

Morphometric Analysis of The Mandibular Incisive Canal in Different Facial Patterns

Eduardo dos Santos Filho, Renata Dantas Barreto, and Rudyard dos Santos Oliveira

ABSTRACT

The study evaluated the morphometry of the mandibular incisive canal correlating with the different patterns of facial growth. The sample consisted of 90 cone beam computed tomography scans, divided into 3 groups: brachyfacial (n=30), mesofacial (n=30) and dolichofacial (n=30). For the determination of these groups, the acquisitions were arranged in the Dolphin 3D software to perform the Ricketts 3D cephalometric tracing and the VERT index. Next, the images were worked on the Ondemand3d software to perform the morphometric analysis of the incisive canal. For data analysis, the Kruskal-Wallis and Mann Whitney test were performed to test the interference of facial patterns, sex and age in the Mandibular Incisive Canal Extension. In the intragroup analysis of the MICE, the Friedman test was used, considering a 95% confidence interval and a significance level of 5%. The sample consisted of 54.4% of males and 45.6% of females. Sex and age had no effect on morphology and incisive canal extension. When the relationship between facial patterns and MICE was observed, brachyfacials (11.09 mm) presented a larger extent ($p<0.001$) than dolichofacial (4.10 mm) and mesofacial (5.55 mm). When the morphology of the MIC was analyzed, most individuals presented the linear horizontal format, and there was no direction between the groups. Thus, we can conclude that the facial pattern influences the MICE and sex, age and morphology were not influenced by the facial pattern.

Keywords: Tomography. Cephalometry. Forame Mental.

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Eduardo dos Santos Filho

Dentistry Department, Uninassau College,
João Pessoa, PB, Brazil.

(email: eduardosantosfilho11@gmail.com)

Renata Dantas Barreto

Dentistry Department, Uninassau College,
João Pessoa, PB, Brazil.

(email: renatadantasbarreto@gmail.com)

Rudyard dos Santos Oliveira *

Dentistry Department, São Leopoldo
Mandic College, Campinas, SP, Brazil.

(e-mail: dr.rudyardoliveira@gmail.com))

**Corresponding Author*

I. INTRODUCTION

Some dental surgeries involve noble structures or areas adjacent to them, such as the mandibular canal, and these require an accurate knowledge of the anatomical form of this structure to avoid injury to the inferior alveolar nerve present in the canal.[1], [2].

The planning of implant treatment should be judicious, as the length, diameter and angulation of the implants are crucial factors to the success of each case. The shape and height of the alveolar bone as well as noble structures such as the mandibular canal and floor of the maxillary sinus should be precisely localized and carefully considered prior to treatment with implants. It is essential an adequate clinical examination and complementary survey of images [3]-[5].

Some dental surgeries involve noble structures or areas adjacent to them, such as the mandibular canal, and these require an accurate knowledge of the anatomical form of this structure to avoid injury to the inferior alveolar nerve present in the canal [6], [7].

The mandibular incisive canal (MIC) usually begins from mesial to the projection of the mental forame and advances from posterior to anterior parallel to the roots of the anterior teeth. Knowledge of the exact location and quantitative parameters of the mandibular incisive canal has high practical value. The implant detection of the aforementioned structure reduces the risk of anatomical and functional complications

of surgical procedures in the mental area, including dental implant, bone harvesting and screwed plating of mandibular fractures [11]-[13].

During surgical procedures in the mandible, the mental interforaminal region is generally considered "a safe region" with minimal morbidity, however, it may present important risks for anatomical and functional damage. The presence of MIC is of significant interest, including the insertion of endosseous implants, the collection of bone from the mental bulge. However, the presence of MIC cannot be underestimated during pre-surgical planning and may cause sensory postoperative disturbances, edema, hematoma, and lack of implant bone integration [14].

