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Occurrence of retromolar canal among a sample of Yemeni adults obtained from cone-beam computed tomography

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ABSTRACT

Retromolar canal (RMC) and Retromolar foramen (RMF) are anatomic variants in the retromolar area of the mandible. The anatomy of human mandible and its variations are very important for planning various surgeries like extraction of third molar, placement of dental implants and mandibular reconstruction. The aim of this study was to determine the occurrence of RMC among a Sample of Yemeni adults obtained from cone-beam computed tomography (CBCT). A retrospective cross sectional study was conducted in Sana'a city among a sample of Yemeni adult obtained from a CBCT images. CBCT images of 163 subjects (222 sides) were evaluated retrospectively. The subjects were 79 males (49.4%) and 84 females (51.6%). Of 163 subjects and 222 sides, a significant 53 (32.51%) subjects and 70 (31.53%) sides were found to have RMC ($p < 0.05$). Among these subjects, 17 (32%) had RMC bilaterally and 36 (68%) were unilaterally. The most common type was A1 (42.9%), followed by type B1 (32.9%). The mean vertical height of the RMC was 9.38 ± 2.30 mm and the mean width was 1.85 ± 0.38 mm. The mean distances of RMC to the second and third molars were (15.2 ± 2.53 mm and 5.60 ± 2.25 mm, respectively). All the mean values of the linear measurements were slightly higher in males than that of females. RMC occurrence in males was (35.4%) slightly higher than that of females (29.8%). There was no statistically significant difference between the right and left sides in the occurrence of RMC (31.9% and 31.1%, respectively) ($P = 0.890$). In conclusion, the RMC is present in a considerable proportion of Yemeni population 32.5%, which highlights the need to raise awareness among dental practitioners and maxillofacial surgeons.

Keywords: Retromolar canal, Yemeni adults, cone-beam computed tomography.

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INTRODUCTION

The retromolar foramen mental foramenis one of the two foramina located on the anterior surface of the mandible; transposes the terminal branches of the inferior alveolar nerve and vessels (the mental artery) (Han and Hwang, 2014). A thorough understanding of the natural morphology of the human mandible and anatomical human differences is essential in dental practice, especially in oral and dental surgery (Han and Hwang, 2014). The mandibular canal originates from the neurovascular bundle and begins in the mandibular foramen on the medial side of the mandibular ramus, and ends at the mental foramen. The mandibular canal presents some anatomical differences. The retromolar channel (RMC) is an important anatomical difference and should be taken into account during the planning and implementation of surgeries in the posterior mandible, as this topic has been neglected in anatomy brochures and thus in academic training for dentists (Kikuta et al., 2018)

There may be multiple extraosseous branches of the inferior dental nerve prior to penetration through the mandibular canal, and such differences may be associated with the presence of accessory foramens and multiple canals (Muinelo-Lorenzo et al., 2014; Claeys and Wackens, 2005). A statistically significant relationship was observed between RMC and the accessory mandibular foramen (Claeys and Wackens, 2005). The retromolar region is delimited by the anterior margin of the ramus of the mandible, the temporal crest and the distal aspect of the last lower molar. In this area, a RMC may be present and emerge through the retromolar foramen (Bilecenoglu and Tuncer, 2006; Rossi et al., 2012). The RMC presents morphological and morphometric variability (Kawai et al., 2012), including a posterior concavity (Langlais et al., 1985) as well as straight RMC (Patil et al., 2013).

