



Intercanine Distance (ICD) Measurement Using Metric Analysis And Digital Imaging in Bite Mark Gender Identification

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Abstrak

Penelitian ini bertujuan untuk mengidentifikasi jenis kelamin melalui pengukuran *Intercanine Distance* (ICD) yang terdapat pada *bite mark* dengan metode *metric analysis* dan citra *digital*. Jenis penelitian yang digunakan adalah *Narrative Literature Review* dengan melakukan pengkajian pada 11 artikel yang sesuai dengan topik penelitian, artikel didapatkan melalui *database PubMed, Science Direct, dan Wiley*. Terdapat perbedaan nilai ICD pada laki-laki dan perempuan dari metode *metric analysis* maupun citra *digital*. Penggunaan metode *metric analysis* lebih disarankan dalam identifikasi jenis kelamin pada *bite mark* dibandingkan dengan citra *digital*, karena metode tersebut sederhana, tidak mahal, tidak memakan banyak waktu, dan menghasilkan insiden kesalahan yang rendah.

Kata kunci:

Bite Mark; Intercanine Distance; Jenis kelamin; Metric Analysis; Citra Digital

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Abstract

This study aims to determine a gender using Intercanine Distance (ICD) measurement on bite marks with digital imaging and metric analysis. This is a Narrative Literature Review on 11 articles that meet the research requirements, and articles obtained from PubMed, Science Direct, and Wiley databases. It was found that the ICD of men and women measured with metric analysis and digital imaging was significantly different. Therefore, it was suggested that metric analysis is an excellent method to identify gender on bite marks compared to digital imaging, this method is practical, low budget, quick, and accurate.

Keywords:

Bite mark; Intercanine Distance; Gender; Metric analysis; Digital imaging

1. INTRODUCTION

Forensic odontology is a part of forensic science utilizing dental analysis for victim identification. The Federation Dentaire Internationale (FDI) claimed that forensic odontology is a branch of dental

science that extent to legal agreement involved in the evidence management and examination based on dental evaluation and presentations. Forensic odontology consist of dental record collection and interpretation. Bite mark identification and

analysis acquired from a victim's body can be used to estimate victim's age based on dental developments and other characteristics [1],[2].

Bite mark analysis is a mandatory competency of a forensic odontologist. Bite mark is an physical alteration of body parts caused by contact or interdigitation upper and lower teeth which traumatized the tissue structure, bite mark can be obtained from human and animals. Physical evidences, such as bite mark on assault, rape, and murder cases often considered valuable [3].

In the forensic odontology, dental canines play a key role on gender identification, and it is considered valuable in forensic odontology [4]. Inter-canine Distance (ICD) is included in the investigation parameters, similar to anterior teeth impressions, which is the most distinct and measurable. Bite mark analysis are based on the assumption that individual dental development is a unique trait, and this feature was replicated onto the incisal and occlusal aspects [5]. In the future, it was expected to build a forensic database obtained from dental morphometric measurement for anthropology, forensic, and legal purposes.

In line with medical science advancements especially in the forensic field, many researchers demanding better technological supports for an efficient identification process. Forensic studies that required a technological support is digital

imaging. This advance method in the forensic field will be a great aid for many law enforcements, intelligent, private investigators, and the medias [6].

Based on the description mentioned above, we aims to study gender identification on bite marks using metric analysis and digital imaging. The result will be able to provide more information and knowledge for the forensic odontologist about the ideal and efficient method to classify gender based on bite marks.

2. METHODS

This is a narrative literature review, a clear, systematic, and comprehensive study with identification, evaluation, and data collections from the published articles. Therefore we will be able to build a better understanding of the study background, purposes, and the results obtained from every publication, as a reference for the new research to be carried out [7].

This study was aimed to review metric analysis and digital imaging as a new method to determine the Inter-Canine Distance (ICD) on bite marks for gender identification. We carried out a comprehensive, critical, and objective study. Articles included in the study was obtained from PubMed, Science Direct, and Wiley databases. We conducted an advance search on the databases, and found 118 articles. Then the articles was checked for

duplications and there were 62 publications remaining.

The article analysis was focused on the determining ICD using metric analysis and digital imaging to identify the gender on bite marks. Next, the selection was made by title and abstract screening and resulted in 23 relevant articles. The feasibility assessment carried out by reading the full

text articles and only the one with focus and objective matched to this literature review were chosen. After filtering process was done, there were 11 articles met our inclusion criteria. As a data source, all articles was extracted using the Design, Sample, Variable, Instrument, and Analysis (DSVIA) method.

