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For A Man or A Woman? Gender Determination from Various Foramina and Canals of Maxilla on Cone Beam Computed Tomography (Cbct): A Retrospective Radiographic Study

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ABSTRACT

Introduction: Identification of corpses is a complex forensic procedure mandated by legal and social frameworks. Forensic dentistry and anthropology focus on addressing challenges in sex determination; often relying on morphological features of the maxilla, particularly foramina and canals. Conventional 2D imaging modalities face limitations, prompting exploration of advanced technologies like cone beam computed tomography (CBCT) to enhance accuracy.

Aim: This study aims to contribute to forensic medicine by evaluating maxillary foramina and canals using CBCT for improved gender determination.

Materials and Methods: A dataset of 200 CBCT scans from the Oral Medicine and Radiology department was analyzed, adhering to strict inclusion and exclusion criteria. Measurements of foramina and canals were conducted, and statistical analysis was performed using SPSS software.

Results: This study reveals gender-based differences in the incisive canal and foramen dimensions, emphasizing the need for gender-specific considerations in anatomical research and clinical applications. Similarly, significant variations in the greater palatine canal and foramen measurements, excluding location characteristics, are found.

Conclusion: The research advocates for the integration of advanced imaging techniques to enhance precision in forensic investigations. This forensic odontology study underscores the evolving landscape of gender determination using CBCT.

Keywords: *CBCT, Maxilla, incisive canal, incisive foramen, greater palatine canal and foramen.*

1. INTRODUCTION

Identification of corpses is a difficult forensic procedure and it is mandated by laws and social rules. The study of anthropometric characteristics is of fundamental importance to solve problems related to identification. Skeletal remains have been used for sexing the individual as bones of the body are last to perish after death, next to enamel of teeth.[1]

The identification and determination of the sex of unknown human skeletal remains pose significant challenges, especially in cases involving mass disasters, severe mutilation, decomposition, or skeletal remains. These daunting tasks have become focal points for forensic dentistry and anthropologists striving to contribute to the field of forensic medicine.[2]

Visual inspection, anatomic measurement and precise measurement of bone dimensions often exceed radiologic contribution, particularly where identification of skeletal remains is required. The most helpful area of the body for comparison radiography is the cranium.[2]

To address the challenges in sex determination, forensic experts often turn to morphological features of the maxilla, a bone in the jaw. Anthropologists and forensic dentists commonly utilize this approach in the quest for accurate identification of skeletal remains, leveraging specific characteristics of the maxilla. [3]

Among the significant features of the maxilla, the foramina and canals through which vital neurovascular bundles pass deserve special attention. These structures serve as valuable parameters in gender determination, offering stable landmarks within the skull. The incisive foramen (IF), greater palatine foramen (GPF), lesser palatine foramen (LPF), incisive canal (IC), and greater palatine canal (GPC) are specifically highlighted for their importance in this context.[4,5]

However, the limitations of conventional 2D imaging modalities, such as periapical and panoramic radiographs, hinder the accurate detection of the location and extension of foramina and canals. Challenges such as overlapping anatomical structures and difficulty in standardization prompt the exploration of advanced imaging technologies.[6]

Recognizing the need for more precise imaging, this study delves into the application of computer-based imaging systems, specifically cone beam computed tomography (CBCT). As a 3D imaging modality, CBCT offers distinct advantages over 2D systems by eliminating superimposition, providing clearer insights into the intricate structures of the maxilla.[6]

The primary focus of this research lies in gender determination, and it seeks to contribute to the field by evaluating various foramina and canals of the maxilla. Through the utilization of advanced imaging technology and a thorough understanding of these anatomical landmarks, the study aims to enhance the accuracy and reliability of sex determination in forensic odontology.[7]

2. MATERIALS AND METHOD

A total of 200 CBCT images of patients were selected from the radiological archives of oral medicine and radiology department of Institute.

This study established specific criteria to ensure quality in cone beam computed tomography (CBCT) scans. Inclusions required high-quality images with correct patient positioning and a large field of view (FOV) covering the entire jaw, including the palatine process. Patients aged 20-60 were included for stability in anatomical features.

Exclusions targeted distorted or incomplete images with a small FOV, ensuring a thorough assessment. Patients with maxillary bone fractures, pathological lesions, previous maxillary surgeries, or jaw anomalies were excluded to maintain data integrity. These criteria create a focused and reliable dataset for analysing foramina and canals.

