme environmental conditions (Mujib, Tarigoppula, Kulkarni, & Bs, 2014; Patil, Naik, Kamble, & Kokane, 2015; Rajarathnam, David, & Indira, 2016; Yadav, Yadav, Kedia, & Singh, 2016). Sexual dimorphism based on teeth is established considering the morphological differences in tooth size between male and female subjects (Boaz & Gupta, 2009; Pandey & Ma, 2016; Silva et al., 2016). Human canines are hard elements showing morphological differences when comparing male to female subjects (Acharya & Mainali, 2009; Ayoub et al., 2014; Mujib et al., 2014; Paramkusam et al., 2014; Sai Kiran et al., 2014, Aggarwal et al., 2016; Pandey & Ma, 2016; Silva et al., 2016). In this context, Rao, Rao, Pai and Kotian (1989) have developed the mandibular canine index (MCI) approach for sexual dimorphism - a formula based on the canine mesiodistal width (MD) and the intercanine (IC) distance.

For optimal outcome, the MCI approach was tested for validation in several populations (Muller, Lupi-Pegurier, Quatrehomme, & Bolla, 2001; Acharya & Mainali, 2009; Paramkusam et al., 2014; Rajarathnam et al., 2016; Silva et al., 2016; Dixit, Sreedevi, Nagarajappa, & Bhashin, 2017; Gandhi et al., 2017; Kumawat et al., 2017; Mohsenpour, Gangadhar, & Samehsalari, 2017; Patel et al., 2017; Singh, Garg, & Singh, 2017) and different results were verified. For example, Kumawat et al. (2017) and Singh et al. (2017) have tested the MCI predicative value for sexual dimorphism in the Indian population and have verified accuracy values of 79.66 and 83.50% respectively. On the other hand, Mohsenpour et al. (2017) have tested the MCI in the Iranian population and found accuracy values of 53.00%, a result close to the one found by Silva et al. (2016), who have verified accuracy values of 54.20% in the Portuguese population. In view of these differences, it is important to test the applicability of the MCI in several populations, as cases presenting a lack or fragmentation of the pelvic bones would make it impossible to apply other methods for sexual estimation. In these situations, dental features can be assessed due to the hardness of teeth.

Some studies have investigated the morphometric information of human canines for sexual dimorphism in Brazilian samples, however, none of them was designed to specifically test the MCI approach (Costa et al., 2012; Fernandes, Sathler, Natalício, Henriques, & Pinzan, 2013; Sabóia et al., 2013; Silva et al.,2016). Based on the above discussion, this study aimed at testing the MCI approach, considering the hypothesis that sexual dimorphism is feasible and accurate, having as a sample mandibular canines of Brazilian male and female subjects.

Material and methods

This observational study was approved by the Human Research Ethics Committee (CAAE 67803717.1.0000.5419). Participants were prospectively selected and signed an informed consent form. The inclusion criteria consisted of Brazilian adults who, through clinical evaluation, presented the permanent mandibular right (*Fédération Dentaire Internationale*: #43) and left (*Fédération Dentaire Internationale*: #33) canines with no caries, cavities, fractures, restorations or prosthetic crowns. Participants with agenesis/absence or mandibular anterior crowding, supernumerary teeth, wear on the proximal surfaces of teeth, diastemas and severe parafunctional habits, such as bruxism and dental clenching, were excluded from this sample, as well as participants with syndromes.

Following the MCI approach, the MD and the IC measurements of tooth #43 were intraorally taken by three trained examiners, in each participant, three times. Thus, 18 measurements (9 MD and 9 IC) and 9 indexes (MCI) were obtained for each participant, since each examiner performed the analysis three times. The measurements were taken in millimeters using a caliper (WesternPro DC-6 150 mm, 0.3 mm/0.01, Western, China). The MD measurement was taken between the most prominent part of the mesial and distal surfaces of the crown (Figure 1A). The IC was established as the distance between the tips of the mandibular canine teeth (Figure 1B). The measurements were taken with the caliper display facing downwards and the values were assessed and registered by an external examiner, ensuring the blindness of the examiners.

