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Morphometric Relationships between the Mandibular Canal and the Molar Teeth. A Tomographic Analysis Report

Relaciones Morfométricas entre el Canal Mandibular y los Dientes Molares. Reporte de un Análisis Tomográfico

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SUMMARY: Some dental treatments that are performed in the mandibular teeth involve manipulation of anatomical structures near the dental periapex, so it is likely to cause nerve damage due to the proximity of the inferior alveolar nerve with the apices of the mandibular teeth, mainly in the molar area. The aim of this study was to determine through Computed Tomography (CT) scan the existing distance between the mandibular canal and the anatomical structures adjacent to its path which will help to reduce the risk of injury to the inferior alveolar nerve during the different dental treatments developed in this zone. A cross-sectional study was performed where the study population consisted of 50 patients of both sexes, between 20 and 30 years with a full dentition mandible. Patients underwent a CT study of the mandible with coronal planes at 1.5 mm, the right side and the left side of each jaw were considered for the analysis and millimetric measuring was held of the distances of the mandibular canal (MC) from different anatomical structures. Subsequently, a statistical analysis was performed to obtain the mean and standard deviation of the distances between the mandibular canal and some adjacent anatomical structures. The distance from the alveolar nerve canal to the apex of the lower third molar in average was 1.49 mm on the right side and 1.69 mm on the left side, the distance between the mandibular canal and lingual cortical at the lower first molar level on average was 3.54 mm on the right side and 4.02 mm on the left side and the distance between the lingual cortical at the second molar level was on average 2.86 mm on the right side and 3.6 mm on the left side.

KEY WORDS: Mandibular Nerve; Molar; Third molar; Trigeminal nerve injuries; Cranial nerve injuries.

INTRODUCTION

The extraction of the Lower Third Molar (LTM) is one of the most performed procedures in clinical practice of oral surgery (Miloro & Peterson, 2012). Inferior Alveolar Nerve Injuries (IANI) occur with a frequency that varies between 0.5 to 8 % (Ueda *et al*., 2012). It has been reported in the literature that the inferior alveolar nerve injury secondary to an extraction of the LTM is associated with factors such as age, sex, anesthetic technique, surgeon's ability, and the anatomical relationship between the mandibular canal (MC) and LTM (Selvi *et al*., 2013). Other dental treatments that have been associated with IANI include apicectomies, root canal treatment and implant placement (Gallas Torreira *et al*., 2003) (Arce De la Cruz & Hernandez Añaños, 2011). A treatment plan that considers preventive measures to reduce the possibility of an IANI includes the integration of various diagnostic imaging resources, the most commonly used remains the panoramic x-ray, however, the most specific study is the computed tomography (TC), although this resource is expensive and causes increased radiation exposure, its use is limited to cases in which there is radiographic evidence of a close relationship between the LTM and the MC (20 to 30 % of cases) (Ueda *et al*.).

Various studies have been conducted to know the morphological characteristics of MC, most through dissections (Anderson *et al*., 1991) and in Mongoloid and Caucasian populations (Domínguez Mejía *et al*., 2010). Recently published studies in Latin American populations evaluate the position of MC in its inter-mandibular journey. Beltrán Silva *et al*. (2007) reported a study with measurements in 10 dissected mandibles which were cut in four sectors of the mandibular body to establish the distances from the MC to

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the lingual, buccal and basal cortical. Ruge Jimenez *et al*. (2009) conducted a study on 50 dry right hemi mandibles where through direct observation and measurement with a microcalibrador obtained distances from the center point of the mandibular foramen to the sigmoid notch, the anterior border of the mandibular ramus, posterior border of the ramus and lower border of the mandible. They also obtained measurements from the mental foramen to the upper border of the mandible, lower border of the mandible and premolars, other measurements obtained were the distance from the MC to the corticals, anterior and posterior border, while in the body they measured relationships from the MC in an inferior, superior, medial and lateral sense, and the canals diameter. Domínguez Mejía *et al*. conducted a study to determine the position and journey of the MC through volumetric tomography using CT scans of 50 hemi mandibles corresponding to 32 patients over 18 years of age with premolars and molars present in the mouth, the anatomical relationships they studied were the distance of the MC to the alveolar ridge, to the external cortical, inner cortical, inferior border and the distance from the mandibular foramen to the anterior border of the mandibular ramus. Albornoz Afanasiev *et al*. (2014) developed a research on 217 patients who underwent volumetric tomography to determine the distance that existed between the MC and mandibular bone ridge, the lingual cortical bone, the vestibular cortical bone, the inferior cortical bone, all these measurements at the level of the lower third molar. Limardo *et al*. (2016) conducted a study that included 44 dissected dry mandibles and 100 random tomography scans to establish morphometric measurements of the MC with structures such as the mandibular foramen and mental foramen.