The presence of RMC has been reported by some authors in different population groups, indicating its increased incidence (Muinelo-Lorenzo et al., 2014; Claeys and Wackens, 2005; laeys and Wackens, 2005; Rossi et al., 2012). There were only a few published studies on this topic and there is no current systematic review of RMC prevalence and its clinical implications, namely risk of inferior alveolar nerve block failures, accidents and surgical complications such as paresthesia and hemorrhage (Rodella et al., 2011; Sawyer and Kiely, 1991). In this peripheral mandibular foramen, there may be myelinated nerve fibers and blood vessels that form direct branches of the inferior alveolar neurovascular bundle. These ramifications may supply the region of the third molar, the mucosa of the retromolar triangle, the buccal mucosa and the lower molars (Kodera and Hashimoto, 1995). Consequently, the accessory neural components in the retromolar region are functionally important for the conduction of the neural and / or vascular components of the lower jaw. Panoramic radiography is one of the most cost-effective radiological examinations for initial evaluation of dental patients, as it provides an overview of the dental and bone structures in the maxilla and mandible. However, many dental surgeons are unaware of the anatomical changes to this canal and may therefore be unwilling to visualize them on panoramic radiographs. Interpretation of such images is essential in planning to control surgical risks and failure in the posterior region of the mandible (Sonick et al., 1994).

For evaluation (Cavalcanti, 2014), cone beam computed tomography (CBCT) has been shown to be superior to conventional imaging for the visualization of the mandibular canal, although imaging of this sign may vary greatly between individuals and even between different areas of the mandibular regions within the same individual. The posterior portions of the mandibular canal are better visualized than the anterior aspects and CBCT is superior to conventional or digital panoramic radiography in detecting the mandible canal and assessing the different mandibular regions (Angelopoulos et al., 2008). The aim of this study was to evaluate the prevalence of RMC in CBCT images and link them to potential clinical effects.

MATERIALS AND METHODS

CBCT images to the area of retromolar area obtained from a Sample of Yemeni Adult. The sample was selected from the data records of CBCT x-ray centers (Al-Waled and Mass centers) randomly. Which meet the study criteria in the period of January 2016 to January 2018. CBCT images from 1386 patients from the archives of the Department of Radiology of Al-Waled and Mass centers, Sana'a city were examined and 490 images were selected first, then 163 were included according to the inclusion and exclusion criteria below.

Inclusion criteria

- The CBCT images of Yemeni adult that shows the retromolar area (the area of interest).
- The exposure settings of: tube voltage, 90 kVp; tube current, 4.0 mA; scan time, 24 seconds; and isotropic voxel size, 0.30 mm or less.

Exclusion criteria

- The presence of pathological findings in the retromolar area, such as osteomyelitis, fibrous dysplasia, tumors, cysts, or mandibular fracture at the angle or extend to the retromolar area, and the presence of any artefacts or blurring due to patient movements affecting the image quality, that makes the proper visualization of the region of interest is difficult.
- Subjects below 16 years old and subjects above 50 years old.
- Patients with a history of mandibular trauma, bone lesions in the lower arch, orthognathic or restorative surgery in the posterior region of the mandible were excluded from the sample

Retromolar canal classification

The mandibular canal and its changes were evaluated using coronal, sagittal, cross-sectional and panoramic reconstructed CBCT images for all semi-mandibles. The BMCs were classified according to the criteria proposed by Naitoh et al. (2009). Based on the source site and the course by the separated canal from the mandibular canal, Naitoh et al. classified into the following four categories: retromolar, dental, forward and buccolingual with CBCT. In addition, the trifid canal type also was included in this study. In the other classifications for describing mandibular canal variations, the panoramic radiography has been used so we used the classification proposed by Naitoh et al. (2009): 1 - Forward canal: the branch emerging from the upper border of the main canal. A- Forward canal without confluence: It separates from the mandibular canal in the mandibular ramus and then extends to the second molar area. B. Forward canal with confluence: It separates from the mandibular canal in the mandibular ramus, extends anteriorly and then rejoins to the main mandibular canal. 2 - Buccolingual canal: the branch emerging from the buccal or lingual side of the main canal. 3 - Dental canal: the end of the separated canal reaches the root apex of the first, second and third molar. 4 - Retromolar canal: the branch emerging from the main canal reaches the retromolar region.

