Mandibular Retromolar Foramen and Canal - A Systematic Review and Meta-Analysis

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Abstract

Introduction: The retromolar fossa is a small triangular area posterolateral to 3rd molar region in the mandible. The retromolar fossa often contains the retromolar foramen (RMF) as an anatomical variant. When the RMF is present, the foramen is connected with the mandibular canal (MC) through another canal known as the retromolar canal (RMC). RMC contains neurovascular bundle, which gives additional supply to the mandible. Although few studies have been conducted in past, a lacunae in comprehensive review is lacking. Although, these variations posed challenging situations for the practicing surgeons, they have been quite neglected and not well presented in textbooks. Hence, we made an attempt to provide a comprehensive and consolidated review regarding RMF and RMC. Materials and Methods: The relevant articles were selected by hand search and electronic media (Google scholar, PubMed, Science Direct, Medline, Embase and Cochrane) from 1987 to 2019. All the relevant articles were properly screened and findings were extracted from the articles. Results: There seems to be wide variations in morphology and morphometry of RMF and RMC. Discussion: Detailed knowledge of these anatomical variations is important in surgical procedure involving the retromolar area to protect the patient from complications such as unexpected bleeding, hematoma formation, and nerve damage. Furthermore, its knowledge makes us understand about the failed inferior alveolar nerve block, spread of infection, and metastasis in case of carcinoma. When there is any suspicious alteration in the MC, we suggest more accurate examination technique like CBCT.

Keywords: Accessory foramina, anatomical variation, mandible, retromolar canal, retromolar foramen

INTRODUCTION

The morphological changes that happen over the years in the mandible imply alterations in the positioning of the structures located in the mandibular rami, such as the mandibular foramen, condylar process, and coronoid process, as well as in the mandibular body, such as the path of the mandibular canal (MC) and the position of the mental foramen. Likewise, accessory foramina and canals will follow these changes. Therefore, it is important that we all should have this knowledge to carry out the necessary adjustments for the anesthetic and surgical procedures.[1]

The retromolar fossa, a triangular depressed area present posterolateral to the mandibular 3rd molar contains retromolar foramen (RMF) and retromolar canal (RMC), as an anatomical variation in the mandible. The boundary of retromolar fossa is formed anteriorly by 3rd molar, medially by temporal crest and laterally by the anterior border of ramus.[2-5] [Figure 1]. The cribrose triangular surface just posterior to mandibular 3rd molar is known as retromolar triangle. The RMC normally arises from the MC, behind the 3rd molar tooth.[6] It travels anterosuperiorly to the RMF which is located within or around the retromolar fossa.[2,7] Although, RMF and RMC posed challenging situations for the practicing surgeons, they have been quite neglected and not well presented in textbooks. Hence, we made an attempt to provide a comprehensive and consolidated review regarding RMF and RMC.

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Furthermore, the artery from the RMC mentioned that the diameter of nerve bundles varied between fibers and a little amount of adipose tissue. A recent study has revealed that the canal has a neurovascular bundle which is found to contain predominantly thin myelinated nerve fibers and a little amount of adipose tissue. A recent study has shown that the diameter of nerve bundles varied between 40-60 μ, the larger ones ranged from 80 to 180 μ. The largest arteriole had a diameter of a maximum of 600 μ. Along with nerve fibers and arterioles, there are numerous venules accompanying those arteries.

**Importance of the retromolar foramen and the retromolar canal**

Neurovascular structures pass through RMC gives additional supply to mandibular molars, buccal area, posterior part of alveolar process of mandible, mucosa over retromolar fossa and also sometimes to temporalis muscle and buccinators muscle. Furthermore, the artery from the RMC anastomose with the branches of buccal artery and facial artery after arising from the MC.