Currently in the oral surgery clinic of ENES Leon, approximately 300 LTM surgeries are performed each month, in order to prevent IANI, a greater knowledge of the morphological characteristics of MC in the population of the region is required. The objective of this study was to determine through CT the distance between the MC and anatomical structures adjacent to its path.

MATERIAL AND METHOD

A cross-sectional study was performed. The study population consisted of 50 patients of both sexs, between 20 and 30 years of age who had to have a complete dentition in the mandible. We excluded patients with pathological, morphological and functional alterations of the mandible and those with partial dentition in the mandible. Once the protocol was approved by the Ethics Committee of the institution and informed consent by the participants was obtained, they underwent a CT study of the mandible with coronal slices at 1.5mm in a Somaton Emotion 6 CT (Siemens, USA). The right side and the left side of each mandible were considered for analysis. CT scans were obtained by a single technician in imaging. To subsequently analyze the scans in OsiriX DICOM Viewer (Pixmeo Sarl, Swiss) software, which enabled, throughout its tools, millimetric measuring of the distances existing from the MC to different anatomical structures.

The measurements obtained to establish the relationship of MC with different anatomical structures were: the apical area of the Lower First Molar (LFM) to the MC, the apical area of the Lower Second Molar (LSM) to MC, the apical area of the Lower Third Molar (LTM) to MC, from the MC to the Vestibular Cortical (VC) at the level of LFM, from the MC the VC at the level of the LSM, from the MC to VC at the level of LTM, from the MC to the Lingual Cortical (LC) at the LFM, from the MC to the LC at the level of the LSM, from the MC to the LC at the level of the LTM, from the MC to the Basal Cortical (BC) at the LFM level, from the MC to BC at the LSM level, from the MC to BC at the LTM level.

The data analysis was performed on SPSS statistical software version 22, 2013 (IBM Corporation, USA), where Standard Deviation (SD) and Medium (M) were obtained. In addition, a student T test was applied to identify statistical differences by sex and side (right and left).

RESULTS

Mandible CT corresponding to 50 patients were evaluated, of which 28 were female and 22 male. All patients were between 20 and 30 years of age with a mean of 24.8 ± 5.4 All patients consented to participate in the study.

Lower Left First Molar. The distance of the MC to the apical area in male patients was (M = 4.76 mm ± 1.14) and in female patients was (M = 6.38 mm ± 1.80). Statistical difference was observed in the distance from the MC to the apical area by sex (p = .016). The distance from the MC to the LC in male patients was (M = 3.61 ± 0.92 mm) and in female patients (M = 4.34 ± 0.78 mm) and observing a significant statistical difference in the distance from the MC to the LC (P = .043). The distance from the MC to the VC in male patients was (M = 6.51 ± 2.03 mm) and in female patients (M = 6.13 mm ± 1.54) and (P = .599). The distance from the MC to the BC in male patients was (M = 7.55 mm ± 1.32) and in female patients (M = 7.42 mm ± 3.48) and (P = .897) (Table I).

Table I. Distance from the MC to anatomic structures of reference at the lower left first molar level.

Relation	Female		Male		
	M	SD	M	SD	p
Apical	6.38	1.80	4.76	1.14	.016 *
Lingual	4.34	.78	3.61	.92	.043 *
Vestibular	6.13	1.54	6.51	2.03	.599
Basal	7.42	3.48	7.55	1.32	.897

Lower Right First Molar. The distance from the MC to the apical area in male patients was (M = 4.77 mm ± 0.90) and in female patients was (M = 6.50 mm ± 1.57) observing a significant statistical difference in the distance from the MC to the apical area by sex (P = 0.004). The distance from the MC to the LC in male patients was (M = 3.83 mm ± 1.68) and in female patients (M = 3.31 mm ± 1.22) and (P = .379). The distance from the MC to the VC in male patients was (M = 6.74 mm ± 1.78) and in female patients (M = 6.71 mm ± 1.88) and (P = .815). The distance from the MC to the BC in male patients was (M = 0.55 ± 8.3 mm) and in female patients (M = 8.17 mm ± 2.12) and (P = .807). (Table II).

Table II. Distance from the MC to anatomic structures of reference at the lower right first molar level.