The lower incisor canal is the medial extension of the mental nerve, which is performed in the anterior region of the mandible and can open lingually near the mental tubercle. The nerve may have varied course, with multi-morphic representation. The number of cases with surgical intervention in the interforaminal area has increased considerably since this region has good quality and bone quantity along with the perception that this is a safe zone. Failure to determine the exact position of the neurovascular bundle in this region may lead to complications such as transient or long-term paraesthesia of the associated region [15].

Detailed preoperative study of anatomical structures with cone-beam computed tomography is crucial for the success

of the procedure and to reduce the number of postoperative complications after procedures in the area of the synphysis. Several studies have shown that, due to its excellent anatomical resolution, this test is the best method for obtaining incisor canal and for preoperative measurements, due to its reproducibility and high degree of reliability, results similar to anatomical studies in dry skull have been obtained [16], [17].

Thus, the present study will aim to collaborate with surgical planning by means of cone-beam computed tomography by evaluating the shape and metric of the mandibular incisor canal correlating with different facial growth patterns.

II. MATERIALS AND METHODS

The retrospective observational study was submitted and approved by the Ethics and Research Committee of the Federal University of Paraíba, João pessoa/PB, under the protocol CAAE 01617318.0.0000.5374.

A. Sample determination

In a total of 258 exams observed, from January 2015 to May 2019, 90 CBCT tests of extended face were selected after the facial growth patterns were determined and the exclusion criteria were applied: patients with bone malformation; with the presence of lesions in the region; history of trauma or previous surgical procedure; presence of impacted teeth and images with unsatisfactory quality for visualization of the region of the mental forame. This sample size of 90 participants provided test power of 0.80 ($\beta=0.20$), for significance level of 0.05 ($\alpha=0.05$) and effect size $w=0.39$, using the Gpower program.

The sample consisted of examinations of patients over 18 years of age and of both sexes and divided into three groups according to facial growth pattern: brachyfacials ($n=30$); mesofacials ($n=30$) and Dolicofacials ($n=30$). Subsequently, the CBCT images were evaluated in order to perform morphometric analysis of the mandibular incisor canal.

All images observed were acquired with the same protocol using the i-CAT tomography (Imaging Sciences International, Hatfield, PA): 12-bit gray scale, voxel size of 0.25 mm, FOV 13 X 22 cm. As standardization of tomographic evaluations, the images were analyzed by two previously calibrated examiners. Interobserver reproducibility (IOR) in the classification of facial growth patterns and morphometric analysis of the mandibular incisive canal was evaluated by intraclass correlation coefficient (ICC) and Kappa, respectively. The IOR was excellent both linearly ($ICC > 0.9$, $p < 0.0001$) and nominally ($kappa = 1.0$). They were obtained at two different times, when the facial growth pattern and morphometric analysis of the mandibular incisor canal were determined.

B. Determination of facial growth patterns

To determine the facial growth pattern, the VERT index of Ricketts cephalometric analysis was used. The cephalometric points of this analysis were obtained using the Dolphin® Imaging (Dolphin Imaging System, USA) version 11.0. Cephalometric points requested by the analysis were marked

to obtain the cephalometric tracing. The software illustrates all the points and sequence to tract them, offering the possibility of approximate visualization of the area in question without overlap of structures. From the union of the points, the digital tracings and the linear and angular values were obtained, automatically informed. In the final analysis the facial pattern is determined.

C. Mic extension analysis

All images were processed and worked on on Demand3d® (Cybermed, Seoul, Republic of Korea). These procedures were performed according to the protocol described above by Barbosa et al. 2020 [17] as shown in Fig. 1.

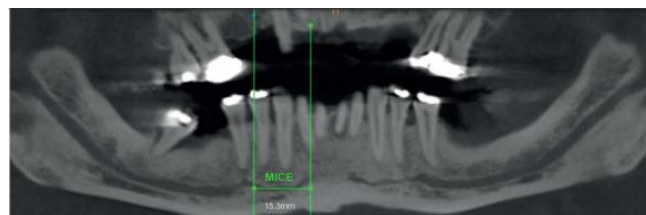


Fig. 1. Measurement of the extent of the mandibular incisive canal.
Source: modified by [17].

