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Study of the prevalence and characterization of the mandibular incisive canal in cone beam computed tomography performed in a school clinic in the Far South of Santa Catarina

Estudo da prevalência e caracterização do canal incisivo mandibular em tomografias computadorizadas de feixe cônico realizadas em uma clínica escola do Extremo Sul Catarinense

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ABSTRACT

Objective: To evaluate the prevalence and characterization of the mandibular incisive canal in patients over 18 years of age, who underwent cone beam computed

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artigo alinhado ao objetivo Boa saúde e Bem-estar dos Objetivos de Desenvolvimento Sustentável (ODS)

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tomography of the mandible in a teaching clinic in the extreme south of Santa Catarina, in the years 2022 and 2023. **Method**: This work refers to quantitative, descriptive, observational and documentary research. Considering the inclusion and exclusion criteria, 320 hemiarches were selected from 160 tomographic exams performed by a single operator and using the same physical factors. The images were evaluated by a dental surgeon specialized in dental radiology. Data regarding age and sex were collected. Furthermore, the presence of mandibular incisive canal was verified and, when present, its length and diameter were measured. The presence of branches and their direction was observed. The research consisted mainly of adult female patients. It was observed that, of the tomographic exams evaluated, 93.4% presented mandibular incisive canal. **Results**: The characterization study demonstrated an average diameter of 1.56 mm and a length of 10.69 mm. The research found that 39.8% of the canals presented branches, with a prevalence of 83.2% in the lingual direction. There was no statistical relevance between the presence of the mandibular incisive canal in relation to sex, presence of teeth, laterality and diameter. **Conclusion**: A high prevalence of mandibular incisive canal was observed. In relation to biological sex, only length showed a statistically significant difference. Cone beam computed tomography is essential before surgical procedures, avoiding iatrogenic injuries and ensuring greater safety for the patient.

Indexing terms: Anatomy. Cone-beam computed tomography. Mandible.

RESUMO

Objetivo: Avaliar a prevalência e a caracterização do canal incisivo mandibular em pacientes acima de 18 anos, que realizaram tomografia computadorizada de feixe cônico de mandíbula em uma clínica escola do Extremo Sul Catarinense, nos anos de 2022 e 2023. **Métodos**: Este trabalho refere-se a uma pesquisa quantitativa, descritiva, observacional e documental. Considerando os critérios de inclusão e exclusão, foram selecionados 320 hemiarcadas de 160 exames tomográficos, realizados por um único operador, e utilizando os mesmos fatores físicos. As imagens foram avaliadas por um cirurgião-dentista especialista em radiologia odontológica. Foram coletados dados referentes a idade e sexo. Além disso, foi verificada a presença do canal incisivo mandibular e, quando presente, seu comprimento e diâmetro foram mensurados. Foi observada a presença de ramificações e sua direção. A pesquisa foi constituída majoritariamente por pacientes adultos do sexo feminino. Observou-se que, dos exames tomográficos avaliados, 93,4% apresentaram o canal incisivo mandibular. **Resultados**: O estudo da caracterização demonstrou um diâmetro médio de 1,56 mm e comprimento de 10,69 mm. A pesquisa constatou que 39,8% dos canais apresentaram ramificações, sendo uma prevalência de 83,2% para a direção lingual. Não houve relevância estatística entre a presença do canal incisivo mandibular em relação ao sexo, presença de dentes, lateralidade e diâmetro. **Conclusão**: Foi observada uma alta prevalência do canal incisivo mandibular. Em relação ao sexo biológico, apenas o comprimento apresentou diferença estatisticamente significativa. A tomografia computadorizada de feixe cônico é essencial antes de procedimentos cirúrgicos, evitando lesões iatrogênicas e garantindo maior segurança para o paciente.

Termos de indexação: Anatomia. Tomografia computadorizada de feixe cônico. Mandíbula.

INTRODUCTION

The Mandibular Incisive Canal (MIC) is a small bony canal located in the region anterior to the mental foramen. It is an extension of the mandibular canal, commonly bilateral. Its function is to protect the anterior incisive nerve of the mandible and blood vessels [1-5], which nourish the lower anterior teeth, including the first premolars, as well as the mucosa associated with this region [2,6,7].

