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Assessment of the Prevalence and Anatomical Variations of the Retromolar Canal using Cone Beam Computed Tomography: A Cross-sectional Study

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Objectives The aim of this study was to evaluate the prevalence and anatomical variations of retromolar canal (RMC). Since RMC contains neurovascular bundle that contribute to the innervation and nutrition of the pulp and periodontium of the mandibular teeth, it is necessary to pay attention to the clinical importance of this landmark, to prevent possible surgical complications and anesthetic failures.
Methods In this descriptive-analytical study, 450 CBCT scans were evaluated. The scans were evaluated for presence of the RMC and linear measurements (distance to second and third molar, height, width and diameter) were made with NNT software. Descriptive statistics were used to assess data. Data were analyzed using paired t-test adopting significance for p value ≤0.05.
Results The prevalence of RMC was 7.1%. Among of the existed RMC, 71.9% were unilateral and 28.1% were bilateral. The mean height of canal was 9.33 ± 3.65 mm, and the mean width of the canal was 0.87 ± 0.4 mm. The mean distance of RMC to the third and second molar were 10.44 ± 5.1 mm and 11.71 ± 3.73 mm respectively. No significant differences were detected between the two genders.
Conclusion The prevalence of the RMC was observed to be 7.1% and was well observed in CBCT images. Accurate assessment of this anatomic landmark helps prevent surgical complications especially prior to third molar anesthesia and extraction.
Keywords Cone-Beam Computed Tomography; Mandibular Nerve; Mandibular Nerve Injuries

Introduction

The retromolar triangle is located between the anterior border of the mandibular ramus and the temporal crest behind the mandibular third molar, and can have one or more apertures known as retromolar foramina. [1, 2] The retromolar canal (RMC) branches in an anterosuperior direction from the mandibular canal and ends in an anteroposterior direction in the retromolar foramen (RMF). [3] Since the RMF and subsequently the RMC are a route for the neurovascular bundle that contribute to the innervation and nutrition of the pulp and periodontium of the mandibular teeth, they play a crucial role in mandibular block anesthesia. [4] In radiograph, the RMC is seen as a dark line with two thin radiopaque borders of dense bone branching out of the inferior alveolar canal. The canal is usually found midway between the mandibular canal aperture and the mandibular third molar. One study identifies it as a type of bifid inferior alveolar canal. Disregarding the presence of this landmark in some cases, can result in anesthetic failure, and damage to it can lead to hemorrhage and paresthesia. [2, 5]

In a study in 2014, Muinelo Lorenzo et al. examined the presence and morphologic characteristics of bifid mandibular canals and RMFs using cone beam computerized tomography (CBCT) and panoramic radiographs (PANs), and found that the bifid mandibular canals were observed in 83 out of the 225 patients (36.8%). In addition, the RMF were detected in 5.3% of the samples.[6]

In a study by Palma LF et al. in 2017 to evaluate RMCs on CBCT scans and PAN radiographs, it was found from analyzing 61 CBCT scans, that 24.6% of the individuals had at least one RMC Among the CBCT identified canals, only four (22.2%) were successfully confirmed on the corresponding digital panoramic radiographs. [7]

Motamedi et al. who conducted a study in 2015 and reported 40% incidence of RMF among 136 patients. [8]

Due to the presence of controversies and limitations presented in the literature, the aim of this study was to assess the prevalence and anatomical variations of the retromolar canal using Cone Beam Computed Tomography.

Methods and Materials

This study was approved by research committee of Shahid Beheshti University of Medical Sciences, Tehran, Iran (IR.SBMU.DRC.REC.1398.002).

Sample size:

In this descriptive-analytical study, 450 CBCT scans were analyzed. The scans were randomly selected regardless of age and sex from CBCTs of individuals who had presented themselves to the Radiology Department of the School of Dentistry at Shahid Beheshti University of Medical Sciences, Tehran, Iran. Scans with any pathological

findings, trauma, or surgical intervention, and those with poor image quality were excluded from the study.

Evaluation of CBCT scans:

CBCT scans were taken with Newtom VGi (Verona, Italy, KVP= 110, Automatic Exposure Control, FOV= 12×8cm, Voxel size 300μm). Scans were analyzed using NNT software on a 19-inch monitor at standard (dim light room) condition. CBCT data were assessed by a general dentistry student, and was approved by oral and maxillofacial radiologist. Intra-class correlation coefficients (ICC) test was performed on 20 samples in order to assess the intra-operator reliability.

