RESEARCH

Incidence of retromolar canal in Egyptian population using CBCT: a retrospective study

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Abstract

Background: Many studies have been done to investigate the incidence and the course of the retromolar canal (RMC) in different populations either osseous studies using cadavers or dry mandibles, panoramic studies, or cone beam computed tomography (CBCT) studies. The location of the RMC is in the retromolar area distal to the third mandibular molar. The retromolar area is considered an imperative site where many dental surgeries are being held.

The aim of this study is to determine the incidence of RMC in the Egyptian population using CBCT and measure the distance between the RMF and neighboring anatomical landmarks to better allocate the RMC and RMF and avoid the complications.

Two hundred and fourteen CBCT scans were examined to detect the presence of RMC. Their course was classified to 3 main types A, B, and C, and linear measurements were done from the retromolar foramen (RMF) to the 2nd and 3rd molars in anteroposterior direction and from the RMF to the mandibular foramen (MF) in anteroposterior and mediolateral directions.

Results: The RMC was present in 24 scans from the 214 with 11.2% incidence rate. The most common type was found to be type A, and type C was the rarest. The RMC has no significant difference between males and females, unilateral and bilateral distribution, and right and left sides. The linear measurements from the RMF to the 2nd and 3rd molars are 14.70 ± 5.07 mm and 4.26 ± 4.21 mm, respectively, and from the RMF to the MF in anteroposterior and mediolateral directions are 15.69 ± 3.43 mm and 2.62 ± 1.60 mm, respectively.

Conclusions: The incidence rate of RMC in Egyptian population represents 11.2%. The use of CBCT is quite important in the evaluation of the retromolar area to visualize the presence of the RMC or RMF and avoid the complications occurring due to different dental surgical procedures performed in the aforementioned site.

Keywords: Retromolar foramen, Retromolar canal, CBCT, Egyptian population

Background

Recent imaging modalities have brought attention to anatomical variations of the mandible, such as bifid mandibular canals [1], accessory mental foramina [2, 3], lingual foramina [4], and RMF [5]. The nerve of retro-molar canal (RMC) is an anatomical variation of the mandible in the retromolar area which was thought to

arise from the accessory inferior alveolar nerve (IAN) [6–8] or the long buccal nerve [9, 10].

A neurovascular bundle that runs through the RMC contains veins, arteries, and myelinated nerve fibers [11, 12]. The course of RMC has been studied in many populations and races, and it varies from one individual to the other and was found to exhibit either a vertical or a horizontal course. It may also appear as an independent canal that starts from a separate foramen in mandibular ramus and ends in the retromolar fossa with the opening

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of RMF. In other instances, its course may start from the retromolar fossa and end in the radicular portion of the lower third molar with no evident relation with the IAN.

What makes the RMC of utmost importance is its location in the retromolar area distal to the third mandibular molar. The retromolar area is considered an imperative site where many surgeries are being held, for instance the removals of impacted lower wisdoms, sagittal split osteotomy, harvesting bone, and implant placement. Thus, the lack of knowledge of this variation during different dental procedures can lead to adverse effects such as difficulty in achieving profound local anesthesia of mandibular molar area due to accessory innervation from the retromolar nerve, traumatic neuroma, severe bleeding, or facial paresthesia "sensory deficits" [13, 14].

The course of the RMC has been investigated in many studies based on population and race. Starkie and Stewart found that it could exhibit either a vertical or a horizontal course [6]. von Arx et al. and Ossenberg. found that it may appear as an independent canal that starts from a separate foramen in mandibular ramus and ends in the retromolar fossa with the opening RMF [11, 14]. However, Patil et al. reported that the course starts from the retromolar fossa and ends in the radicular portion of the lower third molar with no evident relation with the IAN [5]. RMC and its origin, incidence, route, and relations with the surrounding structures were quite reported in literature [15, 16]. In addition, macroscopic osseous studies were performed by Jablonski et al. and Schejtman et al. and confirmed the relation of the retromolar nerve with the IAN or the long buccal nerve [9, 17]. Thus, the retromolar canal is being of clinical interest as it may convey additional or aberrant neurovascular structures to/from the posterior mandible and the cheek.