Study samples

The sample consisted of tomographic examinations of patients, both male and female, ranging in age from 16 to 50 years, who underwent radiographic imaging in without controlling for ethnicity, gender, age or type of dentition. All images had been taken using the Classic I-Cat (Vatech, Korea), with voxel standardized at 0.25 mm, Fov (Field of view) of 13 cm and acquisition time of 40 pulsating seconds according to manufacturer's instructions, with a useful radiation time of 6.6 seconds. The equipment operates at fixed 120 kV (+ or –5 kV) and 7 mA according to the resolution selected.

All images were processed and analyzed in the Ez3D plus software (Vatech, Korea). The anatomical planes were first corrected using the equipment's own workstation via the multiplanar reconstruction page (MPR). From an axial slice (0.25 mm thick), a plane was drawn along the alveolar ridge of each patient. A panoramic image was then generated and subsequent cross-sectional slices were performed, being 1.00 mm in thickness and at a distance of 1.00 mm between slices.

In this study, only RMC with a diameter greater than 1 mm was included. The images were chosen in chronological order of acquisition, using the Ez3D plus software. All images were evaluated by one experienced observer, who was a radiologist. The analysis was performed in a quiet environment with sufficient lighting. The images were evaluated in three spatial planes (axial, sagittal and coronal) and in the trans-axial or oblique sections of the mandible along the path of the mandibular canal. In order to optimize identification of the mandibular canal, small modifications were made in the section plane, such as brightness, contrast and application of image filters, since the path of the mandibular canal is not linear and should be individualized for each side of the patient. Cases in which the presence of RMC was verified, oblique sections were also performed, in order to obtain images in the buccal-lingual direction.

Satisfactory tomographic quality was included in the sample of patients of both genders who underwent concomitant computed tomography. Patients with a history of mandibular trauma, bone lesions in the lower arch, orthognathic or restorative surgery in the posterior region of the mandible were excluded from the sample.

As images were derived from archived scans, the patients were not exposed to additional X-rays. For images with a positive identification of changes in the mandibular canal, the patient was informed in the original radiographic report. For data collection, an Excel spreadsheet (Microsoft) was developed to store data such as accession number, affected side, age and gender of the patient.

Statistical analysis

Data were analyzed by SPSS program (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Aromnk, NY: IBM Corp.) and presented by using tables. Percentage (%) was used to describe the qualitative variables. Mean and standard deviation was used to describe the quantitative variables for the normally distributed data. Chi-square with Yate correction and Fisher tests were used to show the significance of the association between the outcomes at the level of significance less than 0.05 (P).

Ethical approval

Ethical approval was obtained from the Medical Research & Ethics Committee of the Faculty of Medicine & Health Sciences at Sana'a University. All data, including patient identification and X-rays, were kept confidential.

RESULTS

Table 1 shows the distribution of data according to gender. The study includes 163 subjects, 49.4% of them were males and 51.6% were females. When sides were considered, our study includes 222 sides, 50.9% of males and 49.1% of the females.

Table 1. Distribution of data according to gender.

Gender	Subjects (n = 163)	Sides (n = 222)
Male	79 (49.4%)	113 (50.9%)
Female	84 (51.6%)	109 (49.1%)

The mean age was 33.97 (SD = 10.56).

Of 163 subjects and 222 sides, 53 (32.51%) subjects and 70 (31.53%) sides were found to have RMC. Among these subjects, 17 (32%) were found to have RMC bilaterally and 36 (68%) were unilaterally, in which 21 (58.3%) were found in the right and 15 (41.7%) were in the left (Table 2). The most common morphologic type was type A1 (42.9%) and was slightly more in the right side (24.2%) and in females (24.2%), but with no statistically significant difference between the sides or gender in the occurrence of RMC (*P* = 0.7176, 0.3726 respectively) (Table 3). The mean vertical height of the RMC was 9.38 ± 2.30 mm with a range from 5.4 to 16.2 mm. There was no statistically significant difference between the right and left sides in the mean vertical height of the RMC (9.32 ± 2.13 mm and 9.44 ± 2.52 mm respectively) (*P* = 0.419) (Table 4).

