RESEARCH PAPER

A Descriptive Analysis of the Radiographic Evaluation and Classification of Bifid Mandibular Canal Using Panoramic Imaging in Indian Population

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Received: 30th May, 2026; **Revised:** 10th June, 2026; **Accepted:** 15th June, 2026; **Available Online:** 18th June, 2026

ABSTRACT

Introduction

To establish whether bifid mandibular canals (BMCs) and retromolar foramens (RFs) are visible on panoramic radiographs (PANs) and to use cone beam CT (CBCT) to assess their existence and morphologic features.

Methods

Length, height, diameter, angle, and the existence of BMCs were examined in a sample of 225 CBCT exams. Additionally, the RF's diameter was measured. The visibility of the BMCs and RFs was then ascertained by analysing related PANs.

Results

The BMCs were observed on CBCT in 83 out of the 225 patients (36.8%). With respect to gender, statistically significant differences were found in the number of BMCs. There were also significant differences in anatomical characteristics of the types of BMCs. Only 37.8% of the BMCs and 32.5% of the RFs identified on CBCT were also visible on PANs. The diameter had a significant effect on the capability of PANs to visualize BMCs and RFs (B = 0.791, p = 0.035; B = 1.900, p = 0.017, respectively).

Conclusions

PANs are unable to sufficiently identify BMCs and RFs. The diameter of these anatomical landmarks represents a relevant factor for visualization on PANs.

Keywords: Inferior Alveolar Nerve, Cone Beam Computed Tomography, Panoramic Radiography.

How to cite this article: Saha A, Kanchan Malawat P, Singh S, Gulzar A, Sarma SM, Kalantri SS. A Descriptive Analysis of the Radiographic Evaluation and Classification of Bifid Mandibular Canal Using Panoramic Imaging in Indian Population. Int J Drug Deliv Technol. 2026;16(61s):709-713. DOI: 10.25258/ijddt.16.61s.78

Source of support: Nil.

Conflict of interest: None

Introduction

Investigations employing both PANs and CBCT have documented anatomic differences of the mandibular canal.[1,2] Bifid mandibular canals (BMCs) were reported at rates ranging from 0.08% to 8.30% on PAN and from 10% to 66% on CBCT. The retromolar canal, which terminates in the retromolar foramen (RF), is one kind of BMC. While PANs have produced a lower range, CBCT investigations have indicated frequencies of RF between 16% and 65%, which are comparable to dry mandible studies ranging from 1.7% to 72.0%.[3,4,5] There are significant clinical ramifications to identifying these anatomical structures. It might help prevent some of the problems that arise from damaging BMCs during surgery, include paraesthesia, sensory abnormalities, traumatic neuromas, and unexpectedly heavy bleeding. Six Additionally, accurate BMC identification may aid in appropriate anaesthesia planning. The retromolar canal, which is traversed by branches that supply the third molar, the most posterior region of the alveolar process, and the buccal gingival of mandibular premolars and molars, deserves particular attention. A variety of anatomical structures have been reported to arise from the RF, such as the buccal nerve, fibres innervating muscle temporalis and buccinators.[7,8] Because of its accessibility, affordability, and wide field of view, panoramic radiography is still a commonly utilised diagnostic method even though cone-beam computed tomography (CBCT) is thought to be the gold standard for identifying BMCs. However, depending on viewer perception and image quality, anatomical changes may or may not be seen on panoramic photographs.[7,8] This study aimed to determine the prevalence and morphological classification of BMCs using panoramic radiographs in Indian population.