Imaging modalities in dental fields like panorama and CBCT have significant importance in visualizing the anatomical variations. Panoramic radiograph-based studies were numerously conducted, but owing to their two-dimensional (2D) nature, the diagnostic value is limited by the geometric distortions and anatomical superimpositions. The capability of the panoramic radiographs was found to be not efficient in the detection of the incidence rate, or either the relation of the RMC [14, 18]; three-dimensional (3D) modality may be required for detailed interpretation. The use of 3D imaging modalities such as multislice computed tomography (MSCT) and CBCT has a great impact on oral and maxillofacial disciplines, and its usage became quite indispensable in dental or non-dental fields [19]. However, the CBCT offers much lower radiation dose, shorter scanning time, and reduced cost and it also introduced revolutionary third-party software packages which helped dentists and dentomaxillofacial specialists to navigate the scans independently [20].

The revolutionary introduction of the CBCT in the dental field expedites the investigation of such abnormal variation regarding the incidence and the course of the RMC. The results showed much higher incidence rate, accuracy, and specificity compared to panoramic radiographs [5, 12, 14, 21].

Many studies have been done to investigate the incidence and the course of the RMC in different populations either osseous studies using cadavers or dry mandibles, panoramic studies, or CBCT studies [5, 22–25]. A recent study was conducted by the Faculty of Medicine, Suez Canal University, on Egyptian dry human mandibles to find the occurrence of the RMF and found that the RMF was observed in three mandibles out of the 11 included in this study with 23% occurrence rate [26]; this study sample is not enough to represent the Egyptian population. Hence, the current study will investigate more about these variations in the Egyptian population to provide detailed information about the RMC and RMF. This data may reduce the possible complications that might be encountered in dental surgical procedures performed at this site and will emphasize the importance of prior CBCT scans to avoid the complications.

Methods
This sample size was determined following a power analysis with estimated probability 0.1 based on previous research, confidence interval 0.95, and margin of error 5%. Digital Imaging and Communications in Medicine (DICOM) files from 214 Egyptian subjects, 104 males and 110 females, representing 428 right and left sides were anonymized and selected from a pre-existing database housed at Ain Shams University, School of Dentistry, which were performed for dental impactions, implants, oral surgeries, and orthodontic treatment purposes. Male and female patient scans were selected between 2015 and 2017 with an age range between 15 and 70 years.

All cases used in this study were scanned using i-CAT next generation CBCT scanner (i-CAT 17-19, Imaging Sciences International LLC, Hatfield, PA, USA). All DICOM images collected were evaluated and examined using *InVivoDental® 5.4.5* (Anatomage, California, USA)

This study is a retrospective study conducted on 214 scans involving 428 mandibular sides observed by two dental radiologists with more than 5 years' experience.

Each case was first examined on the multi-planner reconstruction (MPR). Axial, coronal, and sagittal views were scrolled to identify the presence of RMF or RMC. Scans were examined thoroughly for the presence of any opening on the outer surface of the mandible in the

retromolar area, which may indicate the RMF or any branching from the inferior alveolar canal. Cross sections, reconstructed panoramic view, and reconstructed slice panoramic view were also scrolled thoroughly in arch-section module to facilitate tracing of the inferior alveolar canal (IAC) and identify any sign of branching in the retromolar area from the IAC indicating the presence of RMC (Fig. 1).

When the RMF or RMC is identified, linear measurements were done and recorded for statistical analysis. Sagittal cut was adjusted to be passing through the RMF and the middle of the 2nd and the 3rd molars, and then, linear measurement was done in the anteroposterior direction (Fig. 2). Axial cut was adjusted to be passing through the RMF and the mandibular foramen, and the linear measurements was done between them in both anteroposterior and mediolateral direction (Fig. 3).

All RMCs were classified according to their course and direction to three main types according to Patil et al.'s classification [5] (Fig. 4):

A. Type A in which the RMC branches from the mandibular canal distal to the third molar and course superiorly to open in the retromolar area with RMF. Two variations from type A were noted, A1 (Fig. 4a) and A2 (Fig. 4b). In A1, the canal runs in a straight manner superiorly to open in the retromolar area; however, in A2, the canal runs in a curved manner anteriorly then postero-superiorly to open the retromolar area.
B. Type B in which the canal starts from the retromolar area by the RMF and ends in the radicular portion of the 3rd molar (Fig. 4c).
C. Type C in which the canal starts branching early from the mandibular canal near the mandibular foramen and ends in a higher level in the retromolar area (Fig. 4d).