With the increase in life expectancy, oral rehabilitation has become an extremely relevant option, including procedures such as osteotomies, rehabilitation with intraosseous implants and mentoplasty [5, 8-10].

Although the mandibular interforaminal region is considered a safe area for performing surgical interventions in the oral cavity, a growing number of reports have shown several postoperative complications [1,11,12]. Therefore, detailed knowledge of the anatomical structures of the anterior region of the mandible becomes essential in order to ensure the effectiveness of the treatment [2,13,14]. Furthermore, anatomical variations of the MIC occur constantly, highlighting the importance of studying the region to minimize complications [5].

If during the surgical intervention there is an injury to the Mandibular Incisive Canal, Mental Foramen, Anterior Loop of the Inferior Alveolar Nerve and its possible ramifications, postoperative sensitivity may occur, as well as the risk of hemorrhages and the formation of hematomas on the floor of the mouth, which may be transient or persistent [3,8,9,15].

The three-dimensional analysis of the anatomy provided by Cone Beam Computed Tomography (CBCT) allows a better analysis of the mandibular incisive canal, providing greater detail compared to conventional radiographs [1-3,10,11,13], as it allows the analysis of important aspects for preoperative planning that include the position, average diameter and length of the MIC [8,11], and investigating the presence of possible anatomical variations [16]. Furthermore, guided surgery in implantology, driven by the high predictability of CBCT, has brought significant advances to the field and more reliable results [11,17]. Therefore, evaluation by cone beam computed tomography has been recommended for planning procedures in the interforaminal region [16].

This study aims to evaluate the MIC, seeking information about prevalence, diameter, length, presence of branches, as well as the influence of age and biological sex on the anatomical structure, ensuring better planning and greater safety for professionals and patients who require intervention in the intermental region.

METHODS

This study was developed using a quantitative, descriptive, observational and documentary approach. The research began after being approved by the Human Research Ethics Committee of the current institution under opinion 6.582.066. This approval was based on Resolution 466/2012 of the National Health Council, which regulates research involving human beings, in order to ensure the confidentiality of the participants' identities and the use of data exclusively for the scientific purpose of the research. Data confidentiality is guaranteed by means of a confidentiality agreement signed by the researchers.

The study included 160 medical records of patients over 18 years of age, treated at a teaching clinic in the extreme south of Santa Catarina, who had undergone cone beam computed tomography of the mandible, in the years 2022 and 2023, with a Field Of View (FOV) of 8.0 cm x 15.0 cm. Medical records in which the tomographic examination showed partial reproduction of the area of interest or unsatisfactory image quality were excluded from the sample. They were also discarded when the presence of pathology was observed in the anterior region of the mandible and the absence of the Free and Informed Consent Form signed in the medical record.

Considering the exclusion criteria, no medical records were discarded, therefore, 160 medical records were listed, with each examination being analyzed on the right and left side, resulting in a total of 320 hemimandibles.

The patients' physical and digital clinical records were consulted and data relating to the participants' identification were collected, including full name, date of birth and biological sex. The age range was stratified according to the World Health Organization (WHO). Thus, patients aged 20 to 24 years were considered young, those aged 25 to 64 years were considered adults and, finally, those aged 65 to 87 years were classified as elderly. The presence of teeth in the region was visually assessed on the panoramic reconstruction screen and confirmed during the assessment of each hemimandible in axial, coronal and sagittal planes, being classified as total presence of teeth when all teeth were present, partial presence of teeth when the lack of one or more teeth was observed, but not all, and absence of teeth, when there were no teeth in the region.

Tomographic examinations of the mandible were performed on an OP300 device (Instrumentarium Dental, Finland), by the same operator, without a lip retractor, with a voxel of 0.1 mm, using the Cliniview software (Instrumentarium Dental, Finland). The scanogram was performed in all examinations. The physical factors used were 4 mA and 90 kVp, with a scanning time of 6.1 seconds.