The CBCT data were analyzed in sagittal, axial, and coronal planes (multiplanar reformation - MPR) at different sections. In case of detecting or suspecting the presence of RMC, sections were assessed in the sagittal plane on the relevant side (right or left) of the mandible during the multiplanar analysis. This section was reconstructed made along the longitudinal axis of the alveolar crest or with a slight angle to it. The resulting sections were analyzed in thickness of 0.2 mm which was predefined in the software. In case the RMC was detected, as a branch of mandibular canal posterior to the third mandibular molar, the canal course was marked, and the sections of 0.2 mm thickness in the sagittal plane in that region were analyzed to locate the canal aperture. Finding the canal aperture and marking it, its distance from the distal edge of the socket of the second and third molars (in case tooth is present) to the mid aperture was measured in the sagittal plane. In the same way, the distance from the aperture to the buccal and lingual alveolar crest was determined in the coronal plane. The diameter of the canal was obtained 3 mm below the canal aperture. Finally, the vertical height was measured from the canal aperture to the superior border of the mandibular canal measured (Figure-1).

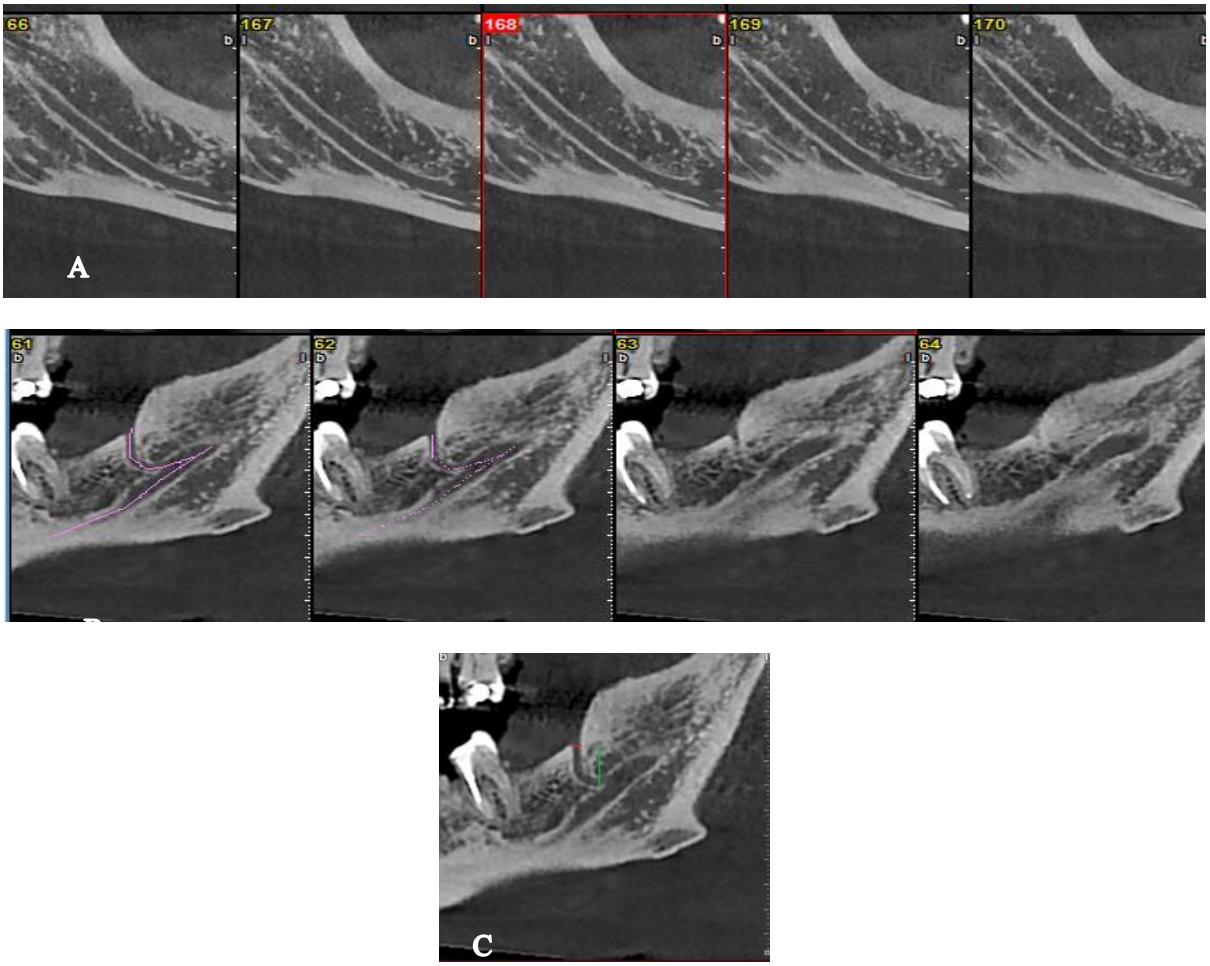

Figure-1: (A) Serial sagittal CBCT images with no evidence of RMC. The absence of RMC. (B) Serial Sagittal CBCT views showing presence of RMC. (C) RMC diameter (red line) and RMC vertical length (green line) are presented.