Statistical analysis
Results in the current study were analyzed and tabulated using the Statistical Package for Social Science (SPSS) software as described by Freitas et al. for their statistical analysis [27]. Intra-reviewer analysis and inter-reviewer analysis were done to determine the reliability of measurements, frequencies, and percentages to find the percentage of RMF in the sample, and χ^2 (chi-square test) and Fisher's exact test were calculated to identify the significant incidence.

Results
The sample consisted of 214 patient scans, 104 males and 110 females. The results showed the presence of 13 RMCs in males and 11 RMCs in females with a total of 24 patients having RMCs out of the 214 and incidence rate of 11.2% (Table 1).

According to the 428 right and left sides in the total sample size, the results showed the presence of 17 RMCs in males and 13 RMCs in females with a total of 30 RMCs out of 428 sides with incidence rate of 7%. The prevalence of RMCs in the left side (n = 16, 3.7%) was slightly higher than that of the right side (n = 14, 3.3%), but with no significant difference (Table 2).

The incidence of the different types of RMCs was evaluated, and type A was found to be the most common type (n = 23, 5.37%) which has two subtypes A1 and A2. Type B is found to be the 2nd most common type (n = 5, 0.7%). Type C was the rarest type (n = 2, 0.23%) (Table 3).

The unilateral presence of RMCs (n = 18, 8.4%) was found to be higher than the bilateral presence of RMCs (n = 6, 2.8%), but also with no significant difference (Table 4).

The distance from the RMF to the second and third molars in the anteroposterior direction was calculated and found to be 14.70 ± 5.07 mm and 4.26 ± 4.21 mm, respectively. The distance from the RMF to the mandibular foramen in both the anteroposterior direction and the mediolateral direction was calculated and found to be 15.69 ± 3.43 mm and 2.62 ± 1.60 mm, respectively (Table 5).

Discussion
Many studies have been conducted on the incidence rate of RMC and RMF using panoramic radiograph which all have reported low incidence rate. Recently, high-resolution CBCT has become notably effective for confirming anatomical variation of mandibular canal that cannot be assessed using panoramic radiograph which

Fig. 1 Slice panoramic view. Slice view of reconstructed panoramic image, the two white arrows pointing to the RMC bilaterally
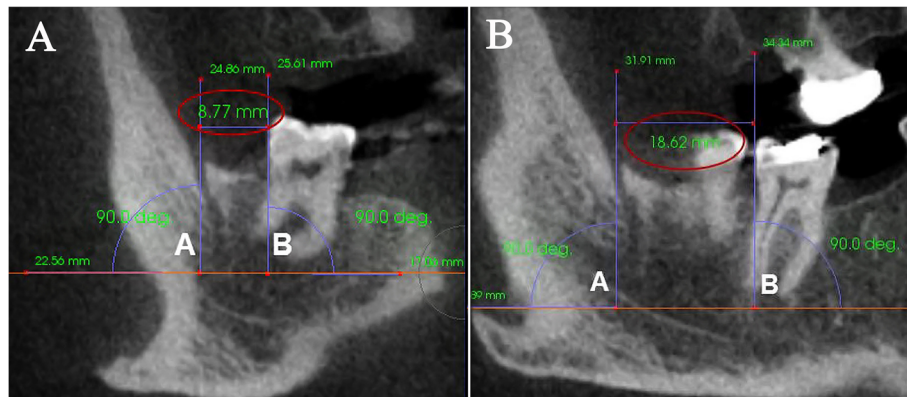
Fig. 2 Linear measurements between the RMF and the 2nd and 3rd molars in anteroposterior direction. **a** Sagittal cut: "A" is the line from the RMF perpendicular to the axial plane reference line, "B" is the line tangent to the 3rd molar distal surface and perpendicular to the axial plane reference line, and the linear measurement between the RMF and distal surface of the 3rd molar is 8.77 mm. **b** Sagittal cut: "A" is the line from the RMF perpendicular to the axial plane reference line, "B" is the line tangent to the 2nd molar distal surface and perpendicular to the axial plane reference line, and the linear measurement between the RMF and distal surface of the 2nd molar is 18.62 mm

all have reported a wide incidence rate ranging from 6.1 to 72% [21, 28].

