KNOWLEDGE OF AN IMPORTANT ANATOMICAL VARIATION IN MANDIBLE TO AVOID UNFORESEEN EVENTS

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BACKGROUND

The aim of this study was to evaluate retromolar canal (RMC) according to side, sex, distance, and relation with the last tooth in cone bean computed tomography (CBCT). Methods. The sample consisted of 500 CTCB of individuals of both sexes, with a minimum age of 14 years. RMC course, morphology, length, angle, diameter, and distance from the RMC with the most distal molar were evaluated. Results. RMC was found in 17 (3.7%) patients, aged between 19 and 73 years. Twenty-one RMC were observed; 9 (42.85%) were present on the right side and 12 (57.14%) on the left side. Four individuals (23.52%) had RMC bilaterally; 12 (70.6%) were female, and 5 (29.4%) were male; and regarding the individuals with bilateral canals, 3 were female. Conclusions. Female and the left side presented a higher frequency of RMC. RMC presence and course were not related to the age. There was no association between RMC course, side, angle measurements, diameter, and distance to the last tooth in the dental arch.

Keywords: Mandible. Mandibular canal. Anatomic variation. Cone beam computed tomography. Anatomy.

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INTRODUCTION

Knowledge of all anatomical variations of the maxilla and mandible is essential for the establishment of a previous diagnosis, assist a surgical intervention, and protect the patient from complications.

Mandibular canal may present some anatomical variations during its course, such as being duplicated or emitting accessory canals in the retromolar region, designated retromolar canals. Retromolar canal (RMC) is a structure that presents morphological and morphometric variability. Although the presence of this canal is recognized in anatomy books [1], some of them do not mention its occurrence or characteristics.

The content of the retromolar canal may present arterioles, venules and myelinated nerve fibers coming from the inferior alveolar nerve. This innervation may extend to the tendon areas of the temporal and buccinator muscles, from the posterior area of the alveolar process, and from the third molar. They may contribute to the innervation and nutrition of the pulp and periodontium of the lower molar teeth [2, 3].

In clinical practice, anatomical variations such as complementary or accessory canals and foramen especially the retromolar canal can be detected by radiographs, but conventional two-dimensional radiographs, such as panoramic radiographs are often insufficient to detect all anatomical variations. Sectional images, like computed tomography, have been used successfully in dentistry. The presence of retromolar canals also has been detected by cone bean computed tomography (CBCT) [4-8].

Studies which evaluated RMC in computed tomography observed great frequency variability (7.7%-72.5%) [9-14].

The retromolar area is related to surgical procedures (extraction of a third molar, sagittal osteotomy). Unexpected bleeding, traumatic neuroma or paresthesia may occur due to the damage to blood vessels and nerves which courses by RMC. Therefore, the knowledge of the mandible anatomy as well as the path of the inferior alveolar nerve by the mandibular canal is of great importance for dentists.

The aim of this study was to evaluate retromolar canal according to side, sex, distance and relation with the last tooth in CBCT.

MATHERIAL AND METHODS

The present study was submitted and approved by the Research Ethics Committee of the School of Dentistry of Araraquara, UNESP (CAAE: 56869016.4.0000.5416).

We evaluated 500 CBCTs of individuals of both sexes, with a minimum age of 14 years, who performed this examination of the mandible for purposes other than research. CBCT were archives of a private Radiology Clinic in the city of Araraquara – SP, Brazil.

The images were obtained by an Imaging Sciences Tomograph, model iCAT, using FOV of 8cm, 120Kv, 36,12mA, with exposure time of 40 seconds and voxel size of 0.25mm. In the region of interest, sections were made with a thickness of 1 mm, and the amount of them varied according to the size of the patient's mandible.

In the first stage of the study, 500 CT scans were evaluated for the presence or absence of RMC in the region, from a new software model Xoran Technologies Inc., version 3.1.62. For RMC visualization, mandibular image standardization in the axial reconstruction of CBCT was rotated to the resting plane parallel to the sagittal reconstruction line, where the mandible canal could be observed and verified by a presence of some branch, thus identifying RMC. When RMC was present, its course, morphology, length, angle, diameter and distance from the retromolar canal with the most distal molar viewed in the sagittal CBCT reconstructions. The measurements in the CBCT were performed using OnDemand 3D software (OnDemandeDApp 1.0.9.2225, Cybermed Inc., South Korea), CPU (Dell Intel ® Xeon ® E52609, 2.40GHz), belonging to the cone beam computerized tomography workstation of Scanora 3DX (Soredex, Tuusula, Finland) on the 24" LCD monitor (Dell U2410, 1920x1200, 64-bit resolution).