In this study, we conducted a comprehensive analysis of 50 cone beam computed tomography (CBCT) scans that adhered to predetermined inclusion criteria. Our examination focused primarily on multiplanar reformatted images derived from the dataset, utilizing all available sections to identify various foramina and canals. To ensure patient confidentiality, de-identified digital imaging and communications in medicine (DICOM) files were provided for a thorough assessment. The specific list of foramina and canals analysed included the greater palatine foramen and canal (bilaterally), the incisive foramen and canal. This systematic approach aimed to enhance understanding of these anatomical structures and contribute valuable insights to the fields of radiology and dentistry.

In the case of the incisive foramen and incisive canal, linear and area measurements were determined on sagittal reconstructions. Specific parameters, such as incisive canal (IC) surface area, IC length, IC width at the palatal opening, and IC width at the nasal opening and shape and number (coronal section) of canal were recorded.[7] [Figure 1(A)]

For the greater palatine foramen (GPF), measurements were taken between the mid maxillary suture (MMS) and the anterior nasal spine (ANS) in the axial section.[8] [Figure 1(B)] Additionally, the diameter of the both right and left greater palatine foramen were noted in the axial section.[9] [Figure 2 (A)] The length of the GPCs (right and left) were measured according to the methodology of Howard-Swirzinski et al. in both the sagittal and coronal planes. [Figure 2 (A)] The measurements from both planes were then averaged to obtain the final GPC length. In the sagittal plane, the GPC was measured from the centre point of the PPF (superior aspect) to the posterior wall of the GPF (inferior aspect). In the coronal plane the GPC was measured from the centre point of the PPF (superior aspect) to the inferior surface of the horizontal hard palate for standardization due to variance in the shape of the foramen (inferior aspect).[10] Relationship of the GPF to the upper molars as described by Ajmani (1994). Between the upper first and second molar– A In the midline of the upper second molar– B Between the upper second and third molar– C In the midline of the upper third molar– D Distal to the upper third molar- E.[11] [Figure 2 (B)]

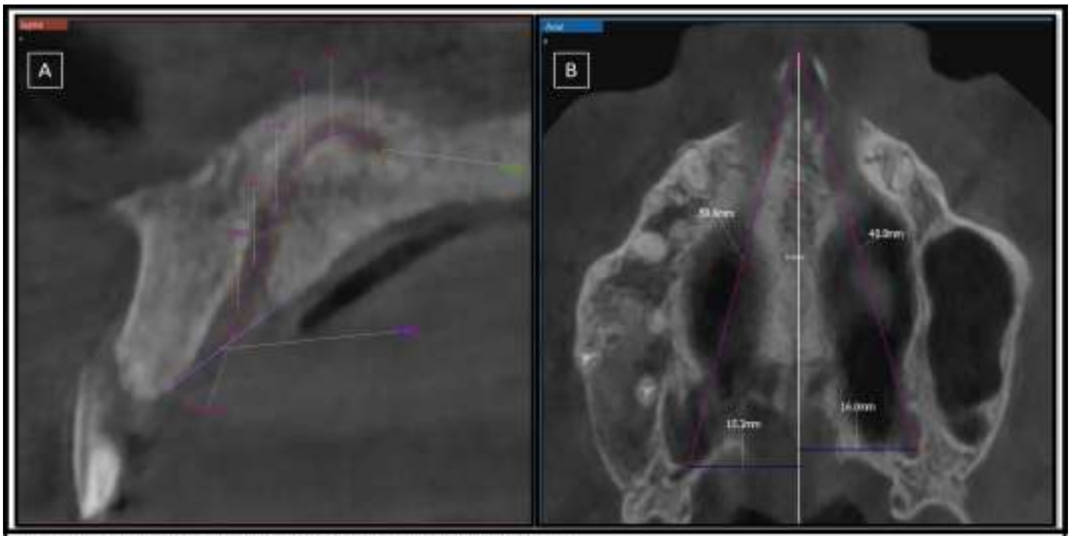

FIGURE 1 (A): INCISIVE CANAL ON SAGGITAL RECONSTRUCTION
FIGURE 1 (B): MID MAXILLARY SUTURE(MMS) AND THE ANTERIOR NASAL SPINE (ANS) IN THE AXIAL SECTION