It has been observed that the neurovascular bundle of foramen originated in the MC. High incidence of RMC is due to genetic crossbreeding of European individuals with Aboriginal Argentineans. Penetration of the neurovascular bundle into distal lamina dura of the distal root of the 3rd molar has been noted. Clinician should be aware of this accessory innervation provided by RMC in the endodontic treatment. Postoperative hematomas caused by damage to the contents of canal and foramen during a surgical procedure or implantation should be kept in mind. The presence of RMC which was crossed by additional sensory fibers reported. The presence of this foramen can be the reason to the failed analgesia with the classical anesthetic techniques. Thus, detailed study of RMF is important to avoid failure in regional anesthetic techniques for blocking the inferior alveolar nerve and buccal nerve fibers. Singh, during surgery of a 3rd molar, injured a nerve that crossed an unusual foramen located in the retromolar fossa. After the surgery, it was found that the patient presented paresthesia of the buccal mucosa from the retromolar region until the canine on the operated side. They have conducted many tests and found out that the nerve injured was a branch of the buccal nerve passing by foramen. Anderson et al. confirmed that the components in the RMF and canal are the nerves that provide innervation to the pulp of 3rd molar, retromolar region and to the fibers of the temporalis and buccinator muscles. Damage to nerves of canal will have huge impact on the functions of temporalis and buccinator muscles. Pinsolle et al. suggested that because the RMC also allow the passage of vascular components, may facilitate the spread of infection and metastases from the oropharynx. During surgery of 3rd molar extraction or sagittal osteotomies of the mandible, neurovascular bundle may get disturbed and cause bleeding if injured. These neurovascular elements may be injured in the dieresis procedures, flap lifting, bone tissue for autologous bone grafts, osteotomy for the surgical extraction of mandibular 3rd molars, placement of osseo-integrated implants for orthodontic or during the division of the mandibular ramus in the sagittal split osteotomy surgery. The lesion of the vascular component of the RMC during insertion of surgical implants is reported. Many authors have confirmed the contents of the canal with histochemical staining’s and histological quantifications.
Location of the retromolar foramen
The RMF is found in the retromolar fossa above the occlusal plane and below the coronoid process of the ramus. The retromolar area is bounded by the external oblique ridge, the attachment of the pterygomandibular raphe and the last molar in the mandible. The histological analysis determined that the retromolar nerve extends from the anterior border of the ramus and continues to the buccal gingival of up to two teeth anteriorly in the 1st molar region. Potu et al. found that RMF is located mostly in the medial aspect of the retromolar fossa, proximal to the lingula. According to Truong et al., some cases, particularly in RMCs with a large diameter (>1 mm), were positioned more anteriorly. Rarely, in cases with large diameters, the RMF was positioned in the anterior temporal crest of the coronoid process.

Age and the retromolar foramen
Capote et al. found no significant difference in the presence of RMF based on age. Higher occurrence rate in adolescent cohort has been found by Ossenberg and can be correlated with increased nutrient requirements related to the adolescent growth spurt and eruption of the wisdom tooth. Furthermore, the preferential distribution of the nerve that runs through the RMC on the temporalis tendon may relate to the adolescent peak of RMF and increased masticatory strength.

Gender and the retromolar foramen
Higher occurrence rate in male than female. However, some studies have also shown higher occurrence rate in female than male. The bilateral occurrence of RMF is found to be also higher in females. Overall, as such there is no gender predilection. Overall, as such there is no gender predilection.

Number of the retromolar foramen
Generally RMF is single on each side. Alves et al. have reported one case with bilateral double RMF and one case of double left RMF. He et al. have reported triple RMF. Diameters of the RMF were 0.8 mm, 1.0 mm and, 1.1 mm respectively. Distance from distal edge of the 3rd molar was measured as 4.0 m, 3.6 mm, and 0.5 mm respectively.

Side prevalence of the retromolar foramen
Many studies have different opinion. RMF in more common in the right side of the mandibles. In general, there is no side predilection. Unilateral RMF is more common than bilateral but the ratio of bilateral to unilateral increases with the population incidence.

Diameter of the retromolar foramen
The diameter of RMF has been reported to range from 0.2 mm to 3.29 mm. Males have been reported to have larger diameters of RMF, which can be explained by the fact that male mandibles are usually larger than females. Malik et al. had concluded that the mean diameter of the RMF is 1.01 mm.

Distance of the retromolar foramen from teeth
The reported distances between RMF and the distal edge of the 3rd molar were between 4.23 mm and 10.5 mm. The reported distances between the RMF and the distal edge of the second molar were between 11.91 mm and 16.8 mm. These values suggest that the locations of RMF are not constant.

Von Arx et al. by his study had shown that age can be a significant factor for the horizontal distance between the RMF and the 2nd molar, with younger patients having a longer distance. It can be speculated that the presence of 3rd molar in younger patients maintains a larger distance between the RMC and 2nd molar. In older patients, whose 3rd molars have been removed, the 2nd molar might move slightly or tip distally, reducing the distance.

