ORIGINAL ARTICLE

A study of the morphology of retromolar, mandibular, and accessory mandibular foramen in dry mandibles belonging to the Southern part of Karnataka state and their clinical significance

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Abstract

Background: Variations in osteological features are not uncommon; the mandible bone is one such paramount component of the facial skeleton fostering lower dentures, blood vessels, nerves, muscles, and ligaments for their structural and functional stability possessing numerous osteological features which tend to show variations in its anatomical presentations. *Aim and Objectives*: To study the morphology of retromolar, mandibular, and accessory mandibular foramen in dry mandibles belonging to the Southern part of Karnataka state and their clinical significance. *Material and Methods*: One hundred and twelve mandibles of either sex were used to study the retromolar region, accessory mandibular foramen along with the pattern of the mandibular canal. Morphometric measurements of these bony features were taken by using a digital caliper. Measurements of the exact anatomical location of the above-mentioned bony features were subjected to statistical analysis and results were expressed (millimeters) in terms of percentage, and mean +/- standard deviation. *Results:* Retromolar foramen was found in 25%; their bilateral and unilateral existence were found at 4.5% and 20.5% respectively. Accessory mandibular foramen was found in 30.4% of specimens. It was located in posterior and posterosuperior relation with mandibular foramen opening in 4.5% and 8% of specimens respectively. The unusual bifurcation of mandibular foramen was found in 3% of specimens. *Conclusion:* The occurrence of uncommon features like retromolar foramen, accessory mandibular foramen, and split mandibular foramen and their occupancy with aberrant neurovascular channels and their relations with other bony features play an important role in several dental surgical and oromaxillary procedures including prosthetic rehabilitation.

Keywords: Morphometry, Oromaxillary, Osteology, Prosthetic

Introduction

During the embryonic period, the formation of foramina or canals in the mandible bone with its subsequent stages of growth and development gives provision to create a definitive and uniform morphological pattern to synchronize with the invasion of developing neurovascular channels. This process may be influenced by a subtle change in molecular events which may give rise to a slightly diversified pattern of mandibular features with occasional variations. The mandible is presented with uncommon features like Retromolar Foramen (RMF) or Retromolar Canal (RMC) which may become the sites through which neurovascular structures can travel, or it could be the site through which infections can spread to the distal areas [1]. The features like Accessory Mandibular Foramen (AMF) and the pattern of mandibular foremen variations were some uncommon presentations noticed in earlier studies.

The RMF is an inconstant feature that occupies the region of the Retromolar Trigone (RMT); latter is a small triangular region with a slightly depressed bony surface located behind the last molar tooth, and in front of the bifurcated temporal crest, which is covered by the gingival mucosa. The retromolar fossa is presented in various morphological patterns with or without retromolar foramen in different mandibles. The anatomy of such infrequent features is well-demarcated under advanced radiological findings [2]. Topography of unusual bony features presenting with neurovascular structures is important from the point of inferior alveolar nerve block, third molar tooth extraction, bleeding control, dental implantation, mandibular reconstruction, and several surgical manipulations to avoid minor or major complications [3]. Based on the diversity of the above-mentioned uncommon presentation of bony features, we conducted this study with the aim to study the morphology of retromolar, mandibular, and accessory mandibular foramen in dry mandibles of either sex belonging to the south Indian population located in Karnataka state.

Material and Methods

One hundred and twelve mandible bones of either sex were procured from the Anatomy department museum, JSS Medical College, and Mysuru Medical College, Mysuru. The mandibles with existing third molar teeth/sockets were included and mandibles with extensive degenerative changes were excluded. The retromolar region of the mandible was inspected for its external appearance, and later presence of the RMF, pattern of mandibular foramen, and AMF were noted. By using a digital vernier caliper, various bony landmarks were considered to scale (all in millimeters) the exact placement / location of the above-mentioned features [4]. Under the beam of light, the mandibular foramen was observed for any bifid pattern of the mandibular canal [5]. All measurements were recorded by two individuals separately, and the average was taken for analysis. This was a cross sectional study conducted over a period of 6 months. Mandibles were procured from the above mentioned institutes through convenience sampling method. Ethical approval was obtained from the Institutional Ethics Committee (Registration ECR/387/Inst/KA/ 2013/ RR-19).

Statistical analysis

Data were entered in an excel sheet followed by statistical analysis using SPSS version 22. Frequencies, percentages, arithmetic Mean and Standard Deviation (SD) were calculated. A comparison of the distance between the two sides was done using the independent sample t-test.