In view of the panoramic tomographic reconstruction, the morphology of the canal was evaluated according to the review by Greenstein and Tarnow [18] (Fig. 2).

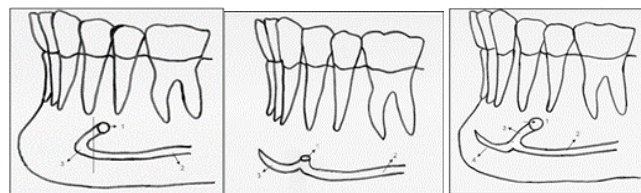


Fig. 2. Morphological evaluation of the mental region.
Source: Greenstein and Tarnow Modified (2006).

D. Statistical Analysis

The data were tabulated in Excel and analyzed in SPSS v.20 (IBM Statistics) in order to verify the normality of data distribution using the Kolmogorov-Smirnov test. Due to the abnormality in the distribution of numerical data related to the extension of the mandibular incisive canal (right side, left side and mean between canals) the Kruskal-Wallis test was used to test the interference of facial patterns, gender and age in the dependent variable. In the post-hoc analysis, the Mann-Whitney test was used to determine in which groups there was a statistically significant difference with the measurements of incisive canal extensions. The Friedman test was used in the intragroup analysis of the dependent variable. The chi-square independence test was used to verify differences between categorical variables. A confidence interval of 95% and a significance level of 5% were considered.

III. RESULTS

Conical beam computed tomography scans were analyzed in 90 individuals, divided into three groups containing 30 of each facial pattern, in order to obtain the relationship of the extent, shape and location of the incisive canal (Table 1).

TABLE 1: SAMPLE CHARACTERIZATION

		N	%
Sex	Male	49	54,4
	Female	41	45,6
	Total	90	100
Age	<30	88	97,8
	>30	2	2,2
	Total	90	100

A. Facial Pattern Analysis on Incisive Channel Extension

The kruskal-wallis test showed that there is effect of the facial pattern on the right extension [$X^2(2)=16.217$; $p<0.001$] and left of the incisive canal [$X^2(2)=19.823$; $p<0.001$], and on the average between the sides [$X^2(2)=25.384$; $p<0.001$].

In analyse the post-hoc analysis, comparison was performed using the Mann-Whitney test, which showed statistically significant difference between dolichofacials and mesofacials individuals for both REIC ($U=231$; $p=0.240$), LEIC ($U=225$; $p=0.445$) and for LEIC ($U=159$; $p=0.124$). However, brachyfacials individuals diverged both from mesofacial individuals [REIC= ($U=112$; $p=0.001$); LEIC ($U=106$; $p=0.001$); LRIC ($U=41$; $p<0.001$)], for dolichofacials individuals [REIC ($U=105$; $p<0.001$), LEIC ($U=116$; $p<0.001$) and for LRIC ($U=51$; $p<0.001$)] in all measurements performed in the present study (Table 2).

In the intragroup analysis performed using the Friedman test, no difference was observed between the incisive canal length in REIC, LEIC and LRIC [$X^2(2)=1$; $p=0.607$] (Table 2).

The median size of the mandibular incisor canal in the dolichofacial group was 4.24 mm in REIC, 4.25mm in LEIC and 4.10mm in LRIC (Fig. 3). In mesofacial individuals, the values were 5.30 mm in REIC 5.27mm in LEIC and 5.55mm in LRIC (Fig. 4). Considering brachyfacial individuals, the median extensions were 10.32 mm in REIC, 10.63mm in LEIC and 11.09mm in LRIC (Fig. 5).

