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Morphological and Morphometric Analysis of the Incisive Foramen: A Retrospective Study on Dry Human Skulls

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A B S T R A C T

Objectives: This study aimed to examine the morphological and morphometric characteristics of the incisive foramen and incisive canal in dry human skulls.

Materials and Methods: The sample consisted of 150 dry adult skulls, with no distinction regarding sex or ethnicity. The analysis included the number of incisive canals within the foramen, their dimensions (area and diameter), and their anatomical connections with the incisive fossa and the nasal cavity.

Results: All incisive canals were found to communicate with the nasal cavity. The most frequently observed configuration was foramina containing two or more canals.

Conclusion: Precise anatomical knowledge about the incisive canal and its foramen is essential for clinical procedures involving the anterior maxilla. Morphological variations in this region may affect surgical access, technique selection, and procedural outcomes.

Keywords: Anatomy; Anesthesia, Dental; Anesthesia, Local

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INTRODUCTION

The incisive canal is an anatomical structure located on the floor of the nasal fossa, near the nasal septum and within the incisive foramen of the maxillary palatine process [1,2]. The incisive foramen commonly contains two incisive canals, although additional canals may also be present [3].

Anatomical studies of the incisive foramen and its canals are highly relevant in dental practice. Important structures responsible for the innervation, blood supply, and venous drainage of the hard palate's soft tissues pass through these canals [4]. These structures include the nasopalatine nerve, the septal artery, and the sphenopalatine vein [3,5].

The anterior region of the maxilla holds significant esthetic, functional, and phonetic importance [6]. However, it is also the area most frequently affected by trauma and tooth loss [7]. Surgical procedures in this region are generally considered safe. Nevertheless, the increase in surgical interventions in the anterior maxilla has been associated with a rise in reports of iatrogenic injuries [8,9].

The Le Fort I osteotomy is among the most commonly performed techniques for correcting midface deformities in hospital settings. In such cases, thorough knowledge of the key anatomical structures in this region is essential to prevent complications during and after surgery [7-9]. Moreover, understanding critical anatomical features such as the incisive foramen and its canals is crucial for dental implant procedures [10-12]. A detailed comprehension of the anatomy, morphology, and morphometry of these structures is vital for performing surgical procedures safely [13,14]. Therefore, the objective of the present study was to evaluate the morphological and morphometric characteristics of the incisive foramen and its associated canals using dry human skulls.

MATERIALS AND METHODS

This study was approved by the Research Ethics Committee under protocol number 1.713.069. A sample of 150 dry adult skulls was selected, with no identification of sex or ethnicity. The following variables were analyzed:

1. Number of incisive canals identified within the incisive foramen
2. Measurements of the area and diameter of the incisive foramen
3. Measurements of the area and diameter of the incisive canal
4. Presence of communication between the incisive canals and the nasal and oral cavities.

The number of incisive canals identified within the incisive foramen was evaluated using a Dino Lite® microscope (AnMo Eletronics Corporation, New Taipei City, Taiwan, 30X) (Fig. 1). After image capture, the measurements of the area and diameter of both the canals and the foramina were performed using the DinoCapture 2.0 software (AnMo Eletronics Corporation, New Taipei City, Taiwan). The number of foramina within the incisive canal was determined from the magnified images obtained through the Dino Lite® microscope. A circle was drawn on the captured image using the DinoCapture 2.0 software to delineate the anterior, posterior, and lateral boundaries of both the canal and the foramen. Based on this outline, the software automatically calculated the area and diameter of each structure.

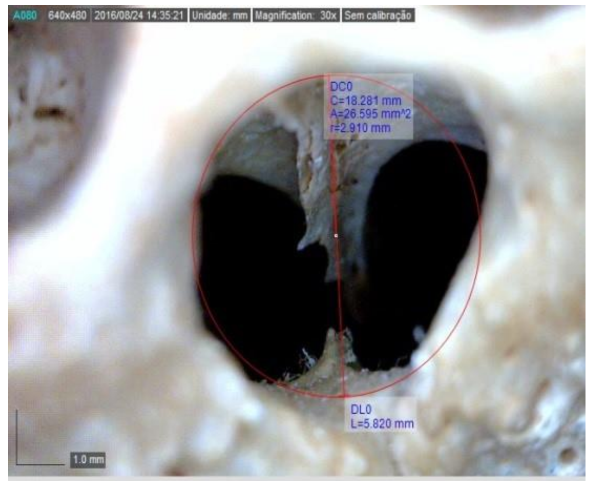

Fig 1. Incisive foramen area (A) and diameter (rx^2) calculated using the DinoCapture 2.0 software

The communication between the incisive canals and the nasal cavity was assessed using a stainless-steel orthodontic wire with a diameter of 0.2mm. The wire was individually inserted into each foramen from the oral cavity. If the wire passed through to the nasal cavity, the foramen was considered to have a connection between the oral and nasal cavities.