Results

The study was conducted on 112 specimens, and we observed RF in 28(25%) specimens. Among that, RMF was present bilaterally in 5(17.9%) specimens, on the right side of the mandible in 12(42.8%) specimens, and on the left side in 11(17.9%) specimens. Also, a single RMF was observed in 26(23.22%) specimens, while two and four foramina were observed in 1(0.89%) specimen each. In 112 specimens, we observed the accessory foramen in 34(30.4%) specimens, with bilateral presence in 12(35.3%), right sided presence in 14(41.2%), and left sided presence in 8(23.5%) specimens. Also, one accessory foramen was noted in 31(27.6%) specimens and two foramina in 3(2.8%) specimens. Out of 112 mandibles, 109(97.3%) were noted to have a single mandibular canal, but in 3(2.7%) specimens we noted a bifurcated or split mandibular canal.

Table 1: The relation of retromolar foramen location

Distance (In millimeter)	Right side		Left side	
	Range (mm)	Mean±SD (mm)	Range (mm)	Mean±SD (mm)
Third Molar Tooth	0 – 10	4.64±2.66	2 - 11	5.59±3.203
Anterior Border	4 – 11	7.84±1.95	4 - 12	7.49±2.443
Lingula	9 – 23	14.94±3.28	4 - 20	14.56±4.100

Table 2: Accessory mandibular foramen

Accessory foramen	Number	Percentage
Absent	78	69.6
Present	34	30.4
Total	112	100

Table 3: Relation of the mandibular foramen location

Distance (in millimeters)	Ride side		Left side	
	Range (mm)	Mean±SD (mm)	Range (mm)	Mean±SD (mm)
Mandibular notch	9.98 - 28.03	20.1±3.35	10.31 - 25.93	19.08±3.27
Anterior border	11.86 - 24.42	16.55±2.23	13.35 - 24.55	17.43±2.08
Posterior border	7.67 - 19.67	12.38±1.96	7.21 - 18.88	12.58±2.3
Base	8.8 - 34.0	25.04±4.10	16.2 - 33.6	25.83±3.55
Gonion	11.86 - 30.57	21.01±3.76	10.56 - 31.82	21.99±3.7

Discussion

The presentation pattern of RMT in the mandible can vary; in our study the appearance of a RMT pattern was noticed in the form of tapering, triangular, and pear-shaped patterns, which were similar to previously reported findings [6-7]. The location of RMF varied considerably from various anatomical landmarks of the mandible (Table 1). In some mandibles, the RMF was merged with the wall of 3rd molar teeth, which is important from the point of surgical extraction of 3rd molar tooth. Clinically it is important to evaluate the bone degeneration causing the impingement of structures if they are invaded by neurovascular channels, especially in senile patients who are often associated with bone resorption changes.

The existence of RMF laying in the RMT region in our study was found consistent with the observational study findings in the western Iranian populations, showing 22% unilateral (Fig. 1) and 5.5% bilateral (Fig. 2) incidence of the existence of RMF, with male preponderance. They classified various patterns of aberrant nerve branch entry into the existing RMC which is derived from the inferior alveolar nerve which in turn is a branch of the mandibular nerve [1]. There were different patterns in the course of RMCs, showing oblique, straight, or curved course patterns, which were connecting above with the retromolar region, and below with the mandibular canal proper. And in some bones, it was showing connections from the mandibular foramen's inlet to the retromolar region. They were occupied by the retromolar nerve branch, a derivative of the inferior alveolar nerve. Such varying patterns of origin, course, and contents of RMC were studied by using advanced radiological investigations [1]. It is probably indicating a variable branching pattern of retromolar nerve originating from the inferior alveolar nerve.

The aberrant neurovascular branches derived from the inferior alveolar nerve and inferior alveolar artery can traverse through RMC. These neuro-vascular branches will cover an additional larger area of distribution, and they supply the large mucosal surface area around the gingiva, buccal mucosa, and the mucosal lining of the retromolar region and third molar tooth. Such additional innervations may become prone to iatrogenic nerve and blood vessel damage during various surgical procedures including tooth extraction [8]. Uncommon inferior alveolar nerve presentations with their high origin in the infratemporal region, and their aberrant branch communication with lingual nerve, have been reported earlier [9]. Such anatomical variations will be having surgical challenges to meeting optimum anesthetic effects. The incidence of such variations will necessitate the surgeons to adopt an alternate measure to achieve successful pain control by injecting anesthetic drugs at the right spot. Hence adopting a higher level of anesthetic drug delivery into the mandibular nerve branches may be one of the measures to be taken to achieve a successful anesthetic effect in the area distributed through them. The dental surgeon needs to be aware of anatomical nonmetric variants that can exist in a discontinuous pattern.