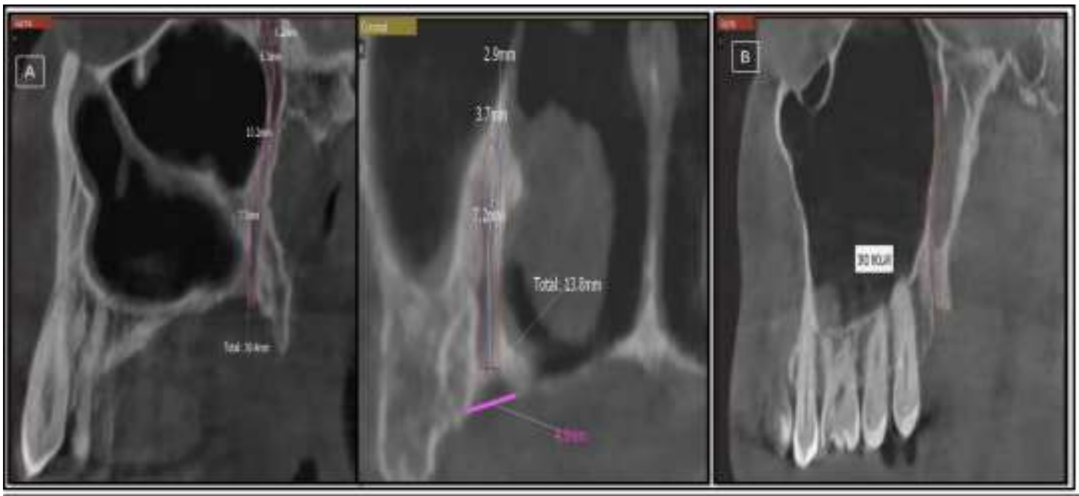

FIGURE 2(A): LENGTH OF GREATER PALATINE CANAL IN SAGITTAL AND CORONAL SECTION
FIGURE 2(B): RELATIONSHIP OF THE GPF TO THE UPPER MOLARS

Data were observed by three independent observers, and in cases of significant discrepancies between their measured values, they were asked to re-evaluate the particular patient. The averaged values were then noted in the study proforma. All observations for the patients were recorded in a Microsoft Excel worksheet, and statistical analysis was performed using SPSS software version 20.

3. RESULTS

While studying Incisive canal and foramen, significant gender-based differences are found in surface area, length, and palatal opening dimensions of incisive canal and foramen. Shape analysis shows variations between genders, with cylinder shape at 30.3%, funnel shape at 41.3%, banana shape at 1.5%, and hourglass shape at 26.9%. However, p-values (> 0.05) suggest no significant association between gender and shape attributes. Regarding the number of incisive canals, 53.7% of the total sample has one canal (50.4% in males, 58.0% in females), 11.9% has two canals (11.5% in males, 12.5% in females), and 34.3% has the Y canal (38.1% in males, 29.5% in females). Chi-Square tests indicate no significant association between gender and the number of canals, as p-values is above 0.05. The shape and number of incisive canals, however, do not show statistically significant associations with gender. The findings emphasize the importance of considering gender-specific anatomical distinctions in comprehensive anatomical studies and clinical applications. [Table: 1], [FIGURE 3]