The number of canals within the incisive foramen ranged from one to six. Accordingly, the incisive foramen was classified into the following types (Fig. 2):

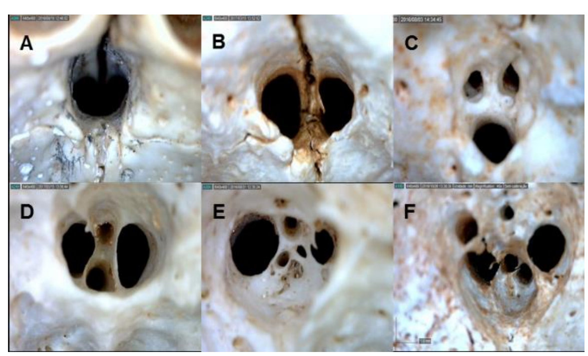

Fig 2. Classification of incisive foramina according to the number of incisive canals: Type 1 (A), Type 2 (B), Type 3 (C), Type 4 (D), Type 5 (E), and Type 6 (F)

Type 1: Presence of one incisive canal
Type 2: Presence of two incisive canals
Type 3: Presence of three incisive canals
Type 4: Presence of four incisive canals
Type 5: Presence of five incisive canals
Type 6: Presence of six incisive canals

Furthermore, nomenclature of the canals was assigned in relation to their anatomical positioning as anterior canal, posterior canal, right lateral canal, left lateral canal, right medial canal, and left medial canal (Fig. 3).

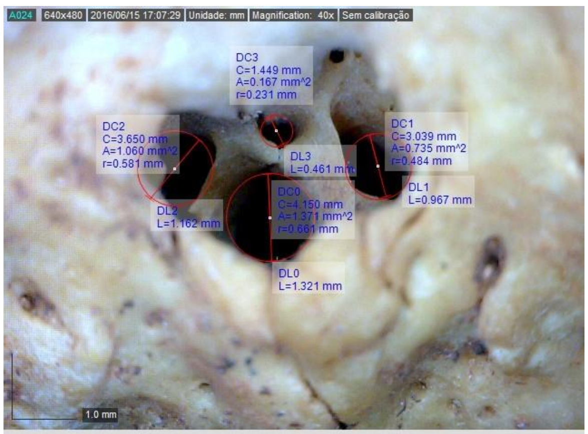

Fig 3. Nomenclature of the canals according to anatomical positioning: DC0 (posterior canal), DC1 (left lateral canal), DC2 (right lateral canal), DC3 (anterior canal)

Statistical analysis:

Descriptive statistics were used to analyze all variables, including absolute frequency (N), relative frequency (%), mean, and standard deviation. A significance level of 5% was adopted for all statistical tests.

RESULTS

Number of incisive canals identified within the incisive foramen:

The frequency of the incisive foramen types was as follows: Type 1: 6.7% (n=10), type 2: 34.7% (n=52), type 3: 34.0% (n=53), type 4: 18% (n=27), type 5: 5.3% (n=8), and type 6: 1.3% (n=2) (Table 1).

Additionally, 54 incisive foramina presented with an anterior canal, 4 with a posterior canal, 123 with a right lateral canal, 127 with a left lateral canal, 10 with a right medial canal, and 10 with a left medial canal (Table 2).

Table 1. Number of incisive canals identified within the incisive foramen (descriptive analysis)

Number	Frequency	Percentage (%)
1	10	6.7
2	52	34.7
3	51	34.0
4	27	18.0
5	8	5.3
6	2	1.3
Total	150	100.0

Table 2. Frequency of incisive canals according to their anatomical position (descriptive analysis)

Canals	Frequency
RLC	123
LLC	127
RMC	10
LMC	10
AC	54
PC	4

RLC: right lateral canal, LLC: left lateral canal, RMC: right medial canal, LMC: left medial canal, AC: anterior canal, and PC: posterior canal

Area and diameter of the incisive foramen:

The mean area of the incisive foramen was 8.148mm^2. The mean diameter of the incisive foramen was 3.101mm (Table 3).

Table 3. Total area (mm^2) and diameter (mm) of the incisive foramen (descriptive analysis)

Parameters	Mean	SD
Total Area	8.148	4.616
Total Diameter	3.101	0.884

SD: standard deviation

Area and diameter of the incisive canals:

The mean canal areas observed were: anterior canals: 0.341mm^2; posterior canals: 1.068mm^2; right lateral canals: 1.975mm^2; left lateral canals: 1.468mm^2; right medial canals: 0.330mm^2, and left medial canals: 0.383mm^2 (Table 4).

The mean diameter of the incisive canals was as follows: anterior canals: 0.572mm; posterior canals: 1.016mm; right lateral canals: 1.281mm; left lateral canals: 1.182mm; right medial canals: 0.644mm; and left medial canals: 0.685mm (Table 5).