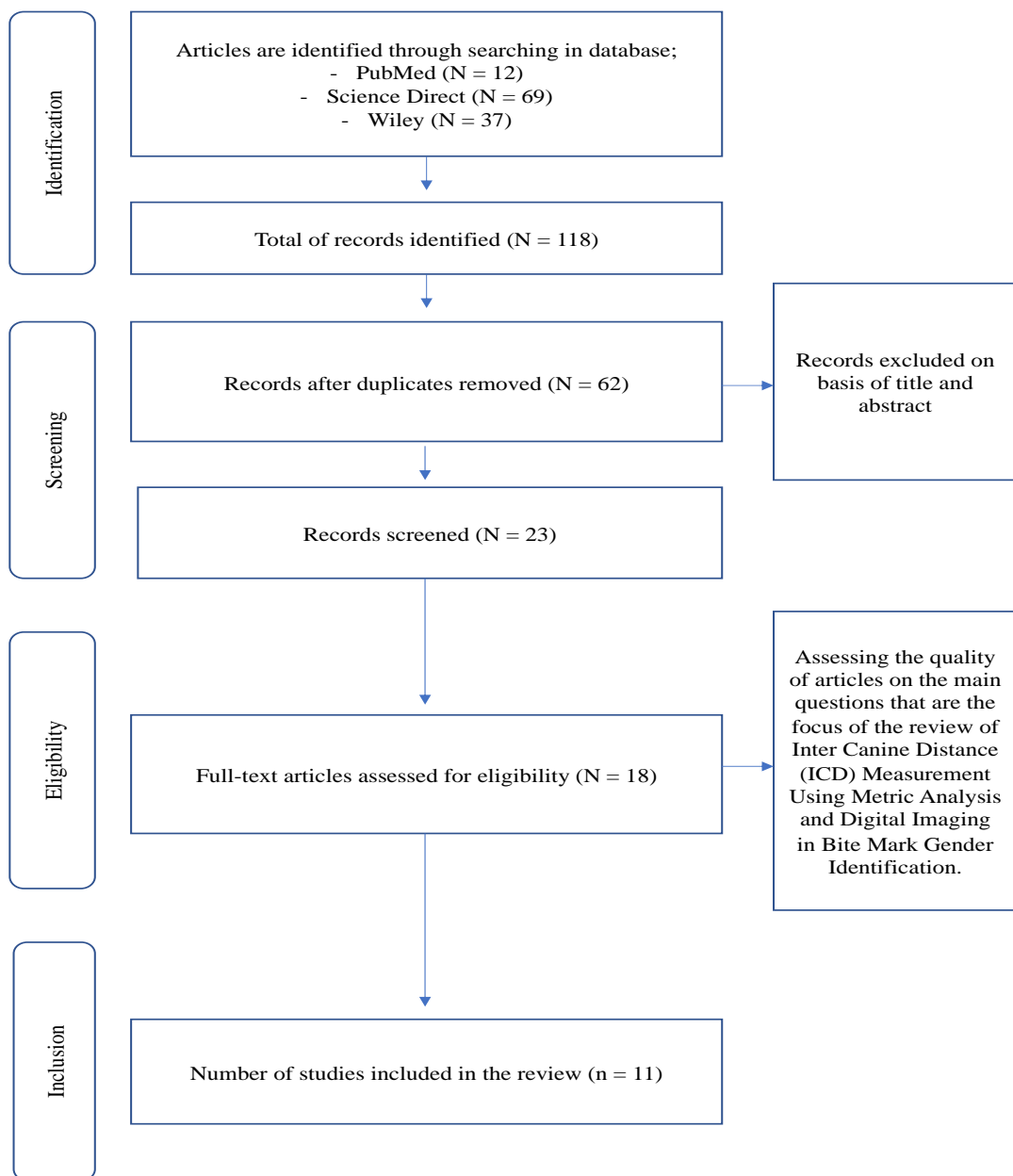


Figure 1. PRISMA –Scr chart

3. RESULT AND DISCUSSION

Dental examination for bite mark analysis were carried out by measuring and analyzing the tooth size, shapes, and positions. Bite mark analysis can be studied manually nor computerized, such as wax biting (at night), xenograft, and radiology [8].

Metric Analysis

The morphology of metric method for gender determination relatively similar on the homogenous sample of the same gender, therefore this method were considered objective because it's using a measurable standards. The method also resulted in lower error incidents. It was claimed that tooth dimension measurement is a non-invasive and more practical technique to evaluate crown features, therefore it is useful in gender identification. This method offer few advantages, such as practical, cost-effective, and time-efficient. The use of dental features in gender determination were mainly based on tooth dimension comparison [9, 10].