The retromolar canal was classified according to its course and morphology using the parameters proposed by Sisman et al. [15], except for classifications IV and V, in sagittal reconstruction. The following parameters were used: Type I - Vertical course of retromolar canal; Type II - Vertical course of retromolar canal with additional horizontal branch; Type III – Vertical course of retromolar canal and then coursing posterosuperiorly toward the retromolar fossa; Type VI - Curved course of retromolar canal branching mandibular canal; Type VII - Retromolar canal running from the retromolar fossa and opening into the periodontal ligament space; Type VIII - Running anteriorly for some distance and then coursing posterosuperiorly toward the retromolar fossa foramen; Type IX - Running anteriorly for some distance and then coursing posterosuperiorly toward the retromolar fossa foramen with additional horizontal branch foramen.

In axial reconstruction, the most vestibular, middle, or lingual position of exit foramen of the retromolar canal in the retromolar fossa was evaluated.

Considering the variation of the visualization of the course of the retromolar canal, it was chosen to perform the measurements in the sagittal reconstructions until its course was clear. Two measurements of height of RMC were performed: 1) a perpendicular line was

drawn from the distal cortex of the retromolar foramen to the upper margin of the mandibular canal; 2) a line of the cortical distal of the retromolar foramen was traced along its course to the upper margin of the mandibular canal, in the region of the bifurcation. The angle formed by these two lines was measured.

The diameters of the origin and exit of the RMC were measured and later classified according to Sisman et al. [15] (21: a) 0-1mm; b) 1-2mm; c) 2-3mm and d) ≥ 3mm.

The distance of the RMC with the most distal molar visualized on the tomography was also performed, tracing a straight line from the most mesial cortical of the RMC, at the height of exit of the foramen to the cortical bone in the distal of the last molar visualized in the CBCT.

In order to study the intra-examiner concordance, a second evaluation was performed on the CTBC scans that presented a RMC within 15 days after the first evaluation with the evaluator. The Kappa statistic (k) and the Intraclass Correlation Coefficient (ICC) were used, respecting the level of measurement of the variables. The results were statistically analyzed using Chi-square test, Fisher's test, ANOVA, and T Student's test, depending on the studied variables (quantitative/qualitative and number of categories). Statistical inferences were based on the significance level of 5%.

RESULTS

Regarding the evaluation of intra-examiner agreement, the agreement was moderate (0.4 - 0.53; Kappa -k) in three parameters, and one presented optimal agreement (1.0; Kappa -k). According to the Intraclass Correlation Coefficient (ICC), concordance was excellent in four parameters (0.93 - 0.96; ICC), and satisfactory in two (0.44 - 0.58; ICC).

RMC was observed in 17 (3.4%) individuals, 13 (2.6%) presented unilateral canals and in 4 (0.8%) RMC was present bilaterally, with a total of 21 (4.2%) visualized RMC. Of these, 9 (1.8%) were on the right side, and 12 (2.4%) on the left side; 15 (3%) were females and 6 (1.2%) males. The minimum, maximum and middle age of the individuals who presented right retromolar canal (RRMC) was 20, 73, and 51.44 years, respectively, 66.6% were female; for LRMC the data were 19, 69, and 43.17 years, respectively, 75% were female.

Two RMC belonging to different individuals could not be measured because of their course. One of them presented a retromolar canal on the left side with a curved course, but it was not possible to perform the measurements because when it located the exit foramen of the canal, the region of the bifurcation of the canal of the mandible did not appear. Already in the other individual, to visualize the RMC had to change the position of the

tomography, thus leaving the standards previously established. Therefore, they were not included in the results.

Table 1 shows the frequencies of right and left RMC according to the courses. RMC with course type II, III and VII was not observed.

Table 1. Frequency of left and right RMC according to the course

	RRMC	LRMC	RRMC + LRMC
Course	Frequency (%)	Frequency (%)	Frequency (%)
I	4 (44.4)	2 (20.0)	6 (31.6)
VI	4 (44.4)	4 (40.0)	8 (42.1)
VIII	1 (11.1)	4 (40.0)	5 (26.3)
Total	9 (100%)	10 (100%)	19 (100)

Frequency of RRMC according to the position of the foramen at the end of the RMC course were buccal position – 3 (37.5%), lingual position – 2 (25%), middle position 3 (37.5%); for LRMC the data were: buccal position 6 (54.5%), lingual position 1 (9.1%), middle position 4 (36.4%).