Relation	Female		Male		
	M	SD	M	SD	P
Apical	6.50	1.57	4.77	.90	.004 *
Lingual	3.31	1.22	3.83	1.68	.379
Vestibular	6.71	1.88	6.74	1.78	.815
Basal	8.17	2.12	8.36	.55	.807

Lower Left Second Molar. The distance from the MC to the apical area in male patients was (M = 2.65 mm ± 0.89) and in female patients was (M = 5.4 mm ± 2.65) observing a significant statistical difference in the distance from the MC to the apical area by sex (P = 0.004). The distance from the MC to the LC in male patients was (M = 2.91 mm ± 0.98) and in female patients (M = 1.15 ± 4.14 mm) obtaining a significant statistical difference in the distance of the MC to the LC by sex (P = .018). The distance from the MC to the VC in male patients was (M = 6.40 mm ± 1.61) and in female patients (M = 1.93 ± 7.6 mm) obtaining a significant statistical difference in the distance from the MC to the VC (P = .048). The distance from the MC to the BC in male patients was (M = 7.20 mm ± 1.98) and female patients (M = 7.30 mm ± 2.56) and (P = .928). (Table III).

Lower Right Second Molar. The distance from the MC to the apical area in male patients was (M = 4.59 mm ± 1.57) and in female patients was (M = 5.50 mm ± 1.99) and (P = .228). The distance from the MC to the LC in male patients was (M = 2.20 mm ± 0.57) and in female patients (M = 3.38 mm ± 1.15486) observing a significant statistical difference in the distance from the MC to the LC (P = .005). The distance from the MC to the VC in male patients was (M = 6.46 mm ± 1.51) and in female patients (M = 7.74 mm ± 1.93) and (P = .085). The distance from the MC to the BC in male patients was (M = 6.65 mm ± 2.62) and in female patients (M = 6.65 mm ± 2.56) and (P = .918). (Table IV)

Table III. Distance from the MC to anatomic structures of reference at the lower left second molar level.

Relation	Female		Male		
	M	SD	M	SD	P
Apical	5.40	2.65	2.73	.89	.004*
Lingual	4.14	1.15	2.91	.98	.018*
Vestibular	7.60	1.93	6.40	1.56	.048*
Basal	7.30	2.56	7.20	1.98	.928

Table IV. Distance from the MC to anatomic structures of reference at the lower right second molar level.

Relation	Female		Male		
	M	SD	M	SD	P
Apical	5.5021	1.99918	4.5900	1.57281	.228
Lingual	3.3871	1.15486	2.2073	.57571	.005*
Vestibular	7.7429	1.93154	6.4645	1.51760	.085
Basal	6.6550	2.5621	6.5464	2.62644	.918

Lower Left Third Molar. The distance from the MC to the apical area in male patients was (M = 1.86 mm ± 1.94) and in female patients was (M = 1.43 mm ± 1.61) and (P = .273). The distance from the MC to the LC in male patients was (M = 4.72 mm ± 0.92) and in female patients (M = 3.94mm ± 0.99) observing a significant statistical difference in the distance from the MC to the LC by sex (P = .003). The distance from the MC to the VC in male patients was (M = 4.72 mm ± 1.06) and in female patients (M = 4.41 mm ± 0.92) and (P = .631). The distance from the MC to the BC in male patients was (M = 10.26 mm ± 1.26) and in female patients (M = 9.51 mm ± 1.32) and (P = .655). (Table V).

Table V. Distance from the MC to anatomic structures of reference at the lower left third molar level.

Relation	Femenino		Masculino		
	M	SD	M	SD	P
Apical	1.4357	1.61394	1.8610	1.9476	.273
Lingual	3.9407	.99624	4.7227	.92430	.003*
Vestibular	4.4179	.92430	4.7218	1.06725	.631
Basal	9.5171	1.32153	10.2618	1.26994	.655

Lower Right Third Molar. The distance from the MC to the apical area in male patients was (M = 1.35 mm ± 1.59) and in female patients was (M = 1.59 mm ± 1.67) and (P = .716). The distance from the MC to the LC in male patients

was (M = 3.07 mm ± 0.56) and in female patients (M = 3.34 mm ± 0.80) and (P = .365). The distance from the MC to the VC in male patients was (M = 4.95 mm ± 1.11) and in female patients (M = 4.83 mm ± 1.42) and (P = .820). The distance from the MC to the BC in male patients was (M = 11.16 mm ± 2.32) and in female patients (M = 11.41 mm ± 4.19) and (P = .863) (Table VI).