Intra- and inter-examiner reproducibility tests were performed by using the Intraclass Correlation Coefficient (ICC). The ICC values for intra- and inter-examiner reproducibility were ⩾ 0.75, confirming the correct training and calibration of the examiners. The MCI was calculated applying the following formula:

$$MCI = \frac{MD}{IC}$$

being:
MCI – Mandibular Canine Index
MD – Mesiodistal width
IC – Intercanine distance

Then, the MCI standard was calculated to provide a threshold between male and female subjects, considering the mean MCI and the standard deviation (SD) data:

$$MCI_{Standard} = \frac{(mean\ male\ MCI - SD) + (mean\ female\ MCI - SD)}{2}$$

being:
$MCI_{Standard}$ – Mandibular Canine Index Standard
MCI – Mandibular Canine Index
SD – Standard Deviation

The obtained threshold was used to classify male and female subjects. Correct and incorrect (accuracy) classifications were compared to the original sex of participants. Descriptive statistics was applied to quantify absolute (n) and relative (%) accuracy rates. The software package R (R foundation, Vienna, Austria) was used in the study.

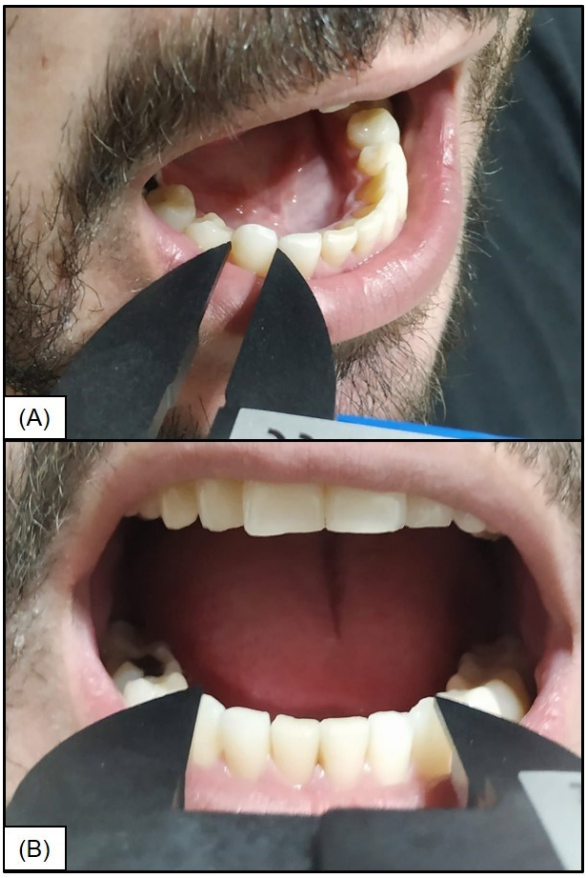

Figure 1. Demonstration of the mesiodistal (A) and intercanine (B) distances measured in this study.

Results and discussion

In Anthropology, the morphology of teeth and bones provides information about sex, age, height and ancestry of a deceased body. Sex figures as the first and, possibly, the most impacting anthropological feature as it places potential victims in two groups – male and female subjects. Consequently, sexual dimorphism is an important tool for the identification of skeletal remains. This pilot study has tested the MCI approach proposed by Rao et al. (1989) for sexual dimorphism in a Brazilian sample, as it is a simple and practical method of evaluation. Thus, the convenience sample comprised 90 participants (45 male subjects and 45 female subjects), aging from 18 to 35 years.

Although the MD distance of both mandibular canine teeth used in isolation presented a higher predictive value than the MCI in the research by Azevedo, Pereira, Gouveia, Tavares and Caldas (2019), the hypothesis of the current study firstly predicted the possibility of obtaining sexual dimorphism applying the original formula of MCI in a Brazilian sample. This hypothesis was confirmed by the MCI values from male subjects (0.255 ± 0.01) and female subjects (0.248 ± 0.01) (Table 1).

In particular, the scientific literature corroborates the fact that morphometric differences in canine size may occur in millimeter levels, in which male subjects present larger teeth than female subjects (Sabóia et al., 2013; Mitsea, Moraitis, Leon, Nicopoulou-Karayianni, & Spiliopoulou, 2014; Sai Kiran et al., 2014; Shireen et al., 2014; Aggarwal et al., 2016; Pandey & Ma, 2016; Silva et al., 2016). However, it is important to consider that the opposite may occur. Female subjects were previously found with larger teeth (incisors, canines and premolars) than male subjects in specific populations such as in Nepal, Dharwad, Orissa and South India (Acharya & Mainali, 2009; Boaz & Gupta, 2009; Prabhu & Acharya, 2009; Dash et al., 2018).