Table 4. Mean area (mm^2) of incisive canals based on their location (descriptive analysis)

Canals	Mean (mm^2)	SD
RLC	1.976	3.709
LLC	1.469	1.828
RMC	0.331	0.125
LMC	0.383	0.192
AC	0.341	0.407
PC	0.961	1.430

RLC: right lateral canal, LLC: left lateral canal, RMC: right medial canal, LMC: left medial canal, AC: anterior canal, and PC: posterior canal, SD: standard deviation

Table 5. Mean diameter (mm) of incisive canals (descriptive analysis)

Canals	Mean (mm)	SD
RLC	0.662	0.063
LLC	0.681	0.274
RMC	0.135	0.441
LMC	0.165	0.432
AC	0.224	0.224
PC	0.763	0.346

AC: anterior canal, PC: posterior canal, RLC: right lateral canal, LLC: left lateral canal, RMC: right medial canal, and LMC: left medial canal, SD: standard deviation

Communication between the incisive canals and the nasal cavity:

All analyzed incisive canals showed communication between the nasal and oral cavities. Most incisive foramina presented at least two canals. The right lateral canal had a mean area of 1.975mm^2 and a mean diameter of 1.281mm. The left lateral canal had a mean area and diameter of 1.468mm^2 and 1.182mm, respectively. The incisive foramen had an average total area of 8.148mm^2 and a diameter of 3.101mm.

DISCUSSION

This study aimed to evaluate the morphological and morphometric features of the incisive foramen and its associated canals in dry human skulls. The findings revealed that most incisive foramina contained two or more canals, all of which exhibited communication between the nasal and oral cavities.

Clinically, the incisive foramen is considered a suitable region for dental implant placement [10-12]. A thorough understanding of the anatomical and physiological aspects of this structure is crucial, particularly because of its close relationship with the maxillary central incisors. This proximity can influence the feasibility and ideal positioning of immediate implants [11].

Additionally, procedures such as rapid maxillary expansion in orthodontics require detailed anatomical knowledge of the incisive foramen, since they involve the separation of the midpalatal suture—an area that encompasses this structure [11].

Placement of implants in the region of the incisive canals and foramina is a common clinical practice. Detailed anatomical knowledge of this structure is essential to prevent injury and ensure patient safety. Key anatomical elements pass through the incisive foramen, including the sphenopalatine vein, which is responsible for the vascularization and venous drainage of the hard palate [1,2,11-13].

Surgical interventions in the cranio-maxillofacial region also require an understanding of anatomical variations. Certain surgical techniques frequently used in clinical settings—such as the Le Fort I osteotomy—depend on precise anatomical knowledge of the incisive canal and its foramina [6,7].

Previous studies have investigated the morphology of the incisive foramen and canals using cone-beam computed tomography imaging [3,10,11]. However, there is a shortage of research in the literature that specifically evaluates the incisive canals and their foramina using dry human skulls. The use of real skulls offers greater accuracy and reliability in assessing anatomical structures and taking precise measurements when compared to imaging studies. Detailed anatomical dissection provides a more in-depth view; while, radiographic examinations are more commonly used as complementary tools for diagnosis and treatment planning. Based on this, the present study analyzed the incisive foramen and canals through direct examination of dry skulls [12].

The incisive canal is defined as a duct arising from the oral cavity, which divides into two small canals and terminates at the floor of the nasal cavity near the nasal septum [5]. This description is consistent with our findings, which demonstrated that most of the examined skulls exhibited two main canals: the right lateral and the left lateral canals. Other authors have proposed classifications of the incisive canal based on symmetry, number of canaliculi, and shape [10,12,13,15].

Mraiwa et al. [16] used 2D and 3D imaging and demonstrated that the incisive canals may appear as two to four openings on the floor of the nasal cavity. On the other hand, some individuals exhibit the incisive canal as one single cylindrical structure with only one nasal opening [16]. These findings are consistent with the results of the present study, which identified accessory canals during the examination of dry skulls. Furthermore, the number of accessory canals found in this study was higher than previously reported, reaching up to six.

Most adult individuals present with two incisive canals, with diameter and width values that vary according to sex [10,12,13]. In this study, the average area and diameter of the right lateral canal were 1.975mm^2 and 1.281mm, respectively. For the left lateral canal, the average area was 1.468mm^2 and the diameter was 1.182mm. To date, no previous studies have evaluated the diameter of accessory canals individually.

The mean area and diameter values found for the incisive foramen were 8.148mm^2 and 3.101mm, respectively. These findings are consistent with previous studies [3,4,14]. However, Friedrich et al. [14] reported that the average diameter of the incisive foramen may vary depending on its anatomical trajectory. The diameter measured at the oral cavity was 4.49mm; while, it was 3.43mm at the nasal floor.

Previous radiographic and tomographic studies have shown morphometric differences associated with sex and ethnic variations [17,4]. In the present study, a historical collection of skulls from previous years was used, without available data on the sex, ethnicity, or age of the individuals. This lack of demographic information is considered a limitation of the study.

CONCLUSION

The anatomy of the incisive foramen and its associated canals showed significant variability. A thorough understanding and evaluation of these anatomical structures are essential for the planning and safe execution of surgical procedures in the anterior maxillary region.

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CONFLICT OF INTEREST STATEMENT

None declared.

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