Table VI. Distance from the MC to anatomic structures of reference at the lower right third molar level.

Relation	Female		Male		
	M	DS	M	DS	P
Apical	1.5993	1.67166	1.3564	1.59398	.716
Lingual	3.3429	.80367	3.0791	.56070	.365
Vestibular	4.8386	1.42133	4.9591	1.11457	.820
Basal	11.4107	4.19771	11.1636	2.32085	.863

Lower First Molar Left-Right. Adding the distances of all individuals on both sides in relation to the LFM, the distances were (right apical area 5.74 mm) (left apical area 5.67 mm) overall sample average 5.6 mm (right LC 3.54 mm) (left LC 4.02 mm) overall sample average 3.7 mm (right VC 6.84 mm) (left VC 6.30 mm) overall sample average 6.3 mm (right BC 8.25 mm) (left BC 7.48 mm) overall sample average 7.8 mm (Fig. 1A).

Lower Second Molar Right-Left. Adding the distances of all individuals on both sides in relation to the LSM, the distances were (right apical area 5.10 mm) (left apical area 4.23 mm) overall sample average 4.6 mm (right LC 2.86 mm) (left LC 3.6 mm) overall sample average 3.2 mm (right VC 7.18 mm) (left VC 7.07 mm) overall sample average 7.0 mm (right BC 6.60 mm) (left BC 7.25 mm) overall sample average 6.9 mm (Fig. 1B).

Lower Third Molar Right-Left. Adding the distances of all individuals on both sides in relation to LTM, the distances were (right apical area 1.49 mm) (left apical area 1.69 mm) overall sample average 1.5 mm (right LC 3.22 mm) (left LC 4.00 mm) overall sample average 3.6 mm (right VC 4.89 mm) (left VC 4.55MM) overall sample average 4.6 mm (right BC 11.30 mm) (left BC 9.84 mm) overall sample average 10.5 mm (Fig. 1C).

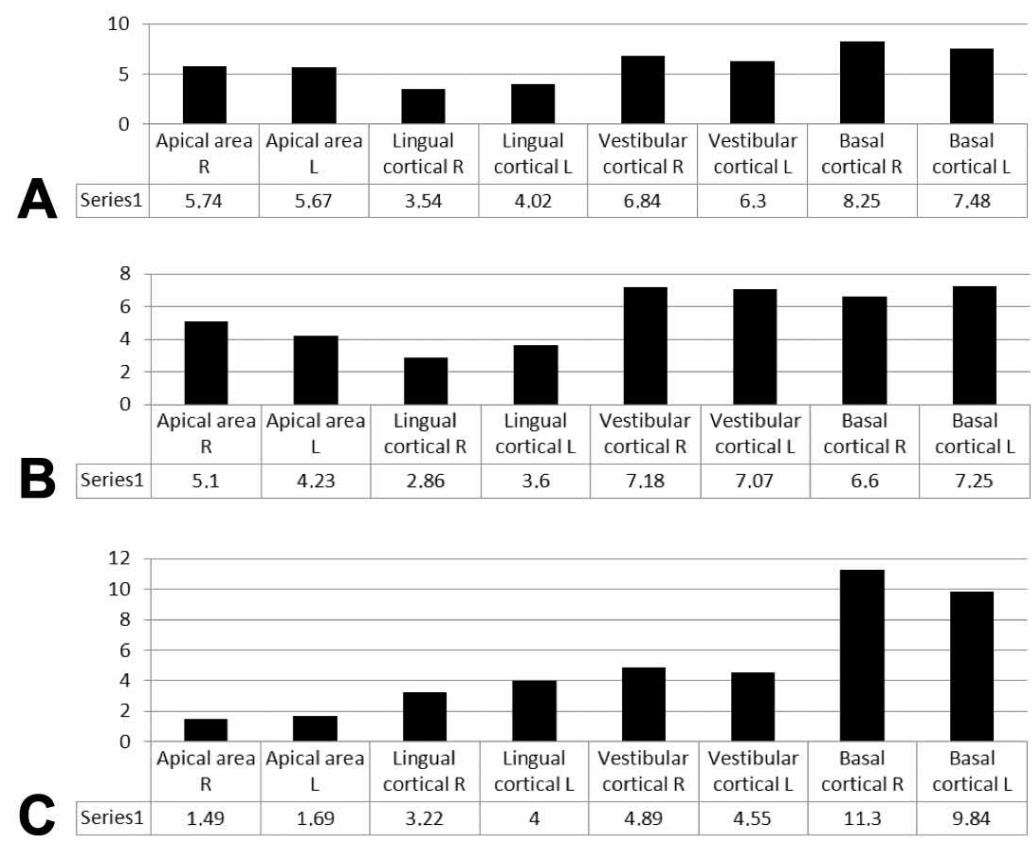

Fig. 1A. Measures from the IANC to the different anatomical relationships at level of LFM both sexes; B. Measures from the IANC to the different anatomical relationships at level of LSM both sexes. C. Measures from the IANC to the different anatomical relationships at level of LTM both sexes.