Table 1. Mean MD, IC and MCI values for male and female subjects calculated from the sample.

		MD (mm)		IC (mm)		MCI	
	n	Mean	SD	Mean	SD	Mean	SD
Male	45	6.73	0.24	26.48	0.59	0.255	0.01
Female	45	6.24	0.19	25.17	0.62	0.248	0.01

n: sample size; MD: mesiodistal width; IC: intercanine distance; MCI: mandibular canine index; SD: standard deviation.

In this research study, it was decided to use the MD distance of tooth #43 to calculate the MCI formula since this was the measure of the original method applied by Rao et al. (1989), in addition to subsequent studies comparing contralateral teeth, founding no statistically significant differences (Ayoub et al., 2014; Costa et al., 2012; Vijayan et al., 2019). The mean MD distance, in male and in female subjects and, the mean IC distance, in male and in female subjects, are shown in Table 1.

The MCI standard applied as a threshold for classifying males and females was 0.24. According to this threshold, the sample was correctly classified in 52.22% of the cases. Specific classification between male and female subjects is shown in Table 2.

Table 2. MCI Standard threshold and its accuracy rate for male subjects, female subjects and overall sample.

MCI Standard	Accuracy		
	Male	Female	General
0.24	82.22%	22.22%	52.22%

MCI: mandibular canine index.

As shown in Table 2, the results of the present research study were not as satisfactory as the results found by Rao et al. (1989) who have verified accuracy rates reaching 84.3% in male subjects, 87.5% in female subjects, and 85.9% in general for India. Additional studies conducted in the country have also presented good accuracy rates, as Dixit et al. (2017), who have found overall accuracy rate of 71.00%; Gandhi et al. (2017), who have found accuracy rate of 76.66%; Kumawat et al. (2017), who have found accuracy rate of 79.66%; Patel et al. (2017), who have found 78.75%; and Singh et al. (2017), who have found an overall accuracy of 83.50%.

However, studies with samples from Iran (Mohsenpour et al., 2017) and Portugal (Silva et al., 2016) have reached overall lower accuracy rates of 53.00 and 54.20% respectively, and considered heterogeneity to the international scenario for the MCI approach. Thus, specific characteristics of the population for the canines may be the most acceptable explanation for the differences between the studies. This is the reason why validation studies are important prior to the application of a method in practice (Atreya et al., 2019).

In the literature, there are no previous studies considering the MCI in the Brazilian population. Therefore, the results from this study may not be representative for the entire Brazilian population – which is heterogeneous and with miscegenation from several European and African countries (Ferreira, Mendes, Wiezel, Luizon, & Simões, 2006; Prabhu & Acharya, 2009; Atreya et al., 2019). Thus, the miscegenation of the Brazilian population may explain the lower accuracy rate found in this research (Table 2).

Research studies applying the MCI in samples of the Brazilian population, considering different regions of the country and classified based on genetic analyzes of ancestry, could provide a better understanding of the effect of miscegenation on the odontometric measures in the Brazilian population (Ferreira et al., 2006; Prabhu & Acharya, 2009; Valle-Silva et al., 2019). However, not, disconsidering reverse dimorphism or monomorphism as a result of human evolution (Boaz & Gupta, 2009; Prabhu & Acharya, 2009).

A clear example of miscegenation in the Brazilian population can be observed comparing our results (Table 1) to the studies of Sabóia et al. (2013) and Costa et al. (2012). In the former, the authors have observed a mean MD width of 6.9 mm for female subjects from Southeast Brazil, while the latter observed a similar value (6.99 mm) for male subjects from Northeast Brazil. These findings show that similar morphometric information of canines can be found between male subjects and female subjects from different regions in Brazil. In practice, it could cause uncertainty and, even, wrong identification. Therefore, the results of the present study contribute to practice by calling the attention to the application of the MCI. More specifically, it shows that there are morphometric differences between the permanent mandibular canines of male and female subjects, but the proposed approach does not have power to accurately classify men and women based on teeth, as demonstrated by Dony, Reddy and Kakodkar (2018).