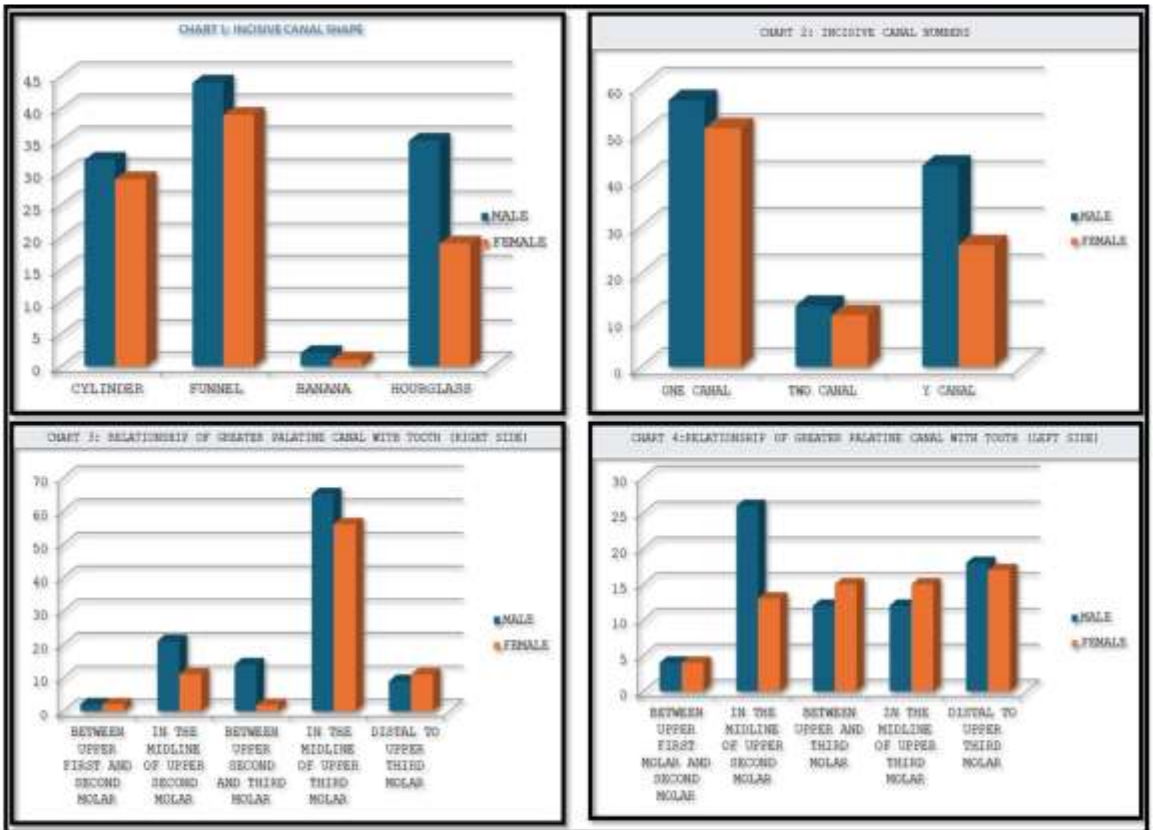

FIGURE 3: GRAPHICAL ARRANGEMENT OF SHAPE AND NNUMBER OF INCISIVE CANAL WITH PLOT STRUCTURE OF RELATIONSHIP OF GREATER PALATINE CANAL WITH RIGHT AND LEFT SIDE TOOTH

While studying gender-related distinctions in greater palatine canal and foramen measurements, significant differences are observed in maxillary molar sum (MMS), alveolar nerve sum (ANS), diameter measurements, and length of the greater palatine canal. Chart 3 and Chart 4 depict the distribution of Greater Palatine Foramen (GPF) relations with teeth for the right and left sides, respectively. In chart 3, for the right side, the most common relation is between the upper 2nd and 3rd molars, constituting 57.5% for males and 63.6% for females. The midline of the upper third molar also shows a significant occurrence. On the left side (chart 4), the midline of the upper 2nd molar is prevalent, with 23.0% for males and 14.8% for females. Gender differences are observed, especially in the midline of the upper 2nd molar for the right side and between the upper 2nd and 3rd molars for the left side. The location characteristics, assessed through Chi-Square tests, do not show significant associations between gender and relation right or relation left. These detailed findings contribute valuable insights for anatomical studies and clinical applications related to dental and anatomical features. [Table: 2], [FIGURE 3]

TABLE 2: PARAMETERS OF GREATER PALATINE CANAL AND FORAMEN

PARAMETERS	GENDER	N	Mean	Std. Deviation	P- Value
GPF MMS R	Male	112	16.834	1.4285	.001
	Female	88	15.078	1.6138	
GPF MMS L	Male	112	15.688	1.4851	.027
	Female	88	15.182	1.7341	
GPF ANS R	Male	112	48.025	7.4843	.001
	Female	88	39.582	6.1913	
GPF ANS L	Male	112	48.058	7.6168	.001

	Female	88	39.575	6.5908	
GPF DIAMETER R	Male	112	3.0536	1.08742	.032
	Female	88	2.7224	1.02891	
GPF DIAMETER L	Male	112	3.0586	1.17066	.009
	Female	88	2.6276	1.07087	
GPC LENGTH R	Male	112	31.2912	5.02681	.001
	Female	88	26.2034	4.30535	
GPC LENGTH L	Male	112	30.9221	5.23218	.001
	Female	88	26.9584	4.62480	

4. DISCUSSION

The examination of incisive canal and foramen measurements in our study revealed intriguing gender-based variations across multiple dimensions. Our findings mirror those of the AI Linjawi[7] and Y. Gönül's[11] study, emphasizing the complexity of gender-specific characteristics in these anatomical features.