DISCUSSION

Some studies show that there have been structural changes in the craniofacial complex including in the dental arches throughout human evolution (Friedland *et al*., 2008).

Littner *et al*. (1986) studied the anatomical characteristics of mandibular canal. Their results indicated a relationship between the mandibular canal and the apex of the lower first and second molar of 3.5 to 5.4 mm. The results of this study are very similar since the distance between MC-LFM and MC-LSM ranged between 4.2 and 5.6 mm.

In the present study, the distance between the lower border of the MC and BC was 9.8 to 11.3 mm at the LTM level, which compared with the results of Bell (1992) turns out to be very compatible, since he established in his results a distance of 10.5 mm. Regarding the distance from the MC to the BC at the first and second molar level, Bell reported that it was 7.4 mm while the results of this study ranged from 6.6 to 8.2 mm at the same molar level. Bell in his text of orthognathic surgery, makes a reference of Rajchel who showed that the greatest distance from the mandibular canal to the buccal cortical was among the first and second molar. The distances reported in this study indicate that the shortest distance is at the LTM level (4.5-4.8 mm) followed by the LFM (6.3-6.8 mm) and the longest distance was located in the LSM level (7.0-7.1 mm).

In this study the distance from the MC to the LC at the LFM, LSM and LTM level, results interesting that the shortest distance is recorded at the level of the LSM which is compatible with the greatest distance to the VC previously described. Thus the distance from MC to the LC at the LFM level ranged from 3.5 to 4.02 mm and in the LTM from 3.2 to 4.0 mm.

Anderson *et al*. conducted an extensive literature review to determine the intraosseous route of the IAN, from literature reviews they refer to Olivers´ dissections (1927) who reported that the course of the IAN in its horizontal portion followed a concave pattern in basal sense that travels forward, in this study, it can also be established according to the measurements obtained that the anterior path of IAN in the horizontal portion makes a concavity in basal direction.

Beltran Silva *et al*. reported measurement results from the MC to the buccal, lingual and mandibular basal cortical, their results show similarity to those of the present study, mainly in measurement of the MC to the BC at the LFM level, where there is no difference, the measurement of the MC to the LC and VC at the LSM level, both have a difference of 4 mm. Where there is a considerable difference is the distance from MC to the BC at the LTM level, the authors report an average measurement of 9.5 mm, whereas in this study the average of this measurement was 10.5 mm. However, this same measurement was presented in this study in the mandibles of women and increased in the mandible of men to 11.1 mm.

In 2009, Ruge Jimenez *et al*. conducted a study to determine the anatomical considerations of the IAN in a sample of 50 dissected right hemi mandibles with slices that were performed to obtain the results. In the present study the universe was similar in quantity, but the measurements were made through a DICOM imaging software which provides high specificity in measurement. The aforementioned authors obtained measurements from the MC to the apex of the LFM (2.6 mm), from the MC to the apex of the LSM (2.9 mm) and from the MC to the apex of LTM (2.7 mm), however it should be noted that the measurement they are presenting corresponds to a slice in the mandible which is distal to the referred molar, increasing the measurement distance. In our results, taking into account only the results on the right side and that the measurement was performed in the same coronal plane in which the apex of the molars were, the measurements were: from the MC to the apex of the LFM (5.7 mm) from the MC to the apex of the LSM (5.1 mm) and from the MC to the apex of LTM (1.4 mm). In their study they did not detail the chronological age of the mandibles which they analyzed, the results of the present study correspond to mandibles of a group of patients in their third decade of life. The results of these authors are very similar to the results obtained in this study; there are measurement differences of 7 mm or less in distance from the MC to the VC at the LFM level, from the MC to the VC at the LSM level, from the MC to the LC at the LTM level. A measurement without difference between the distance from the MC to the LC at the LSM level and a difference of 1 mm in distance from the MC to the VC at the LTM level.