The mean width of the RMC was 1.85 ± 0.38 mm with a range from 1.2 to 2.9 mm. There was no statistically significant difference between the right and left sides in the mean width of the RMC (1.81± 0.04 mm and 1.89 ± 0.37 mm respectively) (*P* = 0.178) (Table 4). The mean horizontal distance of RMC to the second molar was 15.2 ± 2.53 mm with a range from 9.4 to 19.9 mm. There was no statistically significant difference between the right and left sides in the mean distance of RMC to the second molar (15.10 ± 2.43 mm and 15.41 ± 2.67 mm respectively) (*P* = 0.306) (Table 4).

The mean horizontal distance of RMC to the third molar was 5.60 ± 2.25 mm with a range from 1.7 to 10 mm. There was no statistically significant difference between the right and left sides in the mean distance of RMC to the third molar (5.53± 2.04 mm and 5.69 ± 2.50 mm respectively) (*P*= 0.383) (Table 4).

All the mean values of the linear measurements were slightly higher in males than that of females. However, there were no statistically significant differences between the male and female subjects in all linear measurements (P-value < 0.05) (Table 5).

DISCUSSION

In the present study, the prevalence of RMC was 32.5%, this rate is roughly similar to that reported by Sisman et al. (2015) (26.7%), Kikuta et al. (2018) (26.7%), 25.4% in Brazilians (De Castro et al. 2018), 26.2% in Turkish population (Okumus and Dumlu, 2019), but lower than

Table 2. Prevalence of RMCs.

Parameter	Subjects (n = 163)	Sides (n = 222)
Presence	53 (32.51%)	70 (31.53%)
	Subjects (n = 53)	**Sides (n = 70)**
Bilaterally	17 (32%)	34 (48.6%)
Unilaterally	36 (68%)	36 (51.4%)
In right (n = 36)	21 (58.3%)	21 (58.3%)
In left (n = 36)	15 (41.7%)	15 (41.7%)

Table 3. Distribution of RMC based on type for both sides and gender (n = 70).

Type	N(sides)	(%)	Side			Sex		
			Right (%)	Left (%)	P-value*	Male (%)	Female (%)	*P* *
A1	30	42.9	17 (24.2)	13 (18.5)	0.717	13 (18.5)	17 (24.2)	0.372
A2	7	10	6 (8.5)	1 (1.4)		4 (5.7)	3 (4.3)	
B1	23	32.9	11 (15.7)	12 (16.6)	0.557	14 (20)	9 (12.8)	0.312
B2	8	11.4	3 (4.3)	5 (7)		6 (8.5)	2 (2.8)	
C	2	2.8	1 (1.4)	1 (1.4)		2 (2.8)	0	
Total	70	100	38 (54.3)	32 (45.7)		39 (55.7)	31 (44.3)	

*Chi-square.

Table 4. The mean of linear measurements of RMC in the right and left sides (in mm).

RMC	Total			Right		Left		*P* *
	Range	Mean	SD	Mean	SD	Mean	SD	
Height of RMC	5.4 -16.2	9.38	2.30	9.32	2.13	9.44	2.52	0.419
Width of RMC	1.2 -2.9	1.85	0.38	1.81	0.04	1.89	0.37	0.178
Distance of RMC to the second molar	9.4 -19.9	15.2	2.53	15.1	2.43	15.41	2.67	0.306
Distance of RMC to the third molar	1.7 -10	5.60	2.25	5.53	2.04	5.69	2.50	0.383

*Chi-square.

Table 5. Comparison of the mean value of linear measurements of RMC by gender (in mm).

RMC	Male		Female		*P**
	Mean	SD	Mean	SD	
Height of RMC	9.78	2.38	8.87	2.12	0.096
Width of RMC	1.86	0.33	1.82	0.45	0.701
Distance of RMC to the second molar	15.47	2.70	14.96	2.30	0.397
Distance of RMC to the third molar	5.86	2.39	5.28	2.04	0.278

* Welch's t-test.