Individuals who presented RMC and it could be measured by CBCT, the length of the RMC was measured by the distance from the retromolar foramen to the mandibular canal (RF-MC), and the distance from the retromolar foramen to the mandibular canal bifurcation (RF-MCB). The minimum, maximum, mean values for RF-MC related to the 8 RRMC were 5.96mm, 20.27 mm, and 11.98 mm, respectively; the results related to the 11 LRMC were 6.10 mm, 20.14 mm, and 12.32 mm, respectively. The minimum, maximum, mean values for RF-MCB related to the RRMC were 3.34 mm, 13.18 mm, and 9.25 mm, respectively; for LRMC were 3.78 mm, 13.72 mm, and 8.45 mm, respectively.

Regarding angle measurements results, the minimum, maximum, and mean values for RRMC were 8.20º, 92.20º, and 49.05º, respectively; for LRMC were 6.60º, 83.90º, and 39.01º, respectively.

Tables 2 and 3 present the frequency of the classification of the diameter of the RMC in the origin region (ORD) and the region of exit (ERD), respectively, where a) corresponds to measures between 0 and 1 mm, b) between 1 and 2 mm, c) between 2 and 3 mm and (d) measurements equal to or greater than 3 mm.

Table 2. Frequency of classification of RMC origin region diameter (ORD)

	RRMC	LRMC	RRMC + LRMC
Classification	Frequency (%)	Frequency (%)	Frequency (%)
A	0	1 (9.1)	1 (5.3)
B	2 (25.0)	3 (27.3)	5 (26.3)
C	3 (37.5)	5 (45.5)	8 (42.1)
D	3 (37.5)	2 (18.2)	5 (26.3)

Total	8 (100%)	11 (100%)	19 (100)

Table 3. Frequency of classification of RMC exit area diameter (ERD)

	RRMC	LRMC	RRMC + LRMC
Classificarion	Frequency (%)	Frequency (%)	Frequency (%)
A	0	0	0
B	2 (25.0)	7 (63.6)	9 (47.4)
C	4 (50.0)	2 (18.2)	6 (31.6)
D	2 (25.0)	2 (18.2)	4 (21.1)
Total	8 (100%)	11 (100%)	19 (100)

It was verified the relation of the RMC with the last erupted tooth in the dental arch, which should be visualized in the CBCT. From 19 RMC, in 10 (52.6%) the last tooth in the arch was observed. Of those, 4 were RRMC and 6 LRMC. The minimum, maximum, mean values related to RRMC were 3.20 mm, 18.87 mm, and 12 mm, respectively; related to LRMC the results were 1.67 mm, 12.33 mm, and 9.07 mm, respectively.

There was no significant association between the presence of RRMC and sex ($p = 1.0$, Fisher's test) and between the presence of LRMC and sex ($p = 0.550$; Fisher's test). There was also no statistically significant association between the presence or absence of unilateral and bilateral RMC and sex ($p = 0.682$; Chi-square test), as well as types of RMC and sex ($p = 0.682$; Chi-square test). Regarding sex, there was also no significant association with ORD ($p = 0.0563$; Student t test) and ERD ($p = 0.3617$; Student t test).

According to the results, there was no association between age and presence of RMC ($p = 0.1011$; ANOVA), and age and types of RMC ($p = 0.9887$; ANOVA).

When the course was evaluated, there was a non-significant association with side ($p = 0.514$, Chi-square test), angle ($p = 0.0556$; ANOVA), ORD ($p = 0.5737$; ANOVA), ERD ($p = 0.3095$; ANOVA), and DD ($p = 0.6688$; ANOVA).

DISCUSSION

In the present study, 500 CBCT were evaluated and the retromolar canal was observed in 3.4% of individuals, with 2.6% having unilateral canals and 0.8% having RMC bilaterally. The focus of our study was to evaluate the RMC, so other anatomical variations related to the mandibular canal were not included. In the literature, many studies evaluate mandibular canal variation, and RMC is one of the variations cited. Our results are exclusively related to RMC.