The position of RMF is nearer to mandibular 3rd molar region in right side in comparison to the left side. However, some author have proved that the RMF on the right side of
the mandible was overall found to be positioned further distally in the retromolar region than on the left side of the mandible. So overall, it may be dependent on the age and development.

**Correlation with other anatomical variation**

A statistical correlation was made between the occurrence of the RMF and accessory mandibular foramen, accessory mental foramen, mandibular 3rd molar and three rooted mandibular 1st molar. Only the accessory mandibular foramen showed a significant positive correlation with the RMF of the same side. That means when an accessory mandibular foramen is present, there is high chance of having horizontal bony canal leading to a foramen in retromolar fossa. The bony canal could be the temporal crest canal that was first described by Ossenberg in 1986.

### Table 1: Different studies of morphometric analysis of retromolar foramen and retromolar canal in different population

| Population    | Author            | Year of study | Type of study       | Number of mandibles studied | Incidence (%) | Diameter of RMF (mm) | Distance from 3rd molar (mm) | Distance from 2nd molar (mm) | Mean length of RMC (mm) | Mean width of RMC (mm) |
|---------------|-------------------|---------------|---------------------|-----------------------------|---------------|----------------------|-----------------------------|---------------------------|------------------------|------------------------|
| Indian        | Priya et al.      | 1999          | Dry mandible        | 475                         | 7.8           | -                    | -                           | -                         | -                      | -                      |
|               | Narayana et al.   | 2002          | Dry mandible        | 242                         | 21.9          | -                    | -                           | -                         | -                      | 2.4                    |
|               | Athavale et al.   | 2013          | Dry mandible        | 71                          | 14.1          | -                    | -                           | -                         | -                      | -                      |
|               | Gupta et al.      | 2013          | Dry mandible        | 50                          | 18            | -                    | -                           | -                         | -                      | -                      |
|               | Akhtar et al.     | 2014          | Dry mandible        | 224                         | 14.7          | -                    | 5.88                        | -                         | -                      | -                      |
|               | Hosaptna et al.   | 2014          | Dry mandible        | 50                          | 6             | -                    | -                           | -                         | -                      | -                      |
|               | Potta et al.      | 2014          | Dry mandible        | 94                          | 11.7          | -                    | 6.21                        | -                         | -                      | -                      |
|               | Malik et al.      | 2018          | Dry mandible        | 72                          | -             | -                    | -                           | -                         | -                      | -                      |
|               | Narayana et al.   | 2019          | Dry mandible        | 242                         | 21.9          | -                    | -                           | -                         | -                      | 14.5                   |
| Korean        | Park MK et al.    | 2014          | Dry mandible        | 154                         | 93.5          | -                    | -                           | -                         | -                      | -                      |
|               | Kang et al.       | 2014          | CBCT                | 1933                        | 5.4           | 1.36                 | -                           | -                         | -                      | -                      |
|               | Rashisuren et al. | 2014          | CBCT                | 500                         | 17.4          | 2.2                  | -                           | -                         | -                      | -                      |
|               | Han and Hawang    | 2014          | CBCT                | 446                         | 8.5           | -                    | 14.08                       | -                         | -                      | -                      |
| Turkish       | Bilecenoglu et al.| 2006          | Dry mandible        | 40                          | 25            | -                    | 4.23                        | 11.91                     | -                      | -                      |
|               | Orhan et al.      | 2011          | CBCT (Child)        | 242                         | 28.10         | -                    | -                           | -                         | 13.5                   | -                      |
|               | Orhan et al.      | 2013          | CBCT                | 126                         | 11.1          | -                    | -                           | -                         | -                      | -                      |
| Brazilian     | Suazo et al.      | 2008          | Dry mandible        | 294                         | 12.9          | -                    | -                           | -                         | -                      | -                      |
|               | Rossi et al.      | 2012          | Dry mandible        | 222                         | 26.6          | -                    | -                           | -                         | -                      | -                      |
|               | Motta Junior et al.| 2012        | Dry mandible        | 35                          | 17            | -                    | 8.99                        | -                         | -                      | -                      |
|               | Capote et al.     | 2015          | OPG (Child and adult)| 500                        | 8.8           | -                    | -                           | -                         | 13.5                   | 1.41                   |
| Japanese      | Ossenberg         | 1987          | Dry mandible        | 94                          | 3.2           | -                    | -                           | -                         | -                      | -                      |
|               | Kodera and Hashimoto| 1995       | Dry mandible        | 41                          | 20            | -                    | 13                          | -                         | -                      | -                      |
|               | Naitoh et al.     | 2010          | CBCT                | 122                         | 25.4          | -                    | -                           | -                         | 14.8                   | -                      |
|               | Kawai et al.      | 2012          | CBCT                | 46                          | 52            | -                    | 14.4                        | -                         | -                      | -                      |
|               | Ogawa et al.      | 2016          | CBCT                | 319                         | 28            | 0.9                  | 5.5                         | -                         | -                      | -                      |
| Swiss         | Von Arx et al.    | 2011          | CBCT, OPG           | 121                         | 25.6          | 0.99                 | 15.16                       | 11.34                     | 0.99                   | -                      |
|               | Fito et al.       | 2015          | CBCT                | 680                         | 16.1          | 1.03                 | 15.10                       | -                         | -                      | -                      |
| American      | Sawyer and Kiely  | 1991          | Dry mandible        | 234                         | 7.7           | -                    | -                           | -                         | -                      | -                      |
| Eskimos       | Ossenberg         | 1987          | Dry mandible        | 485                         | 8.2           | -                    | -                           | -                         | -                      | -                      |
| Caucasian     | Pyle et al.       | 1999          | Dry mandible        | 475                         | 7.8           | -                    | -                           | -                         | -                      | -                      |
| Argentinean   | Schejman et al.   | 1967          | Cadaveric           | 18                          | 72            | -                    | 10.5                        | -                         | -                      | -                      |
|               | Lagrana et al.    | 2006          | Dry mandible        | 50                          | 18            | -                    | -                           | -                         | -                      | -                      |
| Italian       | Lizio et al.      | 2012          | CBCT                | 233                         | 14.6          | -                    | -                           | -                         | -                      | -                      |
| South African | Gamieldien et al.| 2016          | Dry mandible        | 885                         | 8             | -                    | 10.5                        | 16.8                      | -                      | -                      |