TABLE 2: NUMBER OF PARTICIPANTS, MEDIANS AND INTERQUARTILE DISTANCE OF INCISIVE CANAL EXTENSION IN DIFFERENT FACIAL PATTERNS

		Facial Pattern		
		Dolichofacial	Mesofacial	Brachyfacial
REIC	N	24	24	22
	Median (mm)	4,24 ^a	5,30 ^a	10,32 ^b
	1 st Quartile (mm)	2,33	3,22	6,52
	3 rd Quartile (mm)	6,52	6,63	15,50
LEIC	N	26	20	26
	Median (mm)	4,25 ^a	5,27 ^a	10,63 ^b
	1 st Quartile (mm)	3,17	4,03	6,00
	3 rd Quartile (mm)	7,83	7,44	15,31
LRIC	N	22	20	20
	Median (mm)	4,10 ^a	5,55 ^a	11,09 ^b
	1 st Quartile (mm)	3,14	4,71	7,14
	3 rd Quartile (mm)	6,43	6,96	15,01

REIC*: Right Extension of the Incisive Canal.

LEIC*: Left Extension of the Incisive Canal.

LRIC*: Average between the left and right side of the Incisive Canal.

Different lowercase letters represent statistical differences between facial patterns ($p<0.05$).

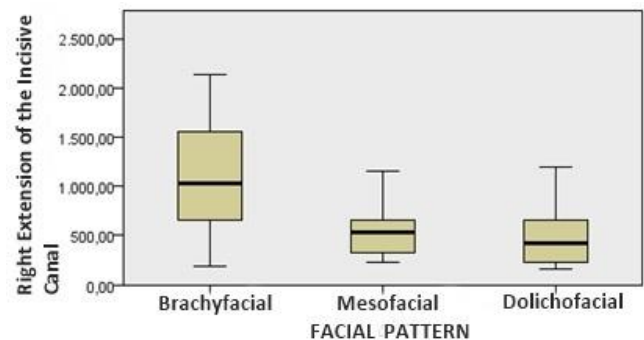


Fig. 3. Distribution of data by facial pattern in the right extension of the mandibular incisor canal.

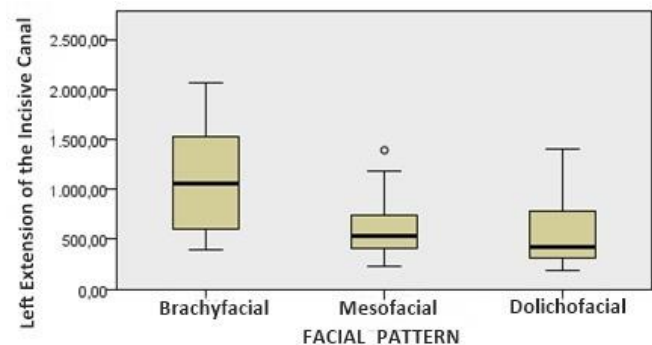


Fig. 4. Distribution of data by facial pattern in the left extension of the mandibular incisor canal.

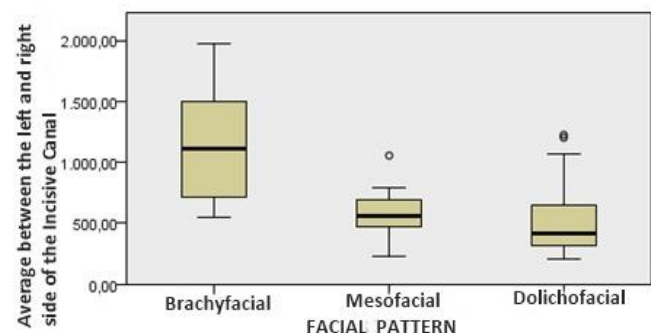


Fig. 5. Distribution of data by facial pattern in the mean values of the left and right extensions of the mandibular incisor canal.

B. Analysis of the Influence of Sex On the Extension of the Incisive Channel

In the analysis, comparing the relationship between sex and the extension of the mandibular incisor canal using the Mann-Whitney test, it showed no statistically significant difference between males and females for both REIC ($U=597$; $p=0.897$), LEIC ($U=504$; $p=0.109$) and for LRIC ($U=442$; $p=0.607$). (Table 3).