Starting with surface area, our results indicated that males, on average, exhibit a higher surface area compared to females, yet the statistical analysis yielded a non-significant p-value. This aligns with Linjawi's[7], Amanda Farias Gomes's[12] and study, Y. Gönül's[11] emphasizing that while a numerical difference exists, it may not be statistically significant. Such nuances underscore the need for a cautious interpretation of anatomical variations.

In contrast, our study found a significant gender difference in incisive canal length, with males displaying a longer length compared to females. This aligns with existing literature suggesting that gender-related differences in craniofacial dimensions may contribute to such variations. According to N Mraiwa[13] the clinical relevance of this finding could be substantial, particularly in orthodontics and oral surgery where precise anatomical knowledge is crucial.

Similarly, the palatal opening dimension exhibited a numerical difference favouring males, though the p-value was marginally significant. This aligns with Linjawi's[7] and Arpita Rai Thakur[14] findings and suggests a trend toward gender-related distinctions in this aspect of oral anatomy. Further studies with larger sample sizes could elucidate the clinical implications of this trend.[1,14]

Notably, our statistical analyses mirrored Linjawi's, revealing non-significant differences in surface area. This congruence highlights the robustness of these anatomical characteristics across diverse study populations.[7]

This study closely mirrors safi Y's research on body shape characteristics in males and females. Both studies show similar prevalence rates for cylinder, funnel, banana, and hourglass shapes. Despite variations, p-values exceeding 0.05 in both studies indicate no significant association between gender and body shape. The consistency in results strengthens the reliability of the findings, contributing valuable insights to the understanding of body shape characteristics across genders.[15,16]

Results from your study align closely with Panjnoush M et. al.'s research on incisive canals, indicating similar prevalence rates among males and females. Both studies show no significant association between gender and the number of canals, with Chi-Square tests yielding p-values above 0.05. In both cases, one canal is the most prevalent, followed by two canals and the Y canal. While lacking statistical significance, these consistent findings between studies contribute valuable insights to the understanding of incisive canal characteristics across genders. Future research could explore additional factors influencing this variations.[17]

Our study results align closely with the findings of Georges Aoun's[8] investigation into the anatomic location and characteristics of the Greater Palatine Foramen (GPF) in the adult population.

The average distances measured between the GPF and midline in Aoun's[8] and Dong Woon Kim[18] study closely parallel our results, with the right side consistently positioned farther from the midline than the left. However, it is noteworthy that vertical distances to the anterior spine and the diameter of the opening did not exhibit significant differences between the right and left sides in both studies. This suggests a lateral asymmetry in the horizontal positioning of the GPF without corresponding differences in its vertical dimensions. Notably, both studies revealed significant differences in distance measurements and GPF diameter, with males consistently exhibiting larger measurements than their female counterparts.[19]

According to Iwona M. Tomaszewska[10] for length of greater palatine canal is long in male and short in female. Our study gives similar result for the same with significant result. Aoun's[8] and Bruno R chrcanovic[20] study highlighted significant variations in the anatomic location of the GPF within the adult population, emphasizing a wide range of horizontal and vertical distances. Similarly, our study corroborates these variations, with GPF distances from the midline ranging significantly, and the majority of foramina located distal to the second molar. This consistency in findings underscores the importance of recognizing the diverse anatomical positioning of the GPF, a factor crucial for clinical interventions in maxillofacial and dental procedures.

5. CONCLUSION

The current forensic odontology study focuses on gender determination through maxillary foramina and canals, crucial in identifying sex from skeletal remains. Utilizing cone beam computed tomography (CBCT), the precision revealing gender-related variations in incisive and greater palatine canals can be enhanced. Advocating for CBCT integration, our research enriches forensic odontology, emphasizing evolving methodologies for accurate gender determination. Advanced imaging and collaborative efforts propel the field towards greater precision, vital for justice in forensic investigations. In essence, our research underscores the evolving landscape of forensic odontology, where technological advancements and meticulous analyses converge to enhance the accuracy and reliability of gender determination.

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