RMF = Retromolar foramen, RMC = Retromolar canal, CBCT = Cone beam computed tomography, OPG = Panoramic radiograph
Types of the retromolar canal
Ossenberg gave the first description of the types of retromolar canal based on its course [Figure 2]. On panoramic radiographic evaluation, RMC has been classified into five types according to course and morphology [Figure 3].

The most common appearance of the canal corresponded to type A (vertical course), whereas type C (horizontal course) occurred least often.

On CT scan evaluation RMC can be classified into three types based on course and morphology [Figure 4].

The RMC is a type 1 bifidity of the MC. A bifid MC (BMC) is an anatomical variation wherein the MC divides into two parts. Each branch may carry its own neurovascular bundle. It is suggested that bifid and trifid MCs occur due to incomplete fusion of separate MC nerves from the incisors, primary molars, and permanent molars during embryonic development. The bifidity may be classified by its course. A type 1 bifidity is a unilateral or bilateral transverse bifidity. A type 2 bifidity is unilateral or bilateral and is limited to the ramus or body of the mandible. A type 3 bifidity is a combination of type 1 and type 2, thus it is a transverse and horizontal bifidity.

The most common variation of the RMC is a branch of the MC below the 3rd molar. The nerve travels in a posterosuperior direction and opens in the retromolar fossa those posterior to the 3rd molar. The second variation of the RMC opens in an anterior direction and the branches of the inferior alveolar nerve (IAN) as it enters the MC. The third and rarer variation of the RMC splits from a more proximal branch of the MC and enters the bone through a canal at the temporal crest, exiting anteriorly through the RMC.

Narayana et al. have observed that foramen opens upwards and backwards with a posterior smooth surface indicating the entry of the neurovascular bundle from the posterior aspect.

Length of the retromolar canal
It has been shown that men have longer RMCs than women. This difference is not necessarily explained by the fact that men have an overall greater height of the mandible in the retromolar area, because the length of the canal was determined as the distance from the MC to the RMF. Hence, the length of the RMC is dependent on the location of the MC within the mandible.

Orhan et al. have reported 13.5 mm is the mean length of RMC. In addition, Naitoh et al. have reported mean length of the RMC 14.8 mm.

Another important aspect of these canals is that they vary considerably in their morphology, especially in their length, indicating that they could form the variable relation to the dental alveoli.