Statistical analysis:

All data were entered into a database system and evaluated using SPSS® for Windows version 26 (SPSS Inc., Chicago, IL, USA, 2012). Data analysis was performed with descriptive statistics (percentage, average, and standard deviation). Data were analyzed using paired t-test. The level of significance was set at p= 0.05.

Intra-class correlation coefficients (ICC) test was performed on 20 samples in order to assess the intra-operator reliability.

Results

Intra-Operator Reliability

RMC assessments for the first and second replicates of 20 patients were recorded and intra-class correlation coefficients (ICC) were established for all measurements. Most measures demonstrated a high degree of reliability between the first and second replicates with ICC values exceeding from 0.73 to 0.99.

Demographic Data

The study was conducted on 450 CBCT scans of patients at the Radiology Department of the School of Dentistry at Shahid Beheshti University, Tehran, Iran. Of this total, 200 were male (44.4%) and 250 were female (55.6%). The individuals were between 8 and 84 years of age with the mean age being 48.23 ± 17.27 years.

Assessing the Prevalence of RMC

Our study on 450 CBCT scans showed that 32 of the individuals (7.1%) were with and 418 (92.9%) of them were without RMCs.

Assessing the RMC as Being Unilateral or Bilateral

Of the RMCs present on the 32 CBCT scans, 23 cases were unilateral (71.9%) and 9 (28.1%) were bilateral.

Assessing the Dimensions of the RMCs

The mean height of the RMCs was 9.33 ± 3.65 mm, reported as min 3.3 mm to max 19.5 mm. The mean width of the RMCs in the 2D images was 0.87 ± 0.4 mm, reported as min 0.4 mm to max 2.4 mm. And the mean vertical distance from the midpoint of the foramen to the superior border of the mandibular canal was 6.67 ± 2.75 mm, reported as min 0.9 mm to max 13.8 mm (Table-1).

Table-1: Mean±SD evaluation of RMC height, width and vertical distance to IANC in relation tounilateral or bilateral, side and gender.

Index / Dimensions(mm)	Canal presence			Side			Gender		
	Unilateral	Bilateral	P-value	Right	Left	P-value	Male	Female	P-value
Height	9.34 ± 3.83	9.3 ± 3.42	0.762	9.26 ± 3.17	9.39 ±4.13	0.753	10.15 ± 3.9	8.26 ± 3.15	0.105
Width	0.83 ± 0.27	0.98 ± 0.63	0.314	0.73 ± 0.17	0.99 ± 0.49	0.1	0.8 ± 0.31	0.94 ± 0.47	0.418
Vertical distance to IANC	7.2 ± 2.72	5.31± 2.5	0.964	6.6 ± 3.01	6.74 ± 2.6	0.885	5.79 ± 2.63	7.67 ± 2.64	0.132

Statistical analysis:

All data were entered into a database system and evaluated using SPSS® for Windows version 26(SPSS Inc., Chicago, IL, USA, 2012). Data analysis was performed with descriptive statistics (percentage, average, and standard deviation). Data were analyzed using paired t-test. The level of significance was set at p= 0.05.

Intra-class correlation coefficients (ICC) test was performed on 20 samples in order to assess the intra-operator reliability.

Table-2: Mean±SD evaluation of RMC distance to second and third molar in relation to unilateral or bilateral, side and gender.

Index / Distance (mm)	Canal presence			Side			Gender		
	Unilateral	Bilateral	P-value	Right	Left	P-value	Male	Female	P-value
From Second Molar	7.85 ± 2,33	11.9 ± 3.35	0.768	11.25 ± 4.81	9.37 ± 0.23	0.776	12.92 ± 4.6	11.11 ± 3.32	0.44
From Third Molar	11.3 ± 5.6	11.62 ± 4.08	0.429	12.02 ± 3.1	11.08 ± 6.62	0.786	9.98 ± 3.5	10.9 ± 6.88	0.99

Assessing the Distance from the RMC Aperture to the Buccal and Lingual Alveolar Crest

The mean distance from the RMC aperture to the buccal alveolar crest was 5.22 ± 1.94 mm, reported as min 2.7 mm to max 11 mm. And the mean distance from the RMC aperture to the lingual alveolar crest was 4.04 ± 1.73 mm, reported as min 1.4 mm to max 8.3 mm (Table-3).