TABLE 3: RELATIONSHIP BETWEEN THE SEX OF THE INDIVIDUALS AND THE LENGTH OF THE MANDIBULAR INCISOR CANAL.

	SEX	N	Ranked Average	U	P-VALUE
REIC	Male	38	35,79	597	0,897
	Female	32	35,16		
LEIC	Male	38	32,76	504	0,109
	Female	34	40,68		
LRIC	Male	33	30,39	442	0,607
	Female	29	32,76		

REIC*: Right Extension of the Incisive Channel.

LEIC*: Left Extension of the Incisive Channel.

LRIC*: Average between the left and right side of the Incisive Channel.

C. Analysis of the Influence of age on incisive channel extension

In the analysis, comparing the relationship between age and extension of the mandibular incisor canal using the Mann-Whitney test, it showed no statistically significant difference between individuals aged 30 years or less, both for REIC ($U=12$; $p=0.371$), LEIC ($U=29$; $p=0.188$) and for LRIC ($U=16$; $p=0.548$) - (Table 2). This absence of difference between age and extension of the mandibular incisor canal may be related to n in the group older than 30 years of age being lower than that of individuals under 30 years of age, due to convenience sampling. The chi-square adherence test showed that the data obtained are inconsistent with the expected distribution [$\chi^2(1) = 82.17$; $p<0.001$] as observed in Table 4.

TABLE 4: RELATIONSHIP BETWEEN THE RANKING OF THE AGE OF THE INDIVIDUALS AND THE LENGTH OF THE MANDIBULAR INCISOR CANAL

	Age	N	Ranked Average	U	P-value
REIC	<30	69	35,83	12	0,371
	>30	1	13,00		
LEIC	<30	70	35,91	29	0,188
	>30	2	57,00		
LRIC	<30	61	31,26	16	0,548
	>30	1	46,00		

REIC*: Right Extension of the Incisive Channel

LEIC*: Left Extension of the Incisive Channel

LRIC*: Average between the left and right side of the Incisive Channel

D. Mandibular Incisive Canal Morphology Analysis and Facial Pattern

Observing the morphology data of the mandibular incisive canal and relating them to facial patterns, we can see that the horizontal linear shape (C) was more prevalent in the three facial patterns, totaling the morphology of 57.8% of the studied sample (Table 5).

A chi-square test of independence was performed to evaluate the difference between the morphologies of the incisive canal and facial patterns and we found that there is no association between the facial pattern and the morphologies of the mandibular incisive canal [$\chi^2(10) = 3.365$; $p = 0.971$].

IV. DISCUSSION

In the present study we observed that the pattern of facial growth significantly influenced the extension of the mandibular incisive canal, and brachyfacials were the ones that appeared greater extension. These results are in accordance with the literature showing that several structures of the maxillofacial complex have their morphology altered according to the facial growth pattern of individuals [19], [20].

In the study by [20] the extension of the mandibular incisive canal was evaluated bilaterally in 150 individuals. The length of the canal found was 13.4 mm (range from 5.6 to 24.7 mm) on the right side and 12.4 mm (range from 4 to 22.5 mm) on the left side, these results are in line with the results established in this study.

The extent of the mandibular incisive canal was established as being the distance from the mental forame towards the roots of the anterior teeth at the level of which the canal can no longer be visualized. Nowadays, many surgeries are performed on the anterior part of the jaw, including dental implants, orthognathic surgeries, removal of grafts among others. The anterior area of the mandibular bone is assumed to be safe for these procedures. The problem is the presence of the mandibular incisive canal which has been shown to have a high frequency of presence [20]-[23].

Regarding gender, the bilateral analyses of the incisor channels concluded that, even if there was a difference between the samples, no important relevance was found for the study. Second [16] in a study to detect the mandibular incisive canal, 50 images of cone-beam computed tomography were analyzed, 25 males and 25 females, and when compared only to gender, the result was also irrelevant.