Additional studies should be conducted with increased sample size, comparing populations from different countries, proposing specific statistical corrections of the population to best fit the MCI to each country, and

even include samples of participants with crowding and diastemas in order to challenge the MCI approach with dental conditions that are commonly found by dentists and anthropologists. Thus, the development of adapted odontometric sexual dimorphism formulae considering specific populations should be considered.

Conclusion

The accuracy of the MCI approach ranged slightly above 50% when differentiating male from female subjects, having as basis the morphometric features of the permanent mandibular canines. This result suggests that, in practice, the MCI should not be considered as the only reliable method for sexual dimorphism.

Acknowledgements

The authors thank the Coordination of Superior Level Staff Improvement (CAPES - Financing Code 001) for the financial support provided for conducting this research study.

References

Acharya, A. B., & Mainali, S. (2009). Limitations of the mandibular canine index in sex assessment. *Journal of Forensic and Legal Medicine*, *16*(2), 67-69. doi: 10.1016/j.jflm.2008.08.005

Aggarwal, B., Gorea, R. K., Gorea, A., & Gorea, A. (2016). Comparative analysis of clinical and experimental methods for determination of sexual dimorphism of mandibular canines. *Journal of Forensic and Legal Medicine*, *44*, 20-23. doi: 10.1016/j.jflm.2016.08.014

Akkoç, B., Arslan, A., & Kök, H. (2017). Automatic gender determination from 3D digital maxillary tooth plaster models based on the random forest algorithm and discrete cosine transform. *Computer Methods and Programs in Biomedicine*, *143*, 59-65. doi: 10.1016/j.cmpb.2017.03.001

Angadi, P. V., Hemani, S., Prabhu, S., & Acharya, A. B. (2013). Analyses of odontometric sexual dimorphism and sex assessment accuracy on a large sample. *Journal of Forensic and Legal Medicine*, *20*(6), 673-677. doi: 10.1016/j.jflm.2013.03.040

Atreya, A., Shrestha, R., Tuladhar, L. R., Nepal, S., Shrestha, R., & Sah, S. K. (2019). Sex predictability by using mandibular canine index. *Journal of Nepal Health Research Council, 17*(4), 501-505. doi: 10.33314/jnhrc.v17i4.2187

Ayoub, F., Shamseddine, L., Rifai, M., Cassia, A., Diab, R., Zaarour, I., ... Rouhana, G. (2014). Mandibular canine dimorphism in establishing sex identity in the Lebanese population. *International Journal of Dentistry, 2014*, 1-4. doi: 10.1155/2014/235204

Azevedo, Á., Pereira, M. L., Gouveia, S., Tavares, J. N., & Caldas, I. M. (2019). Sex estimation using the mandibular canine index components. *Forensic Science, Medicine and Pathology, 15*(2), 191-197. doi: 10.1007/s12024-018-0051-2

Boaz, K., & Gupta, C. (2009). Dimorphism in human maxillary and madibular canines in establishment of gender. *Journal of Forensic Dental Sciences*, *1*(1), 42-44. doi: 10.4103/0974-2948.50889

Capitaneanu, C., Willems, G., Jacobs, R., Fieuws, S., & Thevissen, P. (2017). Sex estimation based on tooth measurements using panoramic radiographs. *International Journal of Legal Medicine*, *131*(3), 813-821. doi: 10.1007/s00414-016-1434-0

Costa, Y. T. F., Lima, L. N. C., & Rabello, P. M. (2012). Analysis of canine dimorphism in the estimation of sex. *Brazilian Journal of Oral Sciences*, *11*(3), 406-410. doi: 10.20396/bjos.v11i3.8641393

Dash, K. C., Panda, A., Behura, S. S., Ramachandra, S., Bhuyan, L., & Bandopadhyay, A. (2018). Employing dimensional disparity of teeth to establish the gender in Odisha population: a dimorphic study. *Journal of International Society of Preventive and Community Dentistry*, *8*(2), 174-178. doi: 10.4103/jispcd.jispcd_42_18

Dixit, A., Sreedevi, Nagarajappa, A. K., & Bhashin, N. (2017). The use of canine teeth in the establishment of sexual dimorphism in the Madhya Pradesh (Mahakoushal Region) population. *British Journal of Medicine and Medical Research*, *19*(11), 1-7. doi: 10.9734/bjmmr/2017/31202