Frequency of retromolar foramen and canal
The frequency of RMF as reported by the cone beam computed tomography (CBCT) studies ranges from 5.4% to 75.4%. The frequency of RMF reported by human dry mandible studies ranges from 3.2% to 72%. The frequency of RMF as reported by the panoramic studies ranges from 3.06% to 8.8%. This large range can be attributed to several factors, including ethnic differences, environmental and genetic factors, and variation in type and sample sizes across studies.

However, studies have suggested that RMF and RMCs are normal anatomical variations of the IAN, rather than anomalies.

The RMF was found to occur more commonly in native populations of North America than in the other populations such as Africa, Europe, India, and Northeast India.

Conclusion
RMC is often treated as a subtype of BMC. It is generally very narrow so it is difficult to detect it on panoramic radiographs. In addition, because the images in the retromolar region overlap the shadow of the opposite side of mandible and other soft tissues, the detailed status of RMC and RMF may be difficult to depict on panoramic radiograph. Hence, high resolution CBCT images are very useful to know the prevalence of these anatomical variations. It remains unknown, how the RMC develops in the mandible, so there is need of further studies to understand its origin and evolutionary importance. RMC and RMF have great importance in the odontostomatological practice due to prevalence of the pathological processes and complications related to retromolar area involved in the practice. Hence, they are not rare anatomical structure and practitioner should not neglect it and have to take these into account in all anesthetic and surgical procedures involving the retromolar region to prevent possible complications such as failed anesthesia, paresthesia, excessive bleeding or traumatic neuroma. When there is any suspicious alteration in the MC, we suggest the indication of more accurate examination technique like CBCT.

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Conflicts of interest
There are no conflicts of interest.

References
1. Capote TS, Gonçalves Mde A, Campos JÁ. Retromolar canal associated with age, side, sex, bifid mandibular canal, and accessory mental foramen in panoramic radiographs of Brazilians. Anat Res Int 2015;2015:1-8.
2. Park MK, Jung W, Bae JH, Kwak HH. Anatomical and radiographic study of the mandibular retromolar canal. J Dent Sci 2016;11:370-6.
3. Truong MK, He P, Adeeb N, Oskouian RJ, Tubbs RS, Iwanaga J. Clinical anatomy and significance of the retromolar foramina and their canals: A literature review. Cureus 2017;9:e1781.
4. Potu BK, Kumar V, Salem AH, Abu-Hijleh M. Occurrence of the retromolar foramen in dry mandible of South-Eastern part of India.
A morphological study with review of the literature. Anat Res Int 2014;2014:1-5.
5. Freitas GB de, Freitas E Silva A de, Manhães Júnior LRC. The prevalence of mandibular retromolar canals on cone beam computed tomography and its clinical repercussions. Rev Odontol 2017;46:158-63.
6. Akhtar J, Parveen S, Madhukar PK, Fatima N, Kumar A, Kumar B, et al. A morphological study of retromolar foramen and canal in Indian dried mandibles. J Evolut Med Dent Sci 2014;58:13142-51.
7. Ossenberg NS. Retromolar foramen of the human mandible. Am J Phys Anthropol 1987;73:119-28.
8. Kumar Potu B, Jagadeesan S, Bhat KM, Rao Sirasanagandla S. Retromolar foramen and canal: A comprehensive review on its anatomy and clinical applications. Morphologie 2013;97:31-7.
9. Kawai T, Asaumi R, Sato I, Kumazawa Y, Yosue T. Observation of the retromolar foramen and canal of the mandible: A C.B.C.T. and macroscopic study. Oral Radiol 2012;28:10-4.
10. Von Arx T, Hanni A, Sendi P, Buser D, Bornstein MM. Radiographic study of the mandibular retromolar canal: An anatomic structure with clinical importance. J Endod 2011;37:1630-5.
11. Shikha Malik, Sunita, Alok Choudhary. Clinical and anatomical study of retromolar foramen on adult dry mandible in Uttarakhand region in India. Int J Cur Res Rev 2018;10:5-7.
12. Gamieldien MY, Van Schoor A. Retromolar foramen: An anatomical study with clinical considerations. Br J Oral Maxillofac Surg 2016;54:784-7.
13. He P, Iwanaga J, Truong MK, Adeeb N, Tubbs RS, Yamaki KI. First report of tripled retromolar foramina. Cureus 2017;9:e1440.
14. Gabra JN, Kim DH, Li ZM. Elliptical morphology of the carpal tunnel cross section. Eur J Anat 2015;19:49-56.