Methodology

The total sample comprised 233 consecutive patients who underwent preliminary CBCT imaging in the Department of Oral and Maxillofacial Surgery at North Bengal Dental College and Hospital between July 2021 and March 2025 for a variety of diagnostic reasons, primarily for planning implants and impacted-tooth extractions. The research's participants provided signed informed consent. The requirements for inclusion were as follows: (i) the CBCT volume had to contain both bilateral mandibular foramens; (ii) individuals had to have a PAN over a year after the CBCT; and (iii) the CBCT voxel size had to be less than 0.3 mm. Individuals with a history of mandibular trauma or mandibular surgery, like orthognathic surgery or inferior alveolar nerve repositioning, were excluded; pathological conditions in the anatomical area, such as osteomyelitis, fibrous dysplasia, tumours, or cysts, were excluded; and any artefacts or blurring resulting from patient movements that affected the quality of the image were excluded.

A CBCT equipment equipped with an amorphous silicon flat panel image detector produced the CBCT images. The patient location and exposure acquisition parameters for each image was as follows: an occlusal plane parallel to the floor base, a tube voltage of 120 kVp, current of 5 mAs, and 14.7 s. Orthophos® DS with a digital charge-coupled device line sensor was used for PANs. With a focus/sensor range of 497 mm, the exposure parameters were set at 80 kVp, 7 mAs, and 14.1 s. A computed radiography system was used for processing PANs. The PANs accepted for the survey met the following criteria: (i) free from any radiolucident or radiopaque lesion in the mandible; (ii) no evidence of current or past jaw fractures; and (iii) devoid of any radiographic exposure or processing artefacts.

Two competent investigators collaborated to examine multiplanar models from CBCT to find any inferior alveolar canal branching in the region between the mandibular foramen and 30 mm from the anterior border of the mandibular ramus. For this reason, i-CAT software was used to reconstitute digital imagery and communications in medical files on a computer. The thickness of the CBCT slice was less than 0.3 mm. Five varieties of BMCs were identified: type I, retromolar canal; type II, dental canal; type III, forward canal; type IV, buccolingual canal; and type V, superior canal. In the mandibular ramus region, the retromolar canal split off from the inferior mandibular canal and travelled upward to the retromolar region. Reaching its end in the root apex of the second or third molars, the dental canal extended forwards. Whether or not it joined the inferior alveolar canal, the forward canal flowed to the front. Since its origin, the buccolingual canals developed in a lingual or buccal orientation. The superior canal was orientated upward and did not fit into any other category.

The dimension of the mandibular bone at the location of bifurcation point was measured on cross-sectional images; the height (vertical distance), length (anterioposterior distance), and diameter of BMCs, the angle of the BMCs with the mandibular canal (angle between the main canal and inferior wall of BMCs), and the diameter of the RF were measured on sagittal images. One investigator took readings using typical equipment (a 15.6-inch screen and a poorly lit room). After one month, 30 individuals' CBCT images were chosen at randomly, and the same investigator remeasured the BMCs and RFs to evaluate intra-observer variability. Para-panoramic 1.5-mm slice thickness reconstructions from CBCT obtained using i-CAT Vision and PANs were imported to image processing and evaluation software (Photoshop® v. 7.0; Adobe® Systems, San Jose, CA). Using CBCT images as a reference, two observers jointly analysed the PANs to determine whether or not the BMCs and RFs were visible.

Statistical analysis

Statistical analysis was performed using SPSS® v. 23.0 for Windows. Descriptive statistics were performed. The level of intra-observer agreement was assessed for anatomical measurements using the intraclass correlation coefficient. The χ^2 test and the *t*-test were used to test differences in frequency and the morphologic characteristic of BMCs between genders. The one-way ANOVA with a *post hoc* Tukey's multiple comparison test were used to compare the characteristics of the different types of BMCs. Differences were considered significant at $p < 0.05$.

Results

The sample consisted of 225 CBCTs selected out of a total of 233 CBCTs. Of the excluded examinations, three CBCTs presented pathology (one patient had lesions consistent with cherubism, another had multiple dental inclusions and the third had an unspecific radiopaque lesion) and five volumes did not have adequate quality for diagnosis. The study sample consisted of 135 females (60%) and 90 males

(40%), with a mean age of 43.87 years (range, 13.00–79.00 years).