Dony, E., Reddy, M. G. S., & Kakodkar, P. (2018). Mandibular Canine Index(McI) not an accurate tool for gender identification: results from a systematic review and meta-analysis. *Indian Journal of Public Health Research & Development, 9*(7), 61-69. doi:10.5958/0976-5506.2018.00614.9

Fernandes, T. M. F., Sathler, R., Natalício, G. L., Henriques, J. F. C., & Pinzan, A. (2013). Comparison of mesiodistal tooth widths in Caucasian, African and Japanese individuals with Brazilian ancestry and normal occlusion. *Dental Press Journal of Orthodontics*, *18*(3), 130-135. doi: 10.1590/s2176-94512013000300021

Ferreira, L. B., Mendes-Junior, C. T., Wiezel, C. E. V., Luizon, M. R., & Simões, A. L. (2006). Genomic ancestry of a sample population from the state of São Paulo, Brazil. *American Journal of Human Biology, 18*(5), 702-705. doi: 10.1002/ajhb.20474

Gandhi, N., Jain, S., Kahlon, H., Singh, A., Gambhir, R. S., & Gaur, A. (2017). Significance of mandibular canine index in sexual dimorphism and aid in personal identification in forensic odontology. *Journal of Forensic Dental Sciences*, *9*(2), 56-60. doi: 10.4103/jfo.jfds_15_16

Joseph, A. P., Harish, R. K., Rajeesh Mohammed, P. K., & Vinod Kumar, R. B. (2013). How reliable is sex differentiation from teeth measurements. *Oral Maxillofacial Pathology Journal*, *4*(1), 289-292.

Khangura, R. K., Sircar, K., Singh, S., & Rastogi, V. (2011). Sex determination using mesiodistal dimension of permanent maxillary incisors and canines. *Journal of Forensic Dental Sciences*, *3*(2), 81-85. doi: 10.4103/0975-1475.92152

Kumawat, R. M., Dindgire, S. L., Gadhari, M., Khobragade, P. G., Kadoo, P. S., & Yadav, P. (2017). Mandibular canine: a tool for sex identification in forensic odontology. *Journal of Forensic Dental Sciences*, *9*(2), 109. doi: 10.4103/jfo.jfds_41_16

Mitsea, A. G., Moraitis, K., Leon, G., Nicopoulou-Karayianni, K., & Spiliopoulou, C. (2014). Sex determination by tooth size in a sample of Greek population. *HOMO*, *65*(4), 322-329. doi: 10.1016/j.jchb.2014.05.002

Mohsenpour, K., Gangadhar, M. R., & Samehsalari, S. (2017). Mandibular and maxillary canine as a tool for sex determination. *Journal of Morphological Sciences*, *34*(4), 247-250. doi: 10.4322/jms.114217

Mujib, A. B. R., Tarigoppula, R. K. V. N., Kulkarni, P. G., & Bs, A. (2014). Gender determination using diagonal measurements of maxillary molar and canine teeth in davangere population. *Journal of Clinical and diagnostic Research*, *8*(11), ZC141-ZC144. doi: 10.7860/jcdr/2014/9944.5218

Muller, M., Lupi-Pegurier, L., Quatrehomme, G., & Bolla, M. (2001). Odontometrical method useful in determining gender and dental alignment. *Forensic Science International*, *121*(3), 194-197. doi: 10.1016/s0379-0738(01)00399-1

Pandey, N., & Ma, M. S. (2016). Evaluation of sexual dimorphism in maxillary and mandibular canine using mesiodistal, labiolingual dimensions, and crown height. *Indian Journal of Dental Research*, *27*(5), 473-476. doi: 10.4103/0970-9290.195616

Paramkusam, G., Nadendla, L. K., Devulapalli, R. V., & Pokala, A. (2014). Morphometric analysis of canine in gender determination: Revisited in India. *Indian Journal of Dental Research*, *25*(4), 425-429. doi: 10.4103/0970-9290.142514

Patel, R. A., Chaudhary, A. R., Dudhia, B. B., Macwan, Z. S., Patel, P. S., & Jani, Y. V. (2017). Mandibular canine index: a study for gender determination in Gandhinagar population. *Journal of Forensic Dental Sciences*, *9*(3), 135-143. doi: 10.4103/jfo.jfds_64_16

