Acta Odontologica Scandinavica, 2013; 71: 650–655

ORIGINAL ARTICLE

Radiographic assessment of the mandibular retromolar canal using cone-beam computed tomography

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Abstract

Objective. The 'retromolar' nerve is a collateral branch of the inferior alveolar nerve. Cone-beam computed tomography (CBCT) provides higher resolution images. This CBCT study reports the frequency of the retromolar nerve. ***Materials and methods.*** From 2007–2010 the CBCT study of 233 hemi-mandibles have been examined. The CBCT study was obtained from an investigation of the posterior mandibular region in 187 patients suffering from different pathologies and it was aimed at detecting in patients the presence of a retromolar canal and foramen. ***Results.*** Thirty-four retromolar canals with a foramen were detected on 233 CBCT (14.6%) in 30 out of 187 patients (16%). In the 46 patients who underwent CBCT bilaterally, the retromolar canal was found in nine subjects (19.6%) and was present bilaterally in four subjects, for an incidence of 8.7%. ***Conclusions.*** The results suggest that the radiological frequency of the retromolar nerve is notable, with a possible relevance in the surgical approach of the mandibular retromolar area. The presence of a retromolar canal, well detected with CBCT, may warn clinicians about the possibility of inadequate pre-surgical anaesthesia, local intra-operative bleeding and post-operative alterations of the sensation in the third molar area.

Key Words: *three dimensional evaluation, inferior alveolar nerve variance*

Introduction

Knowledge of the location of the mandibular canal and of its anatomical variants, such as supplemental or accessory foramina and canals, can facilitate surgical intervention and protect the patient from complications. There have been several articles on mandibular accessory canals and foramina [1–4]. Different authors have classified the principal anatomical variants [4,5]. An important anomaly is the presence of a bifid canal, which corresponds to the type III anatomical variant of Carter and Keen [4].

One bifid mandibular canal is the so-called retromolar canal, which runs distal to the third molar: it seems to correspond to type IV in the classification of Nortjé et al. [5], as a supplemental canal arising in the retromolar pad region and joining with the main canals in the retromolar area.

According to Sicher and Dubrul [6], this branch is normally given off shortly after the inferior alveolar nerve enters the mandibular canal, although it sometimes arises before the mandibular foramen, entering the mandible independently, at a point superior and anterior to the mandibular foramen. Histopathological surveys confirm the presence of myelinated nerve fibres associated with numerous venules and an artery [7]. This branch seems to be involved in the innervation of the third molar, retromolar trigone and part of the buccal mucosa and fibres of the buccinator and temporalis muscles [3]. Knowledge of this anatomical variance and its assessment before surgery involving the posterior mandible may warn the clinician about possible inadequate pre-surgical anaesthesia, local bleeding during surgery or local altered sensation post-operatively [3,8].

In clinical practice, anatomical variation, such as supplemental or accessory canals and foramina, can only be detected radiologically, but conventional two-dimensional radiographs, such as panoramic images, are insufficient for detecting all anatomical structures, especially the presence of a bifid canal [9–12]. Sectional imaging, such as computed tomography

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(Received 2 April 2012; revised 24 May 2012; accepted 11 June 2012)

ISSN 0001-6357 print/ISSN 1502-3850 online © 2013 Informa Healthcare
DOI: 10.3109/00016357.2012.704393

(CT) and cone-beam CT (CBCT), has been used successfully in dentistry [13–17]. Recently CBCT helped to detect the presence of retromolar canals and to distinguish five different morphologies and courses of this structure [12]. If compared with conventional CT, CBCT has the advantages of lower radiation exposure [8,18] with comparable resolution and accuracy [8,19]. Additionally, CBCT machines are available for routine investigations in the dental office. Furthermore, CBCT is more useful for identifying different anatomical variants, distinguishing true from false bifid mandibular canals [10].

This investigation examined the incidence of the retromolar canal and foramen by using CBCT images.

Materials and methods

Patients

In our study data from all CBCT examinations of patients suffering from jaw problems have been analysed. Patients had consulted the Department of Oral and Dental Sciences at the University of Bologna, from January 2007 to March 2010. The main reason for referral was the evaluation of impacted third molars. Two hundred and thirty-three CBCT examinations of hemimandibles of 187 patients, with a mean age of 46 years, that clearly identified the course of the mandibular canal in the posterior mandible (from the coronoid process to the first molar region), were selected for this study. Forty-six patients underwent CBCT examinations bilaterally. The study has been approved by the local Ethical Committee of the Department of Oral and Dental Sciences, University of Bologna. Every patient signed an informed consent form for using the data for