Table-3: Mean±SD evaluation of RMC distance to buccal and lingual plate in relation to unilateral or bilateral, side and gender.

Index / Distance(mm)	Canal presence			Side			Gender		
	Unilateral	Bilateral	P-value	Right	Left	P-value	Male	Female	P-value
From buccal table	11.62 ± 4.08	11.9 ± 3.35	0.343	4.86 ± 1.47	12.02 ± 3.1	0.47	5.51 ± 2.13	4.86 ± 1.69	0.252
From lingual table	11.3 ± 5.61	7.85 ± 2.33	0.6	4.15 ± 1.56	11.08 ± 6.6	0.932	3.22 ± 1.19	4.97 ± 1.8	0.32

Discussion

The aim of this study is to assess the prevalence and anatomical variations of the retromolar canal using CBCT. Awareness of the presence of the retromolar canal is important in the success of block anesthesia and treatment interventions such as impacted third molar surgery, and damage to it can lead to hemorrhage and paresthesia. [2, 9] In addition, knowledge of anatomical variations of this canal is important as RMC may be a potential path for infection and metastasis. [1, 10, 11]

This study shows that the sagittal plane is apparently the most appropriate plane for the observation of the RMC. The results of this study indicated that the presence of the RMC in the examined CBCT scans is not a prevalent occurrence, and only 7.1% of the total 450 scans showed presence of this anatomic landmark. The closest statistical results to those from our study come from a study by Amini et al. conducted in Iran in 2015 [12] which reported a prevalence of 7.3%. Studies conducted in other countries such as those by Thomas von Arx et al. [2] in Switzerland in 2011 and Bilecenoglu et al. in Turkey [13] reported prevalence percentages of 25.6 and 25, respectively. In 2015, Filo K. et al. obtained a 16.12% prevalence, [1] and a study by Lizio G. et al. in 2012 [14] reported a 16% prevalence for RMC. These statistical differences may have arisen from ethnic and sample size differences.

The present study has reported a very low percentage of bilateral RMC occurrence (28.1%), and most cases (71.9%) were unilateral on either the right or the left side of the mandible. Other studies [4, 8] showed the same results. In the study of Kawai et al., [15] RMF was assessed in 46 Cadaver mandibles. They indicated that 52% of mandibles contained RMF and its position was 14.4 mm posterior from the distal edge of second molar. The buccolingual location was 3.0 mm lingual from mandibular canal. Oral and maxillofacial surgeons should be aware of damage to RMC and RMF during surgeries and bone harvesting. In the study of Han et al., CBCT of 446 patients were assessed. The prevalence of RMC was 8.5% with 66% being vertical and 20% being horizontal. [16]

The dimension values obtained in this study for the height (9.33 ± 3.65 mm) and the width (0.87 ± 0.4 mm) of the RMC, and the vertical distance of the canal's aperture from the mandibular canal (6.67 ± 2.75 mm) are close to those obtained in the similar study by Amini et al. (mean canal length: 6.66 ± 2.18 mm; mean canal diameter 1.7 ± 0.6 mm). [12]

Results from other studies show similar dimensions: In the study by Thomas von Arx et al. in 2011, [2] the mean canal height and its mean width were obtained as 11.34 mm and 0.99 mm, respectively. Han et al., indicated that the mean width of RMC was 1.13 mm and the mean distance to the second molar was 14.08 mm. [16]

In the study by Filo K. et al. in 2015, [1] the mean width of the RMC and its mean height were determined to be 1.03 mm and 10.19 mm, respectively, which are again close to the values obtained in the present study.

Since most of the patients in the present study did not have the second and third molars, the quantity of the obtained data was low, hence, only their minimum and maximum have been reported.

Conclusion

In this study, the prevalence of the retromolar canal was observed to be 7.1%. No relationship was found between its prevalence and being unilateral or bilateral.in addition no significant differences were detected between the two genders. CBCT is a useful three-dimensional imaging modality for accurate assessment of RMC.

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Conflict of Interest

No Conflict of Interest Declared■

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