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The elusive retromolar foramen and retromolar canal: A CBCT study

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ABSTRACT

Aim & Objective: This study aims to evaluate the presence of retromolar foramen (RMF) and retromolar canal (RMC) in the mandible using cone beam computed tomography (CBCT) in Chhattishgarh population and to correlate its possible clinical impact.

Materials and Methods: 175 CBCT images were collected from which 100 bilateral CBCT images of patients were retrospectively selected from the Department of Oral Medicine and Radiology of the Chhattishgarh Dental College and Research Institute and evaluated bilaterally which were taken for diagnostic purposes from maxillofacial radiology clinic and data were statistically analyzed. This was an observational descriptive study and all the images were processed and analyzed on CS3D imaging software.

Statistical analysis used: The data was analyzed using chi square test.

Results: The prevalence of RMF and RMC was observed in 8.5%, of which 10 were in females and 7 in males. The RMCs traversed in different directions – horizontal, vertical and angular. Based on the subjective assessment, each of these canals was further subclassified into straight and curved canal. In the present study in 12 of the cases angular curved type was found and in 3 cases, vertical straight was noticed. The bifurcation of the inferior alveolar nerve (IAN) canal was observed in 15% of the scans and remaining 85% had single mandibular canal. The proximity of RMF from buccal and lingual cortical plates was found buccally in 16 cases and in single case was found to be lingually.

Conclusion: Position of RMF might change with the presence and absence of third molar. The absence of third molar results in anteriorly located RMF. In majority of cases it was found that RMF was located more buccal than lingual. The parameters considered in the current study will guide the oral and maxillofacial surgeons while giving incisions in 3^{rd} molar impacted cases, other pathologies and ease to preserve the retromolar foramen.

1. Introduction

Knowing the morphology of the human mandible and its possible variations is important for the planning of several procedures in the dental area as orthognathic surgery, mandibular reconstruction, extraction of third molars and placement of dental implants (Claeys & Wackens, 2005). The retromolar fossa, located between the anterior border of the mandible ramus and the temporal crest, may have one or more inconstant foramen called retromolar foramen (RMF), which permit the passage of vascular-nerve bundles that contribute to nutrition and innervation of the pulp and periodontium molar teeth (Sicher, 1960; Sawyer & Kiely, 1991; Bilecenoglu & Tuncer, 2006).[1] The presence of anatomical variations, such as the RMF, presents clinical implications, if not previously identified, can cause complications to clinical dental practice. Furthermore many authors reported failures in the anesthesia by regional

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blockade of the inferior alveolar nerve due to the presence of the RMF.

The mandibular canal (MC) and its branches mainly provide innervation and blood supply to the mandible and lower teeth. The mandible has multiple separate nerve canals in the embryonic stage of life, most of which disappear or merge into one or more main canals in the next developmental stages.[2] The remaining canals can have different patterns varying from a single MC to a complex arrangement of multiple canals originating from the main MC or other structures. It has been reported that there are many foramina with larger than 0.1 mm diameter in the surface of the posterior segment of the mandible, these foramina are sometimes connected to some canals or to a neurovascular plexus in the spongy portion of the mandibular bone and often have a connection to the inferior alveolar nerve or its dental branches, the largest foramina are found in the retromolar area, and their corresponding canals are referred to as the retromolar canals (RMCs).[3]

Several studies have reported different types of RMCs varying in their origin, course, and exit location. Myelinated nerves and blood vessels comprise the contents of the RC according to microscopic studies.[4–10] These nerves and vessels often originate from the inferior alveolar canal and provide innervation and blood supply to the tendons of the temporalis and buccinator muscles, the most posterior parts of the alveolar process, and the second and third molar's gingival tissue. In some cases, the RMC also contains the buccal and mylohyoid nerves.[11,12] Although the clinical significance of the RMC has not been well studied. The retromolar region in the mandible is also important while performing surgical interventions such as third molar extraction, implant placement, osteotomies, harvesting bone grafts.