The evaluation of the tomographic data was conducted by a dentist specialized in dental radiology, with more than 15 years of experience. The evaluations were performed after intra-observer calibration, with no time limit for each evaluation, in a low-light environment, using the OnDemand 3D software (Cybermed, South Korea). The tomographic images were analyzed on the multiplanar reconstruction screen, using a filter to adjust vertical and horizontal lines.

In the tomographic examinations, the presence of the mandibular incisive canal was evaluated, as well as the average length and diameter, the presence and direction of branches and the presence of teeth in the region (figure 1).

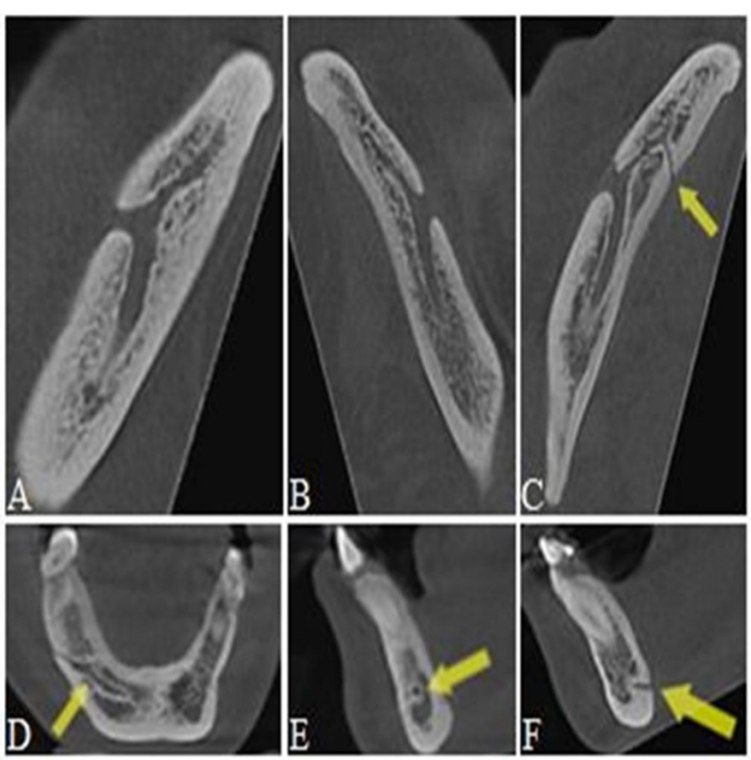

Figure 1. Tomographic images of the mandibular incisive canal and branches.
Source: Authors (2024).

Regarding figure 1, it is worth noting that: A: Axial section of the right hemimandible showing the long axis of the mandibular incisive canal. B: Axial section of the left hemimandible showing the long axis of the mandibular incisive canal. C: Axial section of the right hemimandible showing the branching that follows towards the lingual cortex of the mandible. D: Coronal section of the right hemimandible showing the long axis of the mandibular incisive canal. E: Sagittal section of the right hemimandible showing the mandibular incisive canal. F: Sagittal section of the anterior region of the mandible on the right side showing the branching that follows towards the lingual cortex of the mandible.

First, the presence of the mandibular incisive canal was verified on the right and left sides. When identified, the mandibular incisive canal was aligned with the axial plane and the length was measured from the most anterior point of the mental foramen to the most anterior visible limit of the mandibular incisive canal. Then, the internal diameter, that is, the caliber of the mandibular incisive canal was measured. This measurement was taken 1.0 mm in front of the mental foramen, at its greatest width (figure 2).

Regarding Figure 2, it is shown that A: Axial section of the right hemimandible showing the length of the mandibular incisive canal. B and C: Axial section of the left hemimandible showing the length of the mandibular incisive canal. D and E: Cross section of the left hemimandible showing the diameter of