Domínguez Mejía *et al*. published a trajectory analysis of the mandibular canal. According to the results, the MC in its horizontal portion in the body of the mandible describes a path making a slight concavity in the basal sense and a lingual vestibular direction in measurements at the LFM and LSM. These results are consistent with those presented in this study, although the measurements are different between the two studies, the course of the nerve follows the same pattern in the horizontal portion of the mandibular body, describing a concavity in basal sense and a lingual vestibular direction at the LSM and LFM level for both men and women.

The study by Albornoz Afanasiev *et al*. is very interesting, as they performed measurements from the MC to the VC, LC, BC and apex of LTM at the LTM level, with a sample of 217 CT scans, which reported the results in the following age groups: 15 to 18 years, 19 to 22 years, 23 to 26 years, 27 to 30 years, 31 to 34 years and also classified by sex. They conclude that the narrowest distance between the MC at the LTM level is related with the apex of the LTM, followed by the LC. Although the measurements obtained in this study are not approximate to the results reported by Albornoz Afanasiev *et al*., there is a similarity in the narrowest distance from MC that can be distinguished at the level of LTM is the apex of LTM followed by LC, VC and BC. This information is very important, because the results allow us to know that in our population, the average distance from the MC to the apex of the LTM in women is 1.5 mm on the right side and 1.4 mm on the left side, while in men the same distance is 1.3 mm on the right side and 1.8 mm on the left side, which means being narrower than the report by the mentioned author.

Limardo *et al*. in a study where they sectioned mandibles at the level of the mandibular body into segments corresponding to the second premolar, first molar, second molar and third molar who obtained millimetric measurements from the mandibular canal, reported measurements that allow to describe the path of MC. In their samples, which according to their measurements, follow a pattern of concavity to the outer cortical horizontally from posterior to anterior and with an alveolar concavity. The same concavity to the outer cortical was observed in the results of this study, horizontally from posterior to anterior, but there is a difference in the vertical direction as in the present study a path describing a concavity in the basal direction posterior to anterior at the mandibular body level. This finding is clinically relevant, because it allows us to distinguish the passage that describes the MC in a local population.

CONCLUSIONS

In particular, image study research of high-risk cases to evaluate the route and form of MC provides practical information to reduce the risk of injury to the IAN.

The data obtained in this study confirms that there are characteristics and anatomical variations of the MC different from the results of publications made in other populations around the world.

It was noted that in the study population, the closest point of MC to the apex of the teeth is at the level of LTM, followed by the distance to the lingual cortical at the LSM and LFM level.

The populations dimorphism found suggests that different standardized dental procedures require greater knowledge of related structures MC, rather than a modification of them.

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RESUMEN: Algunos tratamientos dentales que se realizan en los dientes mandibulares implican la manipulación de estructuras anatómicas cercanas al periapice dental, por lo que existe la probabilidad de causar lesiones nerviosas debido a la cercanía del canal mandibular con los ápices de los dientes mandibulares, principalmente los molares. El objetivo de este estudio fue determinar a través de tomografía computarizada la distancia existente entre el canal mandibular a las estructuras anatómicas adyacentes a su trayecto lo que ayudará a disminuir el riesgo de lesiones del nervio alveolar inferior durante los diferentes tratamientos dentales desarrollados en esta zona. Se realizó un estudio transversal en donde la población de estudio estuvo compuesta por 50 pacientes de ambos sexos, entre 20 a 30 años con dentición completa en mandíbula. A los pacientes se les realizó un estudio de Tomografía Computarizada (TC) en mandíbula con cortes coronales a 1.5mm, se consideraron para el análisis el lado derecho y el lado izquierdo de cada mandíbula, y se realizó la medición milimétrica de las distancias que existen desde el CNAI a diferentes estructuras anatómicas. Posteriormente, se realizó un análisis estadístico para obtener Medias y Desviación Estándar de las distancias que existen entre el canal mandibular y algunas estructuras anatómicas adyacentes. La distancia del canal mandibular al ápice del tercer molar inferior en promedio fue de 1,49 mm del lado derecho y de 1,69 mm del lado izquierdo,la distancia entre el canal mandibular y la cortical lingual a nivel del primer molar inferior en promedio fue de 3,54 mm del lado derecho y de 4,02 mm del lado izquierdo y la distancia entre la cortical lingual a nivel del segundo molar fue en promedio de 2,86 mm del lado derecho y de 3,6 mm del lado izquierdo.

PALABRAS CLAVE: Nervio mandibular; Tercer molar; Lesiones del nergio trigémino; Lesiones de los nervios craneales.

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