Hence, it is important to know about the presence and location of both RMF and RMC because unexpected bleeding or paraesthesia and even permanent loss of sensation may occur via damage to the vessels and the nerves passing through the RMC during surgicalprocedures.[13]

The most common technologies used to detect RMF and RMCs are cone beam computed tomography (CBCT), computed tomography (CT), and the panoramic radiography (PAN), with CBCT being the most sensitive technique. Von Arx et al, radiographically evaluated the presence of retromolar canal on CBCT scans and panoramic radiographs and reported its prevalence to be 25.6% on CBCT scans and 5.8% on panoramic radiographs.[14] Singh et al. assessed the prevalence of retromolar canal on panoramic radiographs and reported the prevalence of bifid canal to be 4.3%. However, conventional two-dimensional (2D) radiographs such as panoramic images are insufficient for detecting all anatomical structures, and in particular, the presence of an RC.[15] CBCT is now widely available, specifically for use in dentistry, and has become notably effective for confirming anatomical variations of the mandibular canal that cannot be assessed on panoramic radiographs.[16]

The present study aimed to evaluate the prevalence of RMF and RMC in the mandible using CBCT, to measure the position of the RMF from CEJ of second molar, to determine the length of the RMC, diameter of RMF, proximity (distance) of the RMF to buccal and lingual cortical plates and to relate them to possible clinical implications.

2. Materials and Methods

A total of 137 scans of bilateral mandible was evaluated out of which 100 bilateral scans was selected. 37 scans with artifacts, incomplete area coverage with inferior image quality were excluded.

This retrospective analysis of CBCT scans was performed in the Department of Oral Medicine and Radiology, Chhattisgarh Dental College and Research Institute, Rajnandgaon to detect presence and characteristics of the RMF and RMC. The retromolar region of the mandible on both sides (right and left) was examined in 100 CBCT scans. A computer monitor with display resolution of 1366×768 pixels and screen size of 15 inches was used, and all sections sagittal, coronal, axial and multiplanar showing retromolar region were reconstructed.

The sample consisted of tomographic examinations of patients, both male and female, ranging from 18 years to 45 years, who underwent radiographic imaging for diagnostic purposes from the maxillofacial radiology clinic. As images were derived from archived scans, the patients were not exposed to additional X- rays. A large field of view (FOV) of CBCT scan showing the entire retromolar region of the mandible bilaterally was included.

The images with inferior image quality, artifacts, incomplete area coverage and presence of any obvious jaw bone anomaly in the retromolar region were excluded. Patients with a history of any surgical intervention (eg:- surgical defect following third molar extraction and after harvesting the bone graft, sagittal split osteotomy etc.) in the posterior region of the mandible were also excluded from the sample.

2.1. Methods

Variations with radiographic appearance of these anatomical structures, if present, were noted. The scans were evaluated on the basis of the site on which RMC/RMF were present was mentioned. Data obtained were carefully examined for the presence of these structures.

All sections were examined using the software CS3D imaging (version 3.5.18.0) with slice thickness of 1 mm. The orthographic views were sequentially examined from buccal to lingual cortex in sagittal section, superior to

inferior in axial section, and distal to mesial in coronal section. In 3D module, various sections were reconstructed by moving the center buccolingually and anteroposteriorly by degrees to detect RMC and RMF. Position of RMF with relation to CEJ of second molar was measured on multiplanar reconstruction (MPR) mode.

Length of canal was measured using tapeline (angular lines) for curved canals and ruler (straight lines) for straight canals. The variations in length, direction (vertical, angular, horizontal, or any other variation) of the retromolar canal were observed.