In the study by Lim & collaborators [18] a total of 100 CBCT images were analyzed, all of which identified the MIC. Subsequently, the analyses were advanced by dividing the groups into three age groups (18-38, 39-59, 60-80) in which, after being examined, they did not obtain statistically important variation in relation to the age of the samples.

TABLE 5: TYPE OF MORPHOLOGY, LOCATION OF MORPHOLOGY ACCORDING TO EACH FACIAL PATTERN

		A		B		C		TOTAL
		R	L	R	L	R	L	
DOLICHOFACIAL	N	8	6	7	5	14	20	60
	% in facial pattern	13,3	10	11,7	8,3	23,3	33,3	100
	% in morphology	4,4	3,3	3,9	2,8	7,8	11,1	31,7
MESOFACIAL	N	6	5	6	9	17	17	60
	% in facial pattern	10	8,3	10	15	28,3	28,3	100
	% in morphology	3,3	2,8	3,3	5	9,4	9,4	36,5
BRACHYFACIAL	N	9	5	5	5	16	20	60
	% in facial pattern	15	8,3	8,3	8,3	26,7	33,3	100
	% in morphology	5	2,8	2,8	2,8	8,9	11,1	36,5
TOTAL	N	23	16	18	19	47	66	180
	% in facial pattern	12,8	8,9	10	10,6	26,1	31,7	100
	% in morphology	21,7	8,9	20,6	6	57,8		100

A*:MIC in loop.

B*:MIC Undisplayed.

C*:MIC linear horizontal.

R*:MIC on the right side.

L*:MIC on the left side.

In a study by Barbosa & collaborators [17] the MIC presented an average length of 7.7 mm and different vertical and horizontal diameters in the initial and final parts. In addition, both the distance between mic and lingual cortical of the mandibular alveolar bone and the diameter of mic decreased as its trajectory took a more anterior position.

According to a study by Zhang & collaborators [24] after analysis of 535 images, oscillation was verified in relation to the length of the MIC that was from 6.6mm to 40.3 mm. Large variations in the data in relation to the present study and previous research can be explained by differences in ethnic origin, sample size, image resolution and specifications of anatomical structures.

Morphometric analysis showed that data such as length, width and distances from MIC to dental elements and the lower limit of the mandible are frequently evaluated parameters, due to the fact that this knowledge is clinically interesting to perform treatments in the mandibular intermental area. However, we did not find substantial agreement between the values described in the literature, presenting a high variation of values even when the same technique was used, suggesting that it is still necessary to better define these morphometric parameters [25]-[27].

According to Adamiec et al. [28] the incisive canal of the jaw has its variable morphology, and its symmetry is nonexistent. In the present study, the authors highlight the variation, mainly, in relation to the diameter of the canal that ranges from 0.35mm to 4.12mm. Regarding the path and the way the structure moves in the mandible, a horizontal linear predominance with apical linear destination to the previous dental elements was observed in the analyzed figures, reproducing the data from the current research.

According to Vázquez & collaborators [29] a study conducted with 100 tomographic images involving toothless and toothless patients, divergences were found in relation to the average diameter of the mandibular incisor canal. In toothed patients, the average result was 1.42 mm and in the toothless 1.16 mm, which concludes that the second group presents a flattened form, accompanied by mandible atrophy.

Therefore, we can conclude that brachyfacials, when compared to the bilateral median extension of the mandibular incisive canal, stand out for presenting longer (11.09mm) and with a statistically significant difference compared to the mesofacial group (5.55 mm) and with the dolichofacial group (4.10 mm). There was no relevant difference when compared bilaterally the mandibular incisive canal in relation to age, sex and morphology.

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Rudyard dos Santos Oliveira

Phd in Orthodontics – São Leopoldo Mandic college - Campinas/SP.

Msc in Oral Radiology – São Leopoldo Mandic college- Campinas/SP.

Specialist in orthodontics, implantology, stomatology and public health.