Numerous studies have been conducted studying the incidence of retromolar canal in different populations, all with varying results. The studied populations included Americans, Canadians, Argentinians, Italian, Japanese, Turkish, Brazilian, and Indian. However, there has been no study conducted on the Egyptian population except for only one study that has been conducted on 11 dry mandibles [5, 22–24, 29]. Hence, the current study was aimed to identify the incidence of retromolar canal in the Egyptian population using CBCT.

The CBCT scans of 0.25 mm voxel size were selected which allowed us to evaluate and detect the RMC and RMF of 0.5 diameter or larger, identifying the course and the location of these canals and foramina with good precision and accuracy. Higher resolution scans of 0.125 mm voxel size were available from the same i-CAT next generation CBCT machine in our archive but were not used as they provide limited field of view (FOV) to 4 cm × 16 cm which will limit the height of the scan and will not be enough to evaluate the ramus and the mandibular foramen areas.

The Invivo dental software was used in our study as a reliable and accurate measuring software in accordance
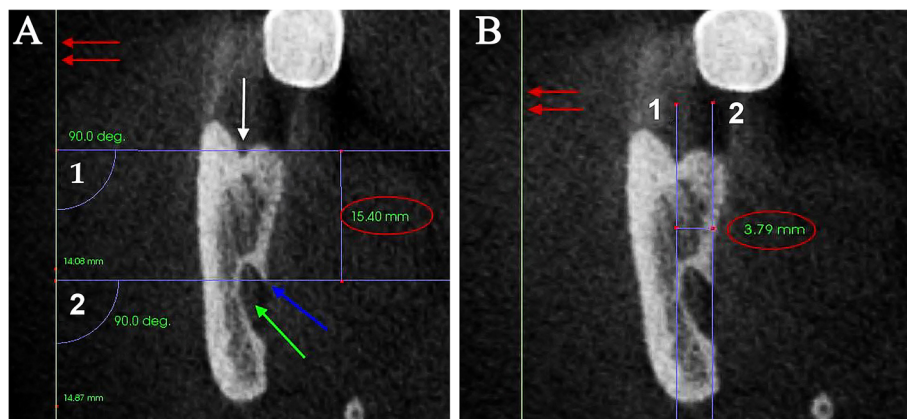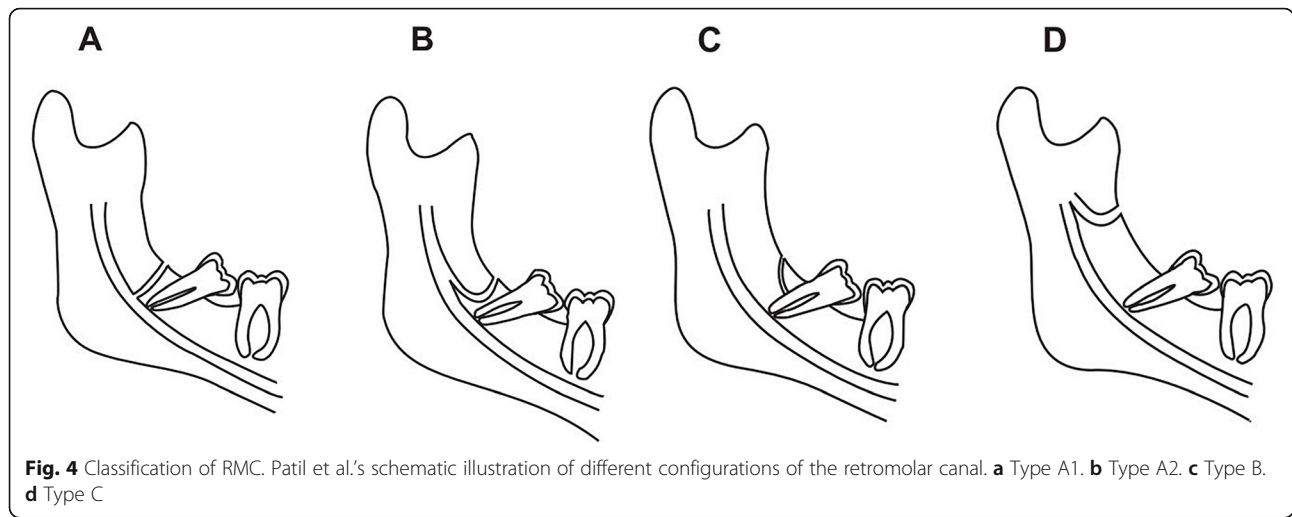