The retromolar canal was evaluated for the following variables:

1. Number of canals
2. Branches of canals, if any
3. Length of canal (from its point of origin to exit, if visualized)
4. Course of canalss
   (a) Horizontalcanals
   (b) Angular canals
   (c) Vertical canals

Diameter of retromolar foramen was measured on the multiplanar reconstruction mode. Proximity (distance) of the retromolar foramen from buccal and lingual cortical plates was measured on coronal section. For data collection, Microsoft excel spreadsheet was developed to store data such as accession number, affected side, age and gender of the patient. The data was recorded and analyzed statistically by using chi square test with IBM SPSS statistics v.18 software.

3. Results

The prevalence of the retromolar canal & foramen (Table 1) in the study sample was found to be present in 17 cases i.e in 8.5% (N=200), of which 10 were in females and 7 in males. A higher prevalence of right-sided RMF was observed in this study. 13% of the scans had unilateral distribution of RMCs, while in 2% occurred bilaterally (Table 2). The bifurcation of the inferior alveolar nerve (IAN) canal was observed in 15% of the scans and remaining 85% had single mandibular canal. Table 3 shows the position, diameter of RMF and length of RMC.

Table 5 shows the descriptive characteristics of RMC, ittraversed in different directions – horizontal, vertical, and angular. Based on a subjective assessment, each of these canals was further subclassified into either a straight or curved canal.

Horizontal: A canal was considered to be horizontal if it was approximately parallel to mandibular canal ±10°. According to its course, it was further divided into a horizontal straight (HS) or a horizontal curved (HC) canal.

Vertical: A canal was considered to be vertical if it was approximately perpendicular to mandibular canal ±10°. It was further divided into a vertical straight (VS) or a vertical curved (VC) canal depending on its course.

Angular: A canal was considered angular if it formed an acute angle with the mandibular canal. These canals were further divided into angular straight (AS) or angular curved (AC) depending on their course.

Angular curved (AC) type of RMC was found to be in 12 cases, vertical straight (VS) was found to be in 3 of the cases; while vertical curved (VC), horizontal straight (HS) and angular straight (AS) was found to be in single case each.

The proximity (distance) of RMF to buccal and lingual cortical plates was analyzed and measured on the coronal section, where it was found to be more buccally in 16 cases and lingually in single case as described in Table 6.

Fig. 1:

4. Discussion

This study evaluated the prevalence and anatomical properties of the RMF, RMC using CBCT images and presented a comprehensive classification of the RMC types by reviewing the previous studies. RMC can be defined as a canal that leads to one or more foramina in the retromolar area. The direction, course, and length of RMC were noted in all cases. The RMC traversed in different directions – horizontal, vertical and angular.[8] Each of the type was further divided into straight and curved. The mean position of the RMF from the CEJ of second molar was 3.3 ±13.8mm. The mean length of RMC and diameter of RMF was 3.4± 11.0 mm and 1.4±2.4 mm respectively. The mean length and diameter of RMC without RMF was 2.1 ± 3.9 mm and 1.1 ±1.5 mm. The mean distance (proximity) of RMF from buccal and lingual cortical plates was found to

Table 1: Prevalence of the Retromolar canal & Foramen and its gender distribution in the study sample

	Male (n=46)		Female (n=54)		P value
	Present	Absent	Present	Absent	
Right	5 (10.9%)	41(89.1%)	3 (5.6%)	51 (94.4%)	0.329
Left	5 (10.9%)	41 (89.1%)	4 (7.4%)	50 (92.6%)	0.547
			Total= 8.5%		

Table 2: Side distribution (unilateral/bilateral) of Retromolar canal

Unilateral	13	13%
Bilateral	02	2%
Total	15	15%

Table 3: Position, Diameter of RMF and Length of RMC (Right and left side)

	Minimum	Maximum	Mean	Std. Deviation
Position of RMF (Rightside)	8.90	17.70	14.2250	3.55397
Length of RMC (Right side)	10.70	15.70	12.7875	1.90146
Diameter of RMF (Rightside)	.50	1.30	.9625	.28253

Table 4:

	Minimum	Maximum	Mean	Std. Deviation
Position of RMF (Left side)	8.90	18.40	13.6000	3.37713
Length of RMC (Left side)	1.20	13.70	9.5556	3.97087
Diameter of RMF (Left side)	.50	10.90	1.9556	3.36196

Table 5: Descriptive characteristics of Retromolar canal in the study

Types of RMC	Number of cases
Vertical Straight (VS)	03
Angular Curved (AC)	12
Horizontal Straight (HS)	01
Vertical Curved (VC)	01
Angular Straight (AS)	01

Table 6: Proximity (distance) of RMF to buccal and lingual cortical plate

	Mean (mm)	Std. Deviation
Proximity of RMF to buccal or lingual cortical plate	3.1412	.83371

be 0.8±3.1 mm.

The neurovascular content of the RMC is an issue of clinical concern in surgical procedures involving the retromolar area. Such an anatomic variation is clinically relevant for surgical procedures in the retromolar area such as removal of third molars, sagittal split osteotomy, bone harvesting in retromolar and ramus areas, and removal of cysts and tumors as well as for intraoral dental anesthesia.[9]

A majority of earlier studies have evaluated the prevalence of RMF and RMC on dried mandibles and on cadavers, but relatively few studies have been conducted in living subjects. Imaging is an important adjunct to study human anatomy. Certain imaging techniques (CT and CBCT) because of their image quality, three dimensional (3D) view and interactive display modes are considered the "Third eye" to reveal the hidden mysteries of the human body.[5]

In dental practice, panoramic radiography is one of the most requested diagnostic tests, due to an overview of the components of the maxillary, mandibular, dental complex at relatively low cost. Previous studies using panoramic radiographs have reported incidences barely reaching 1%.[10] In the present study, the evaluations were made using CBCT and the anatomical variations (RMF and RMC) were

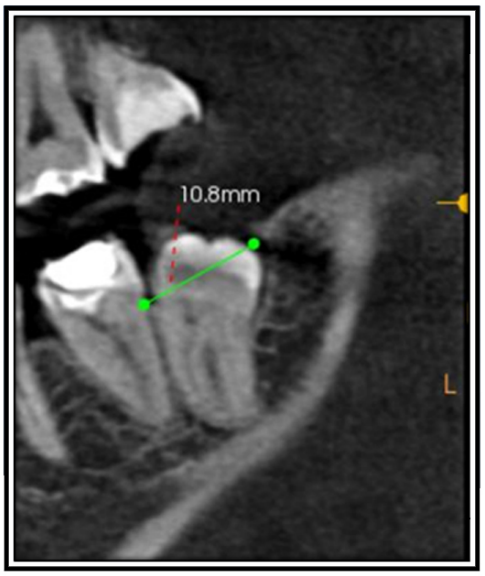

Fig. 2:

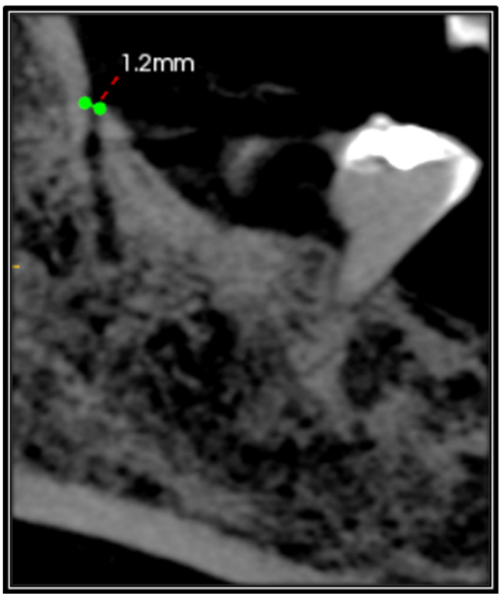

Fig. 4:

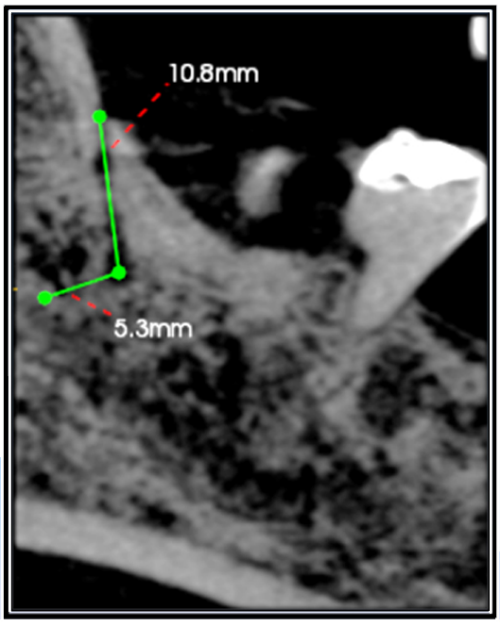

Fig. 3:

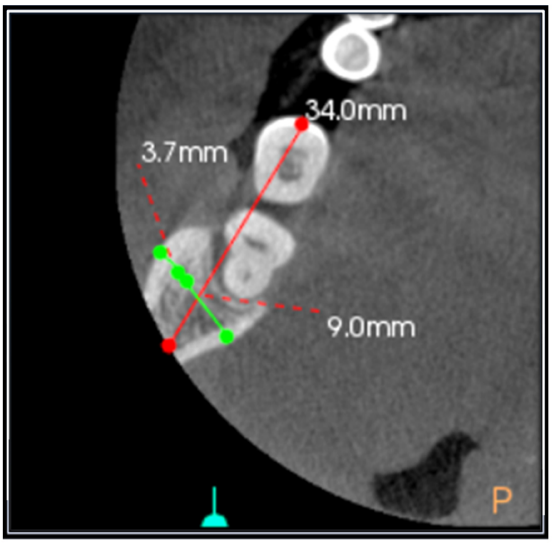

Fig. 5:

observed in 8.5%. CBCT is an excellent tool for studying the osseous structures of the maxillofacial region. The theory of natural selection propounded by Charles Darwin highlights that variations exist both at the individual and species level.[11] One such accessory foramen in the retromolar region that has been infrequently described in literature is the RMF. RMF is an anatomical structure occasionally identified on the alveolar surface of the retromolar triangle. This foramen is the termination to the RMC, which diverges from the mandibular canal.[12] A higher prevalence of right-sided RMF was observed in this study. 13% of the scans had unilateral distribution of RMCs, while in 2% occurred bilaterally. The bifurcation of the inferior alveolar nerve (IAN) canal was observed in 15% of the scans and remaining 85% had single mandibular canal.

It is extremely important for the maxillofacial radiologist to identify and report all anatomic variations both within and outside the region of interest which is of clinical importance. The radiologic evaluation of RMF and RMC will guide an oral and maxillofacial surgeon while performing surgical procedures.[7] Due to the limited descriptive characteristics of these structures was found to be limited in the literature,

hence the present study was designed. In the current study position, length, diameter of RMF and RMC was evaluated. All sections, i.e axial, coronal, sagittal and multiplanar reconstruction are evaluated for the presence of RMF and RMC. The presence of RMF and RMC occurred more frequently in males, though there was no gender predilection.

Ahuja et al conducted a study to determine the prevalence of RMF and RMC in the mandible, the length of the RMC, diameter of RMF, and proximity (distance) of the RMF from the cementoenamel junction (CEJ) of the mandibular molars using CBCT. A retrospective analysis was carried out for the presence and characteristics of the RMC and RMF. The retromolar region of the mandible on both sides (right and left) was examined in 80 CBCT scans. Out of 80 scans, in 16 of the scans identified RMC (20%). RMC was identified in 6 (19.35%) of the 31 CBCT scans or 7.5% of the sample in females and 10 (20.4%) of 49 CBCT scans or12.5% of the sample in males. (P- value = 0.91 [P >0.05 which is non significant]). The mean length of 10 RMC on right side was 9.292, and was 9.3136 for 11 canals on left side. RMF was found in 3 cases unilaterally (3.8%), out of which 2 were males (2.5%) and 1 was female (1.2%).