Cone-beam Computed Tomography (CBCT) is considered one of the most well-distinguishable radiological investigations used to track the existence and extent of such unusual retromolar foramen and the course of the RMC and their contents [10]. Mandible bone is highly focused from the point of subtle variation in its

osteological features and may be found in association with the structural diversity involving the anatomical entities like vessels, nerves, teeth, etc. which is surgically important. It is often a site of an impacted supernumerary tooth found within the mandible, which can be better appreciated under radio diagnostic aid [11]. Such impacted teeth occupying the RMT region embedded posteriorly within the deeper strata of the lower denture portion of the mandible may cause undue complaints with age-advanced changes.

The oral cavity is the paramount site of diversified malignant incidences which accounts for considerable incidences of cancers involving the head and neck region [12]. Especially, malignancies of the RMT often present with squamous cell malignant changes. The retromolar region is clinically an important site with the rare incidence of Basaloid Squamous Cell Carcinoma (BSCC) of the oral cavity. Such malignant transformations can invade the nearby tissues in the oral cavity, and may further spread to the mandible bone or perineural sheath, affecting the inferior alveolar nerve [13-14]. In the case of surgical transplants, the retromolar region of the mandible is an important site for harvesting autologous grafts obtained from this region in building intraoral bone grafts, which can show encouraging surgical outcomes [15]. Clinically, the lower denture is a relatively common site of odontogenic lesions compared to the upper denture contributed by maxillary bone [16]. The mandibular foramen that continues as the mandibular canal is an important surgical landmark and was found to be inconsistent among different populations studied [17]. The variation in the mandibular canal pattern shows an important association with different facial index ratios irrespective of sex, age, and particular side of the bone studied. Hence its knowledge is essential for the success of numerous dental procedures in endodontics, periodontics, pediatric dentistry, and interventions such as orthognathic surgery and implantation [18]. The distance between the location of the mandibular foramen inlet and the length of the surgical needle is a prime factor that needs apt knowledge and surgical accomplishments to reach the nerve properly because the distance of the position of MF varies with the vertical length and breadth of the ramus (Table 3) and also the exact location of MF differs in individuals (Fig. 6).

Some studies have showed disparity in the location of MF on the right and left sides of the mandible. These studies underscored the possibility of uniformity or disparity in the existence of such bony features in the facial skeleton. Such topographical knowledge will ensure the success of the nerve-blocking procedure and other various surgical manipulations. [19]. These findings are consistent with our study findings.

Some studies have shown that the mandible bone presented with a rare bifurcation (split) and trifurcation of mandibular canals [20]. In our study, three of the mandibles had shown bifurcation of the mandibular canal unilaterally (Fig. 7). Such split in the mandibular canal may receive additional neurovascular branches from the nearest neurovascular trunk which likely innervates the additional anatomical structures in the oral cavity. Appropriate radiological investigations may be very helpful in the clinical evaluation of such rare topographical presentations.

The RMC should not be confused with AMF; we have observed several mandibles presented with small accessory openings (Fig. 5) lying at a variable distances from the mandibular canal. The

existence, number, and side of AMF vary considerably with the different bones or sides in the same bone (Table 2). If at all any prominent AMF exists it will be seen lying anterior, posterior, or inferior to the opening of mandibular foramen on the medial aspect of the ramus of the mandible. AMF with an existing nerve branch may lead to failure in achieving the optimum anesthetizing effect. Accessory mandibular foramen may lodge nerve branches from the diversified origin including the facial, mylohyoid, buccal, and transcutaneous nerves. It is important from the point of surgical anatomy [21]. The cadaveric dissection study has shown where such multiple foramina were pierced by arteriovenous branches derived from the maxillary artery and maxillary veins. Surgeons need to consider the clinical anatomy of such innervations from the point of "osteotomy of the mandible" [22]. Such additional vascular innervations in the accessory foramen may be a matter of clinical concern that can disseminate the spread of malignancy to remote areas [23]. Our findings have shown AMF only in 34 specimens of the mandibles (Table2). Among them, it was predominantly seen unilaterally on the right side (Fig. 3), while a few were bilateral (Fig. 4) showing uneven distribution.

In our study, 27.6% of the specimens presented with at least a single AMF. Variations in the presenting osteological features associated with RMF, mandibular foramen, and AMF, along with their neurovascular contents entails that the surgeon needs to perform a thorough preoperative clinical evaluation of the patient before attempting any surgical procedure. The outcome of any study involving bones like mandible is based on the type of population involved, sample size, and the methodology where the involvement of gross dry bones or bone study particularly under radiological aid will substantiate the diversity of features and its possible clinical implications. The RMF may exist as solitary or as multiple openings with or without thorough fair communication. Often these foramina may exist as dead-end path. In our study, such possibilities may be assumed as the limitations involving only dry mandibles.