Patil, S. N., Naik, S. B., Kamble S. D., & Kokane, V. B. (2015). To evaluate the accuracy of various dental parameters used for the gender determination in Nagpur District population. *Indian Journal of Dental Research*, *26*(6), 576-581. doi: 10.4103/0970-9290.176918

Peckmann, T. R., Meek, S., Dilkie, N., & Mussett, M. (2015). Sex estimation using diagonal diameter measurements of molar teeth in African American populations. *Journal of Forensic and Legal Medicine*, *36*, 70-80. doi: 10.1016/j.jflm.2015.09.001

Prabhu, S., & Acharya, A. B. (2009). Odontometric sex assessment in Indians. *Forensic Science International*, *192*(1-3), 129.e1-129.e5. doi: 10.1016/j.forsciint.2009.08.008

Rajarathnam, B. N., David, M. P., & Indira, A. P. (2016). Mandibular canine dimensions as an aid in gender estimation. *Journal of Forensic Dental Sciences*, *8*(2), 83-89. doi: 10.4103/0975-1475.186364

Rao, N. G., Rao, N. N., Pai, M. L., & Kotian, M. S. (1989). Mandibular canine index. A clue for establishing sex identity. *Forensic Science International*, *42*(3), 249-254. doi: 10.1016/0379-0738(89)90092-3

Sabóia, T. M., Tannure, P. N., Luiz, R. R., Costa, M. C., Granjeiro, J. M., Küchler, E. C., & Antunes, L. S. (2013). Sexual dimorphism involved in the mesiodistal and buccolingual dimensions of permanent teeth. *Dentistry 3000, 1*(1), 2-6. doi: 10.5195/d3000.2013.10

Sai Kiran, C., Khaitan, T., Ramaswamy, P., Sudhakar, S., Smitha, B., & Uday, G. (2014). Role of mandibular canines in establishment of gender. *Egyptian Journal of Forensic Sciences*, *4*(3), 71-74. doi: 10.1016/j.ejfs.2014.05.003

Shireen, A., Ara, S. A., Azzeghaiby, S. N., Alzoghaibi, I., Tarakji, B., & Umair, A. (2014). Sex determination potential from canine tooth dimensions. *British Journal of Medicine and Medical Research*, *4*(32), 5133-5143. doi: 10.9734/bjmmr/2014/11005

Silva, A. M., Pereira, M. L., Gouveia, S., Tavares, J. N., Azevedo, Á., & Caldas, I. M. (2016). A new approach to sex estimation using the mandibular canine index. *Medicine, Science and the Law*, *56*(1), 7-12. doi: 10.1177/0025802415575415

Singh, R., Garg, K., & Singh, S. K. (2017). Sex determination by evaluating inter-canine distance and mesiodistal width of mandibular canine. *International Healthcare Research Journal*, *1*(9), 284-291. doi: 10.26440/ihrj/01_09/132

Srivastava, R., Jyoti, B., Jha, P., Gupta, M., Devi, P., & Jayaram, R. (2014). Gender determination from the mesiodistal dimension of permanent maxillary incisors and canines: an odontometric study. *Journal of Indian Academy of Oral Medicine and Radiology*, *26*(3), 287-292. doi: 10.4103/0972-1363.145007

Valle-Silva, G., Souza, F. D. N., Marcorin, L., Pereira, A. L. E., Carratto, T. M. T., Debortoli, G., ... Mendes-Junior, C. T. (2019). Applicability of the SNPforID 52-plex panel for human identification and ancestry evaluation in a Brazilian population sample by next-generation sequencing. *Forensic Science International: Genetics, 40*, 201-209. doi: 10.1016/j.fsigen.2019.03.003

Vijayan, A., Jayarajan, J., & Jaleel, B. N. F. (2019). Significance of Mandibular Canine Index in sex determination. *International Journal of Forensic Odontology*, *4*(2), 54-58. doi: 10.4103/ijfo.ijfo_13_19

Yadav, A. B., Yadav, S. K., Kedia, N. B., & Singh, A. K. (2016). An odontometric approach for estimation of stature in Indians: cross- sectional analysis. *Journal of Clinical and Diagnostic Research*, *10*(3), ZC24-ZC26. doi: 10.7860/JCDR/2016/18406.7386