Fig. 3 Linear measurements between the MF and RMF in anteroposterior and mediolateral directions. **a** Axial cut showing the red arrows pointing to the sagittal plane reference line, the green arrow to the MF, and the blue arrow to the lingula. (1) Line drawn from the middle of the RMF perpendicular to the sagittal plane reference line. (2) Line drawn from the middle of the MF perpendicular to the sagittal plane reference line. The linear measurement between the RMF and MF in anteroposterior direction is 15.4 mm. **b** Axial cut showing the red arrows pointing to the sagittal plane reference line. (1) Line drawn from the middle of the RMF parallel to the sagittal plane reference line. (2) Line drawn from the middle of the MF parallel to the sagittal plane reference line. The linear measurement between the RMF and MF in mediolateral direction is 3.79 mm

Fig. 4 Classification of RMC. Patil et al.'s schematic illustration of different configurations of the retromolar canal. **a** Type A1. **b** Type A2. **c** Type B. **d** Type C

with Sabban et al. who evaluated the linear measurements at implant sites using the said software [30].

Previous osseous studies of dry mandibles or cadavers were done on different populations investigating the presence of RMF. These studies showed an incidence rate ranging from 3.2 to 72% [11, 17]. This wide range may be attributed to the lack of 3D visualization of the canal system. These studies were not associated with any RMC classification, as these studies only examined the bony surface without sectioning, and therefore, it can be postulated that some of these foramina were not connected to the RMCs.

It is quite obvious that there is a vast difference between the incidence rate reported in panoramic studies due to the limitation of being a 2D modality and CBCT studies; several studies have reclaimed incidence rates of 3–8% [14, 23, 28] and 7.3–75.4% [5, 27] in panoramic and CBCT studies, respectively. 11.2% was reported in this study which falls in the range of the previously reported studies.

Many studies have been done on the Japanese and Korean populations using CBCT with incidence rate ranging from 25.4 to 75.4% [5, 12, 31] and 8.5 to 17.4% [21, 32, 33], respectively; this wide range of incidence rate can be explained by many factors like the ethnic, genetic, and environmental factors [11, 34].

The wide range of incidence rate of RMC in different studies can be attributed also to the sample size difference in each study and the inclusion and exclusion criteria; a study with large sample size 300 CBCT scans which was done on the Brazilian population showed an incidence rate of 5 % only [27], while the study done on 84 CBCT scans only of the Chilean population showed an incidence rate of 23.8% [35].

Some researchers found a notably higher incidence rate than that found in this current study. For instance, Kawai et al. found a prevalence rate of 52% among the Japanese population [12]. Patil et al. found a prevalence rate of 75.4% as well [5]. This may be attributed to the smaller voxel size used in these studies, which was 0.1 mm and 0.08 mm, respectively. On the other hand, Han and Hwang found an incidence rate of 8.5% when using a 0.38-mm voxel size [21]. Thus, the voxel size of CBCT scans examined affects the quality of the image; a smaller voxel size allows the visualization of much narrower canals therefore affecting the incidence rate in each study [5, 11, 21].

Freitas et al. used a voxel size of 0.25 mm using an i-CAT CBCT Scanner in a protocol similar to ours and showed a comparable result of 7.33% incidence rate in the Brazilian population [27]. Also, a recent study done on the Turkish population showed comparable results [36, 37].

Although the number of RMCs found in males was greater than that found in females, there was no significant difference in gender, which agrees with the findings of Patil et al., Sawyer and Kiely, and Pyle et al. [5, 38, 39].

Table 1 Incidence of RMC according to number of patients

	Sex				Total		χ^2 value	χ^2 sig	Fisher's exact test
	Male		Female						
	No.	%	No.	%	No.	%			
Absence	91	42.5	99	46.3	**190**	**88.8**	.336	.562	.666
Presence	13	6.1	11	5.1	**24**	**11.2**			
Total	**104**	**48.6**	**110**	**51.4**	**214**	**100.0**			

Table 2 Incidence of RMC according to the number of sides

	Sex				Total		χ^2 value	χ^2 sig	Fisher's exact test
	Male		Female						
	No.	%	No.	%	No.	%			
Absence	191	44.6	207	48.4	**398**	**93.0**	.841	.359	.449
Presence	17	4.0	13	3.0	**30**	**7.0**			
Total	**208**	**48.6**	**220**	**51.4**	**428**	**100.0**			