Figure 1: Mandible picture showing unilateral single retromolar foramen

Figure 2: Bilateral single retromolar foramen

Figure 3: Mandible showing unilateral accessory mandibular foramen

Figure 5: Unilateral multiple accessory mandibular foramen

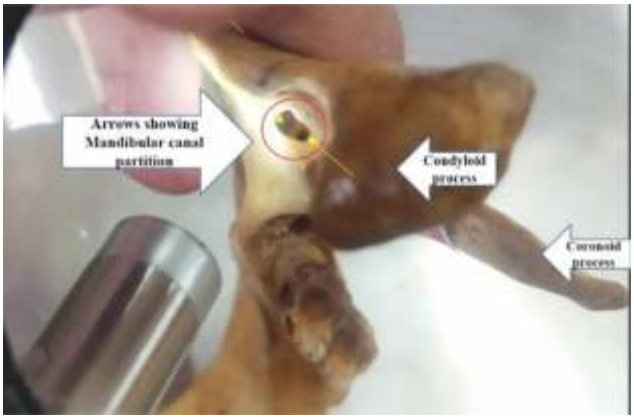

Figure 7: Split mandibular foramen

Figure 4: Mandible showing bilateral accessory mandibular foramen

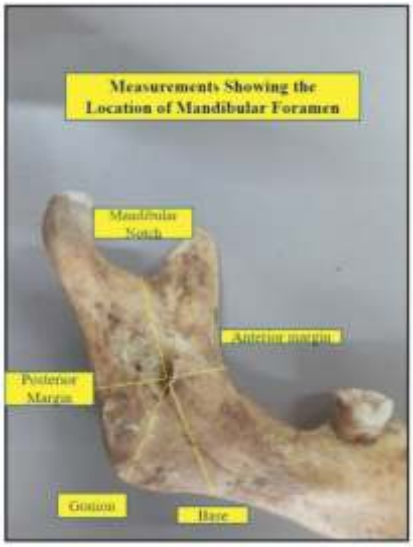

Figure 6:Morphometry of mandibular foramen

Author	Year of study	Number of samples	Place of study
Present study	2022	112, dry mandibles	South Karnataka, India
Pannalal *et al*. [24]	2021	100 patients CBCT	Chhattisgarh, India
Nikkerdar *et al*. [1]	2020	218, dry mandibles	Kermanshah, Iran.
Komarnitki *et al*. [25]	2020	100 patient CBCT	Poland
Park *et al*. [2]	2016	13 dry mandibles, and 50 patients CBCT	South Korea
Potu *et al*. [7]	2014	94, dry mandibles	South-eastern part of Karnataka State, India
Jacob *et al*. [8]	2014	120, dry mandibles	Mangalore, Karnataka
Akhtar *et al*. [26]	2014	224, dry mandibles	Bihar, India
Suazo [6]	2007	66 dry mandibles	Brazil
Narayana *et al*. [27]	2002	242- dry mandibles	South India

Conclusion

Surgical anatomy of the head and neck region is a great challenge in terms of effective surgical handling. Prevalence of variation in the mandible bone with some additional features like RMF, the pattern of the mandibular foramen, and AMF and their neurovascular contents play an important role in effective induction of anaesthesia and bleeding control. Our study underlined the wide anatomical variations in the above-mentioned mandible features in a set of populations studied. Surgeons should be aware of such rare presentations where preoperative clinical evaluation plays an important role; accordingly, it may necessitate an alternate route.

Limitations of the study

Our study has not discriminated against any findings attributing to a particular gender. The set of adult mandibles used in our study may have some bone resorption changes. Our study focused more on the rarity and peculiarity of foramen rather than canals or their contents.

Acknowledgment:

We sincerely acknowledge statistician Mr. Arun Gopi, from the Department of Community Medicine, JSS Medical College, Mysuru for helping us in the statistical analysis of the data.

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How to cite this article:
Shwetha K, Ravishankar MV, Vidya CS, Pushpalatha K, Dakshayani KR. A study of the morphology of retromolar, mandibular, and accessory mandibular foramen in dry mandibles belonging to the Southern part of Karnataka state and their clinical significance. *J Krishna Inst Med Sci Univ* 2022; 11(4):36-45

Submitted: *02-July-2022* ***Accepted:*** *05-Sep-2022* ***Published:*** *01-Oct-2022*