The metric analysis yielded a significant difference between ICD scores on men and women. Table 1 describing similar technique and tools used by the researchers for ICD determination, such as caliper, and the MCI (Mandibular Canine Index) formula was used to calculate average ICD on the intraoral and cast models of both men and women. The result was further calculated using a sexual

dimorphism formula, and processed with the SPSS software, the end results were used to determine the ICD of men and women. This method utilizing arrays of models to obtain samples, such as intraoral direct measurement, dental impressions (wax impression, dental cast), and radiograph [8],[9],[10],[11],[12].

In the metric analysis, there are few points to be measured and recorded: 1) The length, width, and the depth of the imprinted tooth, 2) Total dimension of the bite mark, 3) Inter canine distance, 4) Interdental contacts, 5) Rotation of the normal curve. The same procedures also applied to the suspect and comparison were made between the two models. Simple instruments, such as Vernier caliper can be used in the measuring process [13].

The mandibular ICD, which is the distance between caninus on the opposite sides was measured as a linear distance of the cuspal aspect of left and right mandibular canines. The lowest and highest ICD discrepancies on both women and men was 10,91 mm, and the cross-sectional dimension was 4,42 mm. That is, 41% of the undefined dimension, but 59% were identified. The inter-canines distance showed a high sexual dimorphism which considered statistically significant. Inter-canines distance of the mandible on both men and women, respectively, were 34.20 ± 0.19 and 32.64 ± 0.22 [11, 12].

Digital Imaging Analysis

There are several digitalized method that can be used in jaw and dental examination for forensic odontology purpose, such as CBCT (Cone Beam Computed Tomography), GLCM (Gray Level Co-occurrence Matrix), KNN (K-Nearest Neighbor) extractions, and Fuzzy Logic spatial processing classification. In arrays of digital imaging available, only GLCM and CBCT that can be used in bite mark identification and ICD measurements. CBCT will be combined with image processing using the In Vivo Dental Program (Anatmage, San Jose, California, USA) and the images were saved and sent in DICOM (Digital Imaging and Communication in Medicine) formats. CBCT is a quick, accurate, reliable and reproducible technique to determine the mesiodistal width, ICD, and IMD (Inter-molar distance), and dental arch, compared to digitalizing plaster models (2D), unfortunately there were lack of evidences that CBCT can be used in gender identifications [14].

Bite mark identifications must be done quickly because the pattern distinction on both victim and suspect can be altered, bite mark documentation play an important role in providing information. Bite mark identifications are known as a time-consuming process. This long due predisposed to bite mark distortion, and affecting the identification error, for

example, false analysis may cause an innocent suspect to be sentenced. Therefore, gender determination using GLCM digital imaging needs to be done. In this technique, the canine distance features was added, which is calculated from the right to left canine cusp, in pixels. This additional feature will be grouped into one layer on the feature extraction, therefore GLCM and ICD features will be obtained [15].

The ICD assessment was carried out to compare the ICD of men and women, it was found that the men's ICD was larger than on women. The mean ICD on women and men were 1455.125 pixels and 1525 pixels, respectively. The average number was calculated as a percentage (%), therefore the women's ICD is 0.95% smaller than those of men [15].

The analysis and determination bite mark images revealed the best accuracy were obtained from the combination of second-order parameters, which are contrast, homogeneity, and entropy, this finding may be due to the shorter distance and direction used in the study, the more key features will be obtained, the largest distance and direction testing on GLCM found on $d = 1$ and 45° angle with maximum accuracy of 82,97% and computation time 0,632 seconds. Based on the dental arch parameter, the average ICD of female was 0.97% smaller than on the male. The average canine depth on male was 0, 87% smaller than of female [15, 16, 17, 18, 19].