Table 1- The rate of bifid mandibular canal presence

Mandibular canal	**No. of canals [*n* (%)]**	**In all patients (%)**	**In all sides (%)**
Forward canal	43 (38.7)	16.8	9.1
Retromolar canal	40 (36.0)	12.0	8.6
Dental canal	19 (17.1)	7.5	4.0
Buccolingual canal	6 (5.4)	2.6	1.3
Superior	3 (2.7)	0.8	0.4

Table 2- The prevalence of bifid mandibular canal (BMC) regarding gender on cone beam CT (CBCT) and panoramic radiographs (PANs)

Type of image	**BMC, *n* (%)**		
	Presence	**Absence**	***p*-value**
CBCT			
Patients			
Female (*n* = 135)	**39[a] (28.89)[b]**	**96 (71.11)**	
Male (*n* = 90)	**44 (48.89)**	**46 (51.11)**	**0.002[c]**
Hemimandibles			
Female (*n* = 270)	**49 (18.15)**	**221 (81.85)**	
Male (*n* = 180)	**54 (30.00)**	**126 (70.00)**	**0.006[c]**
PAN			
Patients			
Female (*n* = 135)	**19[a] (14.00)[b]**	**116 (85.90)**	
Male (*n* = 90)	**19 (21.10)**	**71 (78.80)**	**0.168**
Hemimandibles			
Female (*n* = 270)	**20 (7.40)**	**250 (92.50)**	
Male (*n* = 180)	**22 (12.22)**	**158 (87.78)**	**0.085**

Table 3.-Height, length, diameter and angle of bifid mandibular canals (BMCs) by gender and type

Distribution groups	**Height (mm)**	**Length (mm)**	**Diameter (mm)**	**Angle (°)**
Total sample	**6.3 ± 4.1[a]**	**7.1 ± 3.7[a]**	**1.6 ± 0.7[a]**	**30.7 ± 23.3[a]**
Gender				
Male (*n* = 57)	**6.9 ± 4.4**	**7.3 ± 3.8**	**1.7 ± 0.6**	**32.6 ± 21.9**
Female (*n* = 54)	**5.6 ± 3.6**	**6.8 ± 3.6**	**1.5 ± 0.8**	**28.9 ± 24.8**
Type of BMC				
Forward canal (*n* = 43)	**5.0 ± 3.7**	**7.4 ± 4.1**	**1.5 ± 0.4**	**22.0 ± 18.7**
Retromolar (*n* = 40)	**8.4 ± 3.4**	**6.9 ± 2.8**	**1.6 ± 0.7**	**39.0 ± 24.6**
Dental (*n* = 19)	**3.2 ± 1.7**	**6.3 ± 4.0**	**2.0 ± 1.1**	**35.2 ± 20.5**
Buccolingual (*n* = 6)	**12.3 ± 4.6**	**10.1 ± 3.7**	**1.5 ± 0.7**	**12.0 ± 15.1**
Superior (*n* = 3)	**4.5 ± 0.7**	**4.6 ± 1.9**	**0.7 ± 0.2**	**66.8 ± 21.5**
	***p* = 0.019[b]**	***p* = 0.154**	***p* = 0.000[b]**	***p* = 0.000[b]**

Table 4. Height, length, diameter and angle of the bifid mandibular canals (BMCs), width of mandibular bone and diameter of the retromolar foramen (RF) for the visualized and non-visualized BMCs groups on panoramic radiographs (mm, °)

Factor related to visualization	**Range**	**Mean**	**Standard deviation**
Height of BMC			
Visualization (*n* = 42)	**1.5–19.5**	**7.4[a]**	**4.1**
No visualization (*n* = 69)	**0.0–16.5**	**5.6[a]**	**3.9**
Length of BMC			
Visualization (*n* = 42)	**2.2–16.2**	**7.4**	**3.1**
No visualization (*n* = 69)	**2.1–20.4**	**6.9**	**4.0**
Diameter of BMC			
Visualization (*n* = 42)	**0.7–4.0**	**1.8[a]**	**0.6**