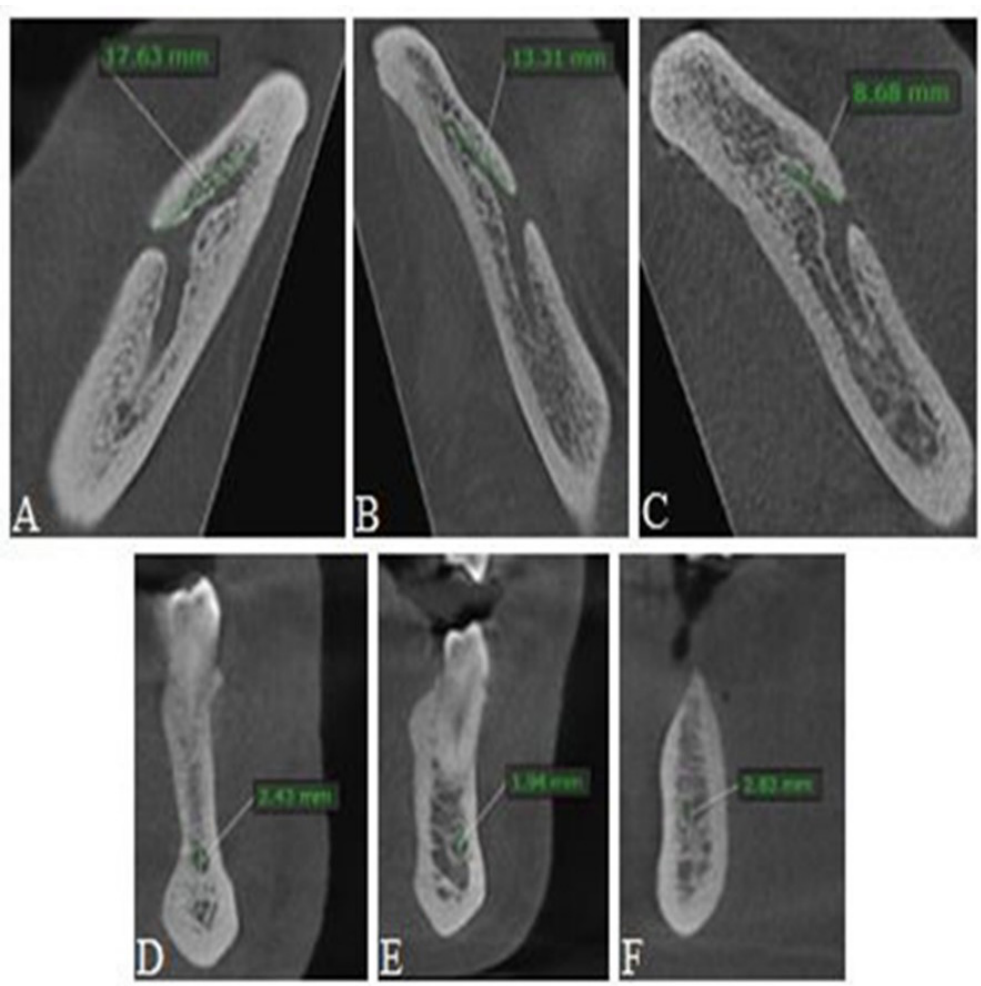

Figure 2. Tomographic images of the length and diameter of the mandibular incisive canal.
Source: Authors (2024).

the mandibular incisive canal. F: Cross section of the right hemimandible showing the diameter of the mandibular incisive canal.

Therefore, the identification of branches was performed visually, by going through the axial and sagittal sections of the examination, on the multiplanar reconstruction screen. In addition to the quantitative evaluation, they were classified according to the cortical bone to which they are directed, that is, to the alveolar ridge, lingual or vestibular cortical bone and to the basilar, when inferiorly.

The information was recorded on a collection instrument and there was no retention of research data.

Then, all collected data were entered into a Microsoft Office Excel file and exported to IBM®SPSS® (version 20.0) Data analysis was performed using descriptive statistics, resulting in the creation of frequency tables and graphs of the most relevant research variables. The Kolmogorov-Smirnov normality test was applied to verify whether the length and diameter data on the right and left sides presented a normal probability distribution.

In hypothesis testing, H0 indicates that the variable has a normal probability distribution, while H1 suggests that the variable does not follow a normal probability distribution.

According to the Kolmogorov-Smirnov normality test, the data for right side length (*p*-value 0.096), left side length (*p*-value 0.200), right side diameter (*p*-value 0.200) and left side diameter (*p*-value 0.190) showed normal distribution.