43.1 % in Korean (Kim et al., 2017), and 58.4% in Japanese (Wamasing et al., 2018). This conclusion means that race plays a role in the presence of RMC. This study showed that RMC present unilaterally in 36 (68%) of the subjects and in 17 (32%) bilaterally. Likewise, other studies which reported the RMC prevalence to be higher unilaterally, as Tassoker and Sener (2017) which investigated 170 CBCT 340 sides and reported unilateral RMC in 10.5% and a bilateral canal in only 0.5%. Also Movahhedian et al. (2017) assessed 500 CBCT 1000 sides and reported unilateral RMC in 9.2% and a bilateral canal in 2%.

Regarding dry mandibles studies, Priya et al. (2005) assessed 157 south Indian mandibles and reported unilateral RMF in 12.7% and a bilateral foramen in only 5.1%, and Narayana et al. (2002) studied 242 dry adult mandibles of south Indian and reported unilateral RMF in 17.8% and a bilateral foramen in 4.1%. However, Rabie et al. (2019) studied 89 dry mandibles and reported unilateral RMF in 31% and bilateral foramen in 55%.

With respect to gender predilection, the present study reported the occurrence of RMC in males as (35.4%) which was slightly higher than that of females (29.8%). But, there was no statistically significant difference between the males and females in the occurrence of RMC (P = 0.439). These results were similar to the majority of studies that found no gender preference (Movahhedian et al., 2017; Rabie et al., 2019; Jacob et al., 2014; Amini et al., 2015; Gamieldien and Van Schoor, 2016). However, Alves and Deana (Luangchana et al., 2018) found more females (23.8%) than males (13.8%) tended to have RMC, but these differences did not reach statistical significance (P = 0.31).

With regard to side predilection, the present study reported the occurrence of RMC in the right side as 31.9% which was almost the same of that in the left side (31.1%). There was no statistically significant difference between the right side and left side in the occurrence of RMC (P-value = 0.890). These findings were similar to the majority of previous studies which have found that no significant difference between the right side and left side in the occurrence of RMC (Movahhedian et al., 2017; Jacob et al., 2014; Luangchana et al., 2018; Alves and Deana, 2015; Potu et al., 2014).

Turning to the morphologic types of RMC, in the present study type A1 was the most common morphologic type (42.9%) and was slightly more in the right side and females (24.2%), but with no statistically significant difference between the sides or gender in the occurrence of RMC (P = 0.7176, 0.3726 respectively). Followed by type B1 (32.9%) which was almost the same in both sides, but slightly higher in males (20%), with no statistically significant difference between gender in the occurrence of RMC (P = 0.3125). Type A2 and B2 were almost equally distributed (10 and 11.4%, respectively). The least common ones was type C (2.8%) which only present in one male bilaterally in this study. These findings were similar to those done by Von Arx et al. (2011) in which most RMC had a vertical course (type A1, 41.9%) or were slightly curved (type B1, 29.0%). Type C, the horizontal course, was never identified. Also Han and Hwang (2014) reported vertically curved courses (Type 1, 66.7%), followed by horizontally curved courses (Type 2, 20%) and (Type 3, 13.3%) was rare. However, according to Movahhedian et al. (2017), Type B1 (50.7%) was the most common, followed by Type A1 (23.9%) and Type C (17.9%).

With regard to the height and width of the retromolar canal, such information has rarely been collected in other studies, and thus direct comparisons between this study and others is difficult. Furthermore, there is no definitive system for measurements among the studies and no uniform reference points to compare with.