Table 1. Characteristics of articles included in inclusion criteria

Title	Authors	Year	Methods	Result & Conclusion
Differences of intercanine distance on dental cast model, wax impression tracing, radiograph of dental impression tracing, and dental cast tracing methods of bitemark	(Fidya and Swastirani)	2019	Metric Analysis	One-way ANOVA and Tukey LSD tests showed that the radiographic tracing was a gold standard of maxilla and mandibular adjustment. It was concluded that radiographic tracing can be use in bitemark analysis.
Mandibular canine dimensions as an aid in gender estimation	(Rajarithnam, David, and Indira)	2016	Metric Analysis	All mandibular canines parameters, such as ICD, canines width, and canines index of both male and female in sexual dimorphism were significantly different. Confidence interval for subjects data on discrepancy analysis was 73%.
Comparison of Bimaxillary Permanent Canine Arch Width in Terms of Human Sex Identification for Metric Analysis of Bite Mark	(B, Cakici et al.)	2017	Metric Analysis	This study showed an accurate dimorphism diagnosis on ICD and cross-sectional area of maxilla and mandibula of both men and women. This study found the minimum and maximum difference of ICD between men and women were 10.91 mm and non-significant cross-sectional dimension of 4,42 mm. Therefore, 41% of them are undefined dimension, and only 59% were identified.
Sexual Dimorphism in Mandibular Canine Width and Intercanine Distance of University of Port-Harcourt Student, Nigeria	(Ibeachu, Didia, and Orish)	2012	Metric Analysis	The study showed that the average male's right and left mandibular canines were 7.79 ± 0.05 and 7.88 ± 0.05 respectively, and on female were 6.76 ± 0.05 and 6.75 ± 0.05 . The higher ICD level showed a statistically significant higher sexual dimorphism. Mandibular ICD on male and female were $34,20 \pm 0,19$ and $32,64 \pm 0,22$, respectively
Sex Determination by Evaluating Intercanine Distance and Mesio-Distal Width of Mandibular Canin	(Singh, Garg, and Singh)	2017	Metric Analysis	This study found that mandibular canines yielded maximum sexual dimorphism, therefore mandibular canines should be considered as a key tooth in human identification. Left MCI identified 90% female and 94% male, right MCI identified 92% female and 91% males.
Identifikasi Jenis Kelamin Berdasarkan Teraan Gigitan Berbasis Pengolahan Citra Digital dengan Metode <i>Gray Level Co-Occurence Matrix</i> (GLCM) dan Klasifikasi <i>Support Vector Machine</i> (SVM)	(Augustin et al.)	2018	Digital Imaging	In bitemark scanning test and analysis, the highest accuracy were obtained from the combination of two-order parameter, which is contrast, homogeneity, and entropy, because the shorter the distance and direction used, more features will be visible, the highest distance and direction measurement on GLCM obtained on $d = 1$ and 45° angle with maximum accuracy of 82.97% and computation period of 0.6432 seconds.
Identifikasi Jenis Kelamin Berdasarkan Teraan Gigitan Berbasis Pemugaran Citra Dengan Metode <i>Gray Level Co-Occurrence Matrix</i> (GLCM) dan Klasifikasi <i>Support System Machine</i> (SVM)	(Leksono, Purnamasari, and Malinda)	2019	Digital Imaging	From the test result, it was concluded that based on dental arc parameter, the average ICD on females was smaller, 0.97% compared to the average ICD on males. The male's average canines depth 0.87% smaller than females. When using the image registration, the maximum accuracy of 77% and computation time of 0.01870 seconds were obtained.
A Comparison Between Dental Measurements Taken From CBCT Models and Those Taken From Digital Method	(Tarazona et al.)	2013	Digital Imaging	CBCT allowed us to determine the mesiodistal width, ICD, IMD, and arcus length in a faster, reliable, accurate, and reproducible manner, compared to digital methods on plaster models (2D).
Analysis of Intercanine Distance and Dimensional Changes in Bite Marks on Foodstuffs Using Cone Beam Computed Tomography	(Ali, Sansare, and Karjodkar)	2018	Digital Imaging	ICD can be effectively measured on any kind of food. Bite mark analysis using CBCT is a non-invasive, accurate, and efficient technique. The CBCT documentation not easily distorted.
Identification of Rugae Palatine Using Digital Image Processing Technique with Spatial Processing and Fuzzy Logic Classification	(Taufik, Hidayat, and Oscandar)	2016	Digital Imaging	The study found the best accuracy of minimum 75% and maximum 100% with computation period of 1,7434 seconds.
Age identification based on image processing of mandibula first molar panoramic radiograph with Discrete Cosine Transform (DCT) method and K- Nearest Neighbor Classification (K- NN)	(Rachmawati, Hidayat, and Oscandar)	2018	Digital Imaging	This study found that the system was not applicable to identify and classify individual age, using Matlab software. The accuracy obtained was 69.11% with 106 digital samples and 68 tests.

4. CONCLUSION

In the metric analysis, the mandible ICD differences of both men and women was 34.29 ± 0.19 and 32.64 ± 0.22 , respectively.

The GLCM digital imaging analysis for SVM classification showed that the average pixels value were obtained if calculated as percentage (%), the women's ICD was 0.95% smaller than in men. Therefore, the ICD value on women is 1455.125 pixels and 1525 pixels on men. GLCM were considered as the fastest and most effective technique, it only took 0.632 seconds with 82.97% accuracies.

However, metric analysis is recommended in gender identification using bite marks because this technique is practical, cost-effective, and time-efficient, with lower error incidence.

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