Therefore, the parametric Student's t-test and Analysis of Variance (ANOVA) were used to assess the presence or absence of differences in mean lengths and diameters between biological sex and age group of patients. Pearson's Chi-square test was used to verify the association between the present dentition, biological sex and age group of patients.

All statistical tests were applied using a significance level (α) of 5% and a 95% confidence interval.

For reproducibility analysis purposes, 20% of the sample was reassessed. The level of agreement between diagnoses was analyzed using the Kappa Statistical Index. There was a high level of agreement, with a kappa value of 1.

RESULTS

The study sample consisted of 320 hemimandibles from 160 patients. Among the patients analyzed, 91 were female, constituting 56.9% of the sample, while 69 were male, representing 43.1% of the total.

The majority of participants belonged to the adult age group (65% of the sample), followed by the elderly (29.4%), and young people (5.6%).

Regarding the right side, 51.3% had all teeth in the anterior region of the mandible and 36.9% were partially edentulous. Considering the left side of the mandible, 56.3% of the individuals had all teeth and 31.9% were partially edentulous. On both sides, 11.9% of the patients were edentulous in this region.

In this study, the Mandibular Incisive Canal was detected in 299 hemimandibles, representing 93.4% of the sample.

MIC was identified in 92.3% of women and 94.9% of men on CBCT images. Although the occurrence is slightly higher in males, no statistically significant differences were observed in the presence of MIC in relation to the biological sex of the individuals analyzed.

MIC was more prevalent in the elderly, being observed in 91.4% of this group, followed by young people, with 88.8%, and adults, with 87.5%.

In the findings of this research, in relation to laterality, the prevalence of MIC was 93.8% for the right side and 93.1% for the left side.

When analyzing the relationship between gender and laterality of the MIC, men presented a significantly higher prevalence on the left side compared to women, being 97.1% and 90.1%, respectively. On the other hand, in relation to the right side, women presented a slight predominance, being 94.5% in women and 92.8% in men, although without statistical relevance.

The MIC presented an overall mean diameter of 1.56 mm ± 0.52. When analyzed by sex, the mean diameter in males was 1.60 mm ± 0.51 and in females 1.50 mm ± 0.50. However, there was no statistically significant difference in the MIC diameter between the sexes.

Analyzing the MIC length data, it was possible to identify the presence of a value well above the average (Outlier) in the length of the right side (20.61 mm) and a value well above the average in the length of the left side (19.36 mm). As outlier values influence the mean and standard deviation values, both were excluded from the calculations of the parametric Student's t-test and Analysis of Variance (ANOVA).

The overall mean length of the MIC was 10.69 ± 2.91. When stratified by sex, the mean length in males was 11.28 mm ± 2.95 and in females 10.22 mm ± 2.80, with statistical significance observed between the values (*p*-value = 0.002). This value was calculated excluding data considered outliers.

Regarding the measurements of length and mean diameter of the MIC, separated by laterality, a statistically significant difference was observed only in the length of the right side between women and men, in which men presented a significantly greater mean length (*p*-value = 0.000) compared to women (Table 1).

Table 1. Measurements of length and diameter of the mandibular incisive canal in relation to biological sex and age group.

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Channel measurement (mm)	Biological sex	n	Average	SD	*p*-value
Length right side	Feminine	85	10.15	2.56	0.000*
	Masculine	64	11.80	2.84	
Length left side	Feminine	82	10.31	3.04	0.341
	Masculine	66	10.78	2.98	
Diameter right side	Feminine	86	1.54	0.51	0.578
	Masculine	64	1.59	0.54	
Diameter left side	Feminine	82	1.46	0.48	0.064
	Masculine	67	1.60	0.48	
Channel measurement (mm)	Age range	n	Average	SD	*p*-value
Length right side	Youth	9	9.41	1.30	0.075
	Adult	95	10.69	2.87	
	Elderly	45	11.50	2.74	

Table 1. Measurements of length and diameter of the mandibular incisive canal in relation to biological sex and age group.