In the present study, the mean vertical height of the RMC (vertical distance from the midpoint of RMF to the upper border of mandibular canal) was 9.38 ± 2.30 mm with a range from 5.4 to 16.2 mm. There was no statistically significant difference between the right (9.32 ± 2.13 mm) and left (9.44 ± 2.52 mm) sides (P-value = 0.419). The vertical height of the RMC was slightly higher in the males (9.78 ± 2.38 mm) than the females (8.87 ± 2.12 mm), but still statistically insignificant (P = 0.096). These findings were similar to those measured by Von Arx et al. (2011) which was 11.34 mm, with a range from 7.43 to 18.17 mm, with male having higher values than females. On other hand, Von Arx et al. (2011) found the gender to be a significant factor with males having longer RMC than females (mean difference, 2.06 mm), but in regarding to the side there was no statistically significant difference. This difference may be explained by the fact that males have an overall greater height of the mandible.

The mean width of RMC in this study was 1.85 ± 0.38 mm with a range from 1.2 to 2.9 mm. There was no statistically significant difference between the right and left sides of the subjects in the mean width of the RMC (1.81 ± 0.04 mm and 1.89 ± 0.37 mm, respectively) (P = 0. 0.178). As well as between males and females (1.86 ± 0.33 mm and 1.82 ± 0.45 mm respectively) (P = 0. 0.701). These results are similar to many studies such as, Motamedi et al. (2016) who found that the average diameter of the RMF was 1.7 mm (range 1.1 to 2.1 mm); the average diameter was 1.8 mm in males and 1.5 mm in females with no statistically significant differences between the sexes.

Regarding the horizontal distance from the RMC to the second molar, in this study the mean horizontal distance was 15.2 ± 2.53 mm with a range from 9.4 to 19.9 mm. There was no statistically significant difference between the right and left sides of the subjects in the mean distance of RMC to the second molar (15.10 ± 2.43 mm and 15.41 ± 2.67 mm, respectively) (P = 0.306), as well as between males and females (15.47 ± 2.70 mm and 14.96 ± 2.30 mm respectively) (P = 0.397). This result is similar to that reported by von Arx et al. (2011) (15.16 ± 2.39 mm), Han and Hwang (2014) (14.08 ± 3.85 mm), Filo et al. (2015) (15.10 ± 2.83 mm), in which there was no statistically significant difference between gender or side and the distance from the RMC to the second molar. However, Amini et al. (2015) reported the distance between the RMC and second molar as 12.76 ± 4.3 mm, which is 3 mm lesser than this study.

Regarding the horizontal distance from the RMC to the third molar, in this study the mean horizontal distance was 5.60 ± 2.25 mm with a range from 1.7 to 10 mm. There was no statistically significant difference between the right and left subjects in the mean distance of RMC to the third molar (5.53 ± 2.04 mm and 5.69 ± 2.50 mm respectively) (*P* = 0.383), as well as between males and females (5.86 ± 2.39 mm and 5.28 ± 2.04 mm respectively) (*P* = 0.278). This result is roughly similar to that reported by Bilecenoglu and Tuncer (2006) (4.23 ± 2.30 mm), Tiwari et al. (2015) (6.15 mm) and Park et al. (2016) (5.8 ± 3.6 mm), in which the distance from the RMC to the third molar were (4.23 ± 2.30 mm, 6.15 mm, and 5.8 ± 3.6 mm respectively), also there was no statistically significant difference between gender and side.

However, Gamieldien and Van Schoor (2016) reported higher values by 5 mm more than this study, which was 10.5 (3.8) mm from the RMC to the third molar. This difference in the values may be related to the different measurments tools , as they used mechanical dial callipers in their study in dry mandibles.

Conclusion

The RMC is present in a considerable proportion of Yemeni population, which highlights the need to raise awareness among dental practitioners and maxillofacial surgeons. There was no statistically significant difference between gender and sides, in the occurrence of RMC; and RMC of type A1 was the most common type. Additional studies are required to determine the occurrence of RMC in other regions of Yemen and refine the scoring criteria and classification system for better and comparable results to be yield in the future. Generally, CBCT should be performed before any operations in the retromolar region.

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