No visualization (n = 69)	**0.5–5.5**	**1.5[a]**	**0.7**
Angle of BMC			
Visualization (n = 42)	**0.0–84.0**	**30.6**	**24.2**
No visualization (n = 69)	**0.0–85.0**	**30.7**	**22.9**
Width of mandibular bone			
Visualization (n = 42)	**3.7–11.5**	**7.8**	**1.6**
No visualization (n = 69)	**5.2–12.3**	**8.4**	**1.5**
RF			
Visualization (n = 13)	**1.0–3.6**	**2.1[a]**	**0.7**
No visualization (n = 27)	**0.9–2.5**	**1.4[a]**	**0.4**

Discussion

The superior canal, a previously unidentified canal type that differs in orientation and fails to fall into any other classification, has been included to the BMC categorisation created by Naitoh et al.[2] Additional classifications are recommended by other PAN-based investigations. According to Kuribayashi et al.[9], dental canal (type II classification of Nortjé et al.)[10] was the most prevalent BMC type, accounting for 85% of their cohort. Furthermore, according to Fu et al. [11], over half of their BMCs belonged to either the retromolar or dental canal types (type IV and II classification of Nortjé et al.).[9] According to Nortjé et al.1[0], forward canals (type I) were the most common using PANs. Previous research on the prevalence of BMCs using PANs varies widely. A unique radiographic characteristic has been suggested to help detect probable BMCs. According to Auluck et al. [12], when the cortical outlines of several canals combine to form triangular islands of bone, the potential existence of BMCs should be taken into account. According to Naitoh et al.[2], only two of the five sides seen on CT scans were considered to have BMCs on PAN imaging, indicating that PAN images misrepresent the true incidence of BMCs. Prior studies documented instances where PANs were bilaterally present on CBCT but did not exhibit bilateral BMCs. The present study involves a large sample and found that the rate of visualization of BMCs on PANs as compared with CBCT was similar to the results reported by Naitoh et al.[2] Kuribayashi et al[9] explained that buccolingual canals can be easily detected on CBCT but might be missed on PANs. Nevertheless, the percentage of buccolingual canals in the current study was extremely low, indicating that characteristics other than the kind of canal must also be important. Neurovascular canal visibility may also be hampered by anatomical structural overlap. The upper airway, soft palate and uvula, opposing side, and submandibular fossae may create ghost shadows and obstruct the view of neurovascular canals because to the two-dimensional nature of PANs. The visualisation rate of BMCs using PANs compared to CBCT was 37.8% in the current investigation, which was comparable to the rate previously reported by Naitoh et al.[3] Neves et al,[13] by contrast, reported a 76% visualization rate, but, this may be owing to the low number of BMCs that they detected on CBCT. Bogdán et al[14] found 19.6% of BMCs in dry mandibles, but only 0.2% of total cases were visible on PANs.

It is being proposed that bone trabeculation in the posterior jaw may impact the mandibular canal's visibility in relation to anatomic landmark visibility. The presence of mandibular canal corticalization and its visibility are known to be influenced by bone trabeculation.[11] Furthermore, cancellous bone density on PANs has been linked to the representation of the mandibular canal. The orientation of the buccolingual canal and the superposition of anatomical components are two examples of characteristics that have been described by various writers as affecting the visualisation of BMCs on PANs.[15]

Conclusion

BMCs and RFs cannot be adequately identified by PANs. One important consideration for visualisation on PANs is the diameter of these anatomical landmarks. Pre-operative imaging that solely use PANs may result in surgical problems, anaesthetic failures, and an underestimating of the existence of BMCs that could have been prevented. A CBCT gadget is preferable to a PAN for accurate BMC assessment.

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