Channel measurement (mm)	Biological sex	n	Average	SD	*p*-value
Length left side	Youth	8	10.79	3.12	0.599
	Adult	96	10.33	2.98	
	Elderly	44	10.87	3.08	
Diameter right side	Youth	9	1.47	0.62	0.694
	Adult	96	1.55	0.50	
	Elderly	45	1.61	0.56	
Diameter left side	Youth	8	1.52	0.53	0.668
	Adult	97	1.50	0.49	
	Elderly	44	1.58	0.47	

Source: Authors (2024).
Note: *Significant differences according to Student's *t*-test for two independent samples; SD: Standard Deviation.

According to the statistical test, there were no significant differences between the mean diameters of the right side (*p*-value = 0.080) and left side (*p*-value = 0.560) of the mandibular incisive canal, considering the absence and partial or total presence of teeth (Table 2).

Table 2. Non-significant differences between mandibular incisive canal diameter and presence of teeth.

Right side diameter measurement (mm)	n	Average	Standard deviation	*p*-value
It has no teeth	19	1.16	0.53	0.080
Presence of teeth	82	1.49	0.62	
Partial presence of teeth	59	1.53	0.66	
Left side diameter measurement (mm)	**n**	**Average**	**Standard deviation**	***p*-value**
It has no teeth	19	1.35	0.55	0.560
Presence of teeth	90	1.40	0.58	
Partial presence of teeth	51	1.47	0.67	

Source: Authors (2024).

The research analyzed the presence and orientation of the MIC branches, evaluating their direction in relation to the vestibular, lingual, basilar or alveolar ridge. It was found that at least one branch was present in 39.8% of the mandibular incisor canals evaluated. Among these, the lingual direction presented the highest prevalence, 83.2%, surpassing the other directions observed.

DISCUSSION

The MIC is an anatomical structure that, contrary to previous conceptions, is not limited to a morphological variation, and its frequent identification in anatomical studies highlights the importance of

correct location and characterization for procedures in the anterior region of the mandible. This study aims to analyze this anatomical structure using Cone Beam Computed Tomography and is not restricted to the analysis of prevalence, but also covers the characterization of MIC, which presents as a small hypodense band with a circular contour, with a discrete hyperdense margin.

The sample was composed mainly of tomographic examinations of female individuals, reinforcing that women are more engaged in seeking health services, which indicates greater concern for well-being compared to men [16].

The presence of the mandibular incisive canal showed a high prevalence in the sample studied, this data corroborates other studies, in which it was found in more than 90% of the exams [7,10,15]. However, a study conducted with the Chinese population, using 500 panoramic radiographs, observed MIC on at least one side of 53% of the evaluated exams. This disparity can be attributed to the fact that the authors used two-dimensional exams, which can make radiographic interpretation difficult, highlighting the importance of studies with CBCT in the interforaminal region [4].

In this study, the overall prevalence of the mandibular incisive canal showed a slight increase on the right side. Regarding sex, the MIC was more prevalent on the left side in men. Only one study in the reviewed database compared the sides and reported a slight increase on the left side, but without considering sex [6]. Therefore, although the number of articles that performed the comparison between the sides is scarce in the literature, the structure is considered bilateral and its occurrence cannot be attributed to a specific side.

Although the presence of the structure was more observed in men, there was no statistically significant difference in relation to the occurrence of MIC according to biological sex. Some authors also found a higher prevalence in men [12]. However, these results differ from other studies [6,16], in which women presented a higher prevalence in their findings. These data allow us to understand that biological sex cannot be attributed as a determining factor for the presence of MIC. Furthermore, data regarding age group also do not seem to influence the occurrence of MIC, as its formation occurs during mandibular ossification and then remains throughout the individual's life, with no possibility of its subsequent development.

During the measurement of the internal diameter, it was visually observed that the internal diameter of the MIC gradually decreases from its origin to the terminal portion, as the mesial direction is reached, a concept that is in line with other authors [5,7,18]. In no examination evaluated in this study did the MIC reach the midline of the mental symphysis, and furthermore, no study demonstrating such anatomical evidence has been found in the literature to date. These results indicate that the MIC may become less evident as it approaches the midline, possibly decreasing in size or branching in this region.

When considering biological sex as a variable, a variation in the diameter of the mandibular incisive canal was observed, with men presenting a larger average diameter on the left side, compared to women, corroborating studies from 2017 and 2019 [12,16].