Table 3 The distribution of canal type presence in each side

Side		Canal types					Total	χ^2 value	χ^2 sig
		Type A1	Type A2	Type A	Type B	Type C			
Left	**N**	7	6	13	2	1	**16**	1.210	.876
	%	1.635%	1.401%	3.036%	0.47%	0.234%	**3.74%**		
Right	**N**	7	3	10	3	1	**14**		
	%	1.635%	0.7%	2.335%	0.7%	0.23%	**3.26%**		
Total	**N**	**14**	**9**	**23**	**5**	**2**	30		
	%	**3.27%**	**2.1%**	**5.37%**	**1.16%**	**0.47%**	7.0%		

The number of unilateral canals was found to be greater than that of the bilateral canals, the majority of which were found in the left side of the mandible. However, there was no significant difference which also agrees with the findings of Patil et al., von Arx et al., and Sagne et al. [5, 14, 40].

In this study, we have adopted Patil et al.'s system for the classification of RMCs [5]. We found it to be the most convenient classification. Ossenberg's [11], Park's [41], and Jamalpour et al.'s [41] classifications did not include the canal type which starts from the RMF and ends in the radicular portion of the 3rd molar.

According to the course of the canals, the most common type in our study was type A (23/30), followed by type B (5/30), and type C was the rarest type with only 2/30. These results are different from Patil et al.'s study that found type B to be the most common. This can be explained by the voxel size used in their study (0.08 mm) which allowed them to investigate much narrower canals, and most of the type B canals in Patil et al.'s study are of very small diameter [5].

Regarding linear measurements, the present study found the distance between the RMF and the distal surface of the second molar to be 14.70 ± 5.07, which was comparable to the results of Han et al. who found the distance to be 14.08 ± 3.85, von Arx et al. who found the distance to be 15.16 ± 2.39 mm, and Park et al. who found the distance to be 12.1 ± 3.3 mm [14, 15, 21]. Park et al. and Ogawa et al. found the distance between the RMF and the third molar to be 5.8 ± 3.6 mm and 5.5 ± 2.1, respectively, which are not much different from our findings of 4.26 ± 4.21 mm [15, 42].

Table 4 Incidence of RMC in each side

	Side				Total		χ^2 value	χ^2 sig	Fisher's exact test
	Left		Right						
	No.	%	No.	%	No.	%			
Absence	198	46.3	200	46.7	**398**	**93.0**	.143	.705	.850
Presence	16	3.7	14	3.3	**30**	**7.0**			
Total	**214**	**50.0**	**214**	**50.0**	**428**	**100.0**			

Table 5 Description of the different linear measurements of retromolar canals

Category	Total
A-P from RMF to MF	15.69 ± 3.43 (8.26–22.94)
M-L from RMF to MF	2.62 ± 1.60 (.38–6.80)
A-P from RMF to 3rd molar	4.26 ± 4.21 (.00–12.09)
A-P from RMF to 2nd molar	14.70 ± 5.07 (.00–23.70)

This study has the merits of being the first study done to investigate the RMC and RMF in the Egyptian population and highlight the incidence rate and the importance of knowing such abnormality; also, these measurements may aid the clinician to better localize the RMF in various clinical procedures. Thus, the 2nd and 3rd molars can be used as anatomical landmarks, hence saving the surgeon from the complication of damaging the retromolar nerve and its associated morbidity.

This study has the limitation of using a relatively large voxel size 0.25 mm which did not allow us to observe and investigate canals narrower than 0.5 mm; also, all data was collected from the Faculty of Dentistry of Ain Shams University located in Cairo governate and so the DICOM data investigated may not represent the whole Egyptian population.

Conclusion

The incidence rate of the RMC in the Egyptian population represents 11.2%.

The use of CBCT is quite important in the evaluation of the retromolar area to visualize the presence of the RMC or RMF and avoid the complications occurring due to different dental surgical procedures performed in the aforementioned site.

Authors' contributions
MS examined all the CBCT scans, recorded the presence of the RMC or RMF, and did the linear measurements. FM performed the second examination of the CBCT scans and wrote the primary manuscript. WM was the major contributor in writing and editing the manuscript. All authors read and approved the final manuscript.

results PDF file: https://drive.google.com/open?id=1FbQIJXA5Ste-5W71JAjsNQbMJj590HwK.

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