Total number of foramens were 5 (6.3%), 4 on the right (5%) and 1 on the left side (1.3%). In one of the cases (case number 4), a peculiar pattern of 3 foramens was noted on the right side. Diameter of foramens measured were 4.10 mm, 3.24 mm, 2.06 mm, 1.57 mm, and 1.16 mm. The distance from the midpoint of RMF to the CEJ of first, second, and third molars, the mean distance calculated was 28.07 mm from the first molar, 21.19 mm from the second molar, and 14.19 mm from the third molar.[1]

M.Y. Gamieldien conducted a study to determine the prevalence of the retromolar foramen in the South African population. All suitable mandibles were inspected for a retromolar foramen. A foramen was considered to be a confirmed retromolar foramen only if it was present in the retromolar area and if it offered no resistance to the introduction of a non-bevelled needle 1.0 mm in diameter. Mandibles were separated into six groups based on sex and ancestry recorded in the cadaver database: total male, total female, black male, black female, white male, and white female, to allow for comparisons between populations. Examination of 885 dry mandibles showed that 70 had a retromolar foramen (8%). There were no significant differences between groups according to age, sex, or ancestry. The mean (SD) distance from molar to retromolar foramen was 16.8 (5.6)mm for the mandibular second molar and 10.5 (3.8) mm for the mandibular third molar.[13] However, present study shows prevalence of 8.5% and the proximity (distance) of RMF to buccal and lingual cortical plates was measured and it was found to be more buccally in 16 cases and lingually in single case which was the new and helpful criteria not evaluated in the other previous studies.

5. Conclusion

According to the results obtained in this study, a prevalence of 8.5% of RMF and RMC was found, occurring more in males and unilaterally. From the present study, it was inferred that all RMC may or may not end into RMF. Position of RMF might change with the presence and absence of third molar. The absence of third molar results in anteriorly located RMF. Variations in the anatomy of the retromolar region are frequently encountered, as evidenced by the results of this study. In majority of cases it was found that RMF was located more buccally than lingual. The parameters considered in the current study will guide the oral and maxillofacial surgeons while giving incisions in 3^{rd} molar impacted cases, other pathologies and ease to preserve the retromolar foramen. The importance of a thorough knowledge of the retromolar region is herein reiterated based on the high prevalence of surgical procedures performed in the posterior region of the mandible. This in turn would benefit predictability in treatment planning and consequently optimize both anesthetic and surgical procedures, thus minimizing failures and accidents.

The oral and maxillofacial radiologist should carefully evaluate the retromolar region and report on these structures, if identified. CBCT scans are being increasingly prescribed in dental practice today. The oral and maxillofacial radiologist has an opportunity to carefully examine and assess the retromolar region wherever it falls within the FOV. The onus of reporting all anatomical variations of clinical interest lies with oral and maxillofacial radiologist. The RMC and RMF are infrequently reported structures which can be well studied on CBCT scans.

It can be concluded that the presence of RMF and RMC (its contents) have great clinical implication and due to lack of awareness, it can be damaged in various surgical activities such as third molar extraction, implant placement, osteotomies, and harvesting bone grafts which may lead to complications such as paresthesia, excessive bleeding, traumatic neuroma and anesthetic failure or insufficient anesthesia. Hence, it is important for the dentist to know the presence and location of both RMF, RMC and its proximity to buccal and lingual cortical plate.

6. Source of Funding

None.

7. Conflict of Interest

The authors declare no conflict of interest.

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