Previous studies using CBCT showed averages of 2.44 mm [14], 1.63 mm [1], 0.93 mm [9] and even 2.60 mm [19] for the diameter. The results of this study are similar to the values described by a study, which recorded an average diameter of 1.40 mm ± 0.1 mm. Lack of knowledge of the MIC diameter is associated with significant risks in surgical procedures, particularly in implants [20,21].

Previous studies [1,9,11,12,16,19,20] performed measurements of the MIC diameter, with emphasis on the evaluation of the vertical diameter, which refers to the determination of the canal in the direction perpendicular to the occlusal plane, providing relevant information on the anatomical and dimensional characteristics in this specific orientation. Thus, the research is in line with this methodological line of

measuring the MIC diameter. Despite this, a study carried out in 2020 was the only one in the database of this research to perform the measurement in the vertical and horizontal directions, this being just a complementary approach, according to the authors [11].

A study published in an Indian journal exclusively reported the overall average length, recording 10.17 mm, which is very similar to the data obtained in this study [19]. In contrast, in the sample of male participants, a study carried out in 2018 described an average length of 22.60 mm ± 0.3 mm, a value significantly higher than the 17.30 mm ± 0.1 mm found in the female sample, indicating that the data exhibited an asymmetric pattern. Although the authors reported having taken the measurement from the mental foramen, they did not specify how far the measurement was taken [20].

When analyzing the relationship between gender and MIC laterality, men showed a significantly higher prevalence on the left side compared to women. Regarding the right side, women showed a slight prevalence. There is no data in the literature that differentiates the prevalence between the right and left sides and the relationship with biological sex. Therefore, biological sex cannot yet be attributed as a determining factor in the presence of MIC.

The dental profile did not influence the diameter and length measurements, as well as the laterality, that is, the hemiarch in which the MIC was observed. However, a study revealed that the presence of teeth significantly influences the location and diameter of the MIC [22]. Although several authors suggest that sex, age and dental status may influence the characteristics of MIC [1,6,12,14,16,20,23], the findings of this study do not justify this statement, since the only significant relationship found was between biological sex and MIC length. Furthermore, the factors mentioned do not influence the prevalence of MIC.

This study presented information regarding the branches of the MIC, analyzing the occurrence and variability of its orientations, for lingual, vestibular, alveolar ridge and basilar, a topic that was not addressed in the literature consulted. The branches were present in less than half of the evaluated exams, and the lingual direction was the most observed.

It is recommended that new studies be carried out to analyze the measurement of bone height in relation to the MIC and the mean diameter at the end of the structure, using CBCT. The three-dimensional image contributes to a detailed anatomical knowledge of the interforaminal region of the mandible, allowing for more accurate surgical planning and resulting in better prospects for success in the procedures, as it reduces possible complications.

CONCLUSION

This study showed a high prevalence of the mandibular incisive canal, approximately 93.4%, confirming that the characterization of this anatomical structure is not influenced by factors such as biological sex, presence of teeth, laterality and age. In the evaluation of the characterization of the MIC, an overall average diameter of 1.56 mm and length of 10.69 mm were observed. In the analysis of the presence and orientation of the branches, it was found that 39.8% of the mandibular incisive canals presented branches. Among the branches observed, the lingual direction presented the highest prevalence, approximately 83.2% of the total. Therefore, it is recommended that the dentist request a CBCT before surgical procedures in the anterior region of the mandible. In this way, the three-dimensional image allows for the precise identification of the location and path of the MIC, avoiding possible iatrogenic injuries during surgery and ensuring greater safety for the patient.

Conflict of interest: The authors declare that there are no conflicts of interest.

Collaborators

NC Rosso, conceptualization, data curation, formal analysis, methodology, project administration, writing – original draft, writing – review & editing. IM Nuernberg, conceptualization, data curation, formal analysis, methodology, writing – original draft, writing – review & editing. A Rodrigues, RA Ceretta, MR Bortot, PFA Ribeiro, and MCN Gava, methodology and validation. AC Maragno, methodology, supervision, validation, writing – original draft, writing – review & editing.

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