Borgonovo et al. [4] evaluated the same number of CBCT to verify the presence and characteristics of accessory mandibular canals, and found them in 8.8% of the sample, with RMC the most frequently accessory canal (70.8%). Afsa and Rahmati [6] evaluated CBCT

of 116 hemi-mandibles, where 31% presented mandibular canal with an accessory branch, among them 25.4% were in the retromolar region. Palma et al. [16] reported that from 61 CBCT, 24.6% presented RMC, with 4.9% of bilateral presence, a higher percentage than that found in our study. Badry et al. [17] found unilateral RMC in 8.4% of the sample and 2.8% was present bilaterally. Our results corroborate with studies that showed a higher frequency of unilateral RMC, when compared to bilateral [7-16, 18, 20]. It is essential to indicate computed tomography when there is a suspicion of anatomical variation in the mandibular canal because this examination presents images more faithful to reality than panoramic radiographs. von Arx et al. [18] found a considerable difference between the identification of RMC in tomography scans (25.6%) compared to panoramic radiographs (5.8%). Fukami et al. [21] compared the presence and visualization of RMC in panoramic radiography, spiral CT and CBCT and concluded that the use of RMC is more reliable for evaluating and confirming the anatomy of the retromolar canals. According to Muniello-Lorenzo et al. [22] panoramic radiographs are unable to satisfactorily identify bifid mandibular canals, retromolar canals and retromolar foramen, since they observed RMC in 36.8% tomography compared to 16.8% radiographs.

Concerning the frequency of RMC associated to sides, 1.8% were on the right side and 2.4% on the left side. Borgonovo et al. [4] also observed a higher frequency of RMC on the left side, as well as Palma et al.[16] and Gringo et al. [7] In contrast, Afsa and Rahmati [6] and Pannalal et al. [10] found a higher prevalence on the right side. It is assumed that those differences are random, and not in fact there is a predisposition per side.

No significant association was observed between the presence of RMC and sex, such as other studies, [7, 8, 11] unlike Patil et al. [12] who found a significant statistical difference, with a higher frequency of RMC in female. We did not find a statistically significant association between the presence of unilateral and bilateral RMC and sex, as well as were the results of other studies [4, 16] RMC course and sex did not show a significant association, same result also found by Palma et al. [16]

An important fact verified in our study is the distance of the RMC in relation to the last tooth in the arch. This data is relevant for surgical planning, avoiding the possibility of complications when RMC is present. The average distance of the RRMC to the last tooth in the dental arch (2 were related to the third molar and 1 related to the second molar) was 12 mm, and to the LRMC (3 related to the third molar and 3 to the second molar) 9.07 mm. Comparing our results to those in the literature, we found that the location of the canal and retromolar foramen is not constant. Kawai et al. [23] evaluated the CBCT of cadaveric mandibles and the distance between the RMC and the second molar, and the average

distance observed was 14.4 mm. Gamieldien and Van Schoor [24] examined dry mandibles and 8% of them presented the retromolar foramen (RMF), and the distance from the RMF to the lower second molar was 16.8 ± 5.6 mm and to the lower third molar 10.5 ± 3.8 mm. Truong et al. [25] in a literature review, found a variation of 4.23 mm to 10.5 mm between the RMF and the distal margin of the third molar, and of 11.91 mm to 16.8 mm between the RMF and the distal margin of the second molar, with data obtained from studies that used CBCT and panoramic radiographs. Pannalal et al. [10] verified that the position of the RMF can change according to the presence of third molar, and RMF was located more buccal than lingual.

The clinical implications of the presence of the retromolar foramen/canal are directly related to its content. A neurovascular bundle including striated muscle fibers, thin myelinated nerve fibers, numerous venules and a muscular artery [2], nerve bundles and artery, [21] nerves, small arteries, venules, [18] neurovascular structures originating from the mandibular canal [23] were structures found in RMC. Therefore, anesthetic failures, hemorrhages, haematomas, paresthesias, postoperative discomforts can occur by injury of the RMC content [2, 3, 18, 19, 23]. This anatomy variation may be a possible route for spread of tumor or infection [2]. Knowing the presence and position of this accessory canal can avoid several complications. Regarding anesthetic failures, anesthetic infiltration in the retromolar region can increase the success of anesthesia after anesthetic failure of the inferior alveolar nerve block [3].

CONCLUSION

Female and the left side presented a higher frequency of RMC, although no statistically significant difference was observed between RRMC, LRMC and unilateral and bilateral RMC, nor course and diameter related to sex. RMC presence and course were not related to the age. There was no association between RMC course, side, angle measurements, diameter, and distance to the last tooth in the dental arch.

Despite the low prevalence of RMC observed in this study, it is essential to carefully evaluate the variations of the mandibular canal, especially prior to surgical procedures in the retromolar region to avoid complications and anesthetic failures. The proximity of the RMC to the last tooth in the dental arch alerts us to the importance of the existence of this anatomical variation before performing procedures in the retromolar region.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

The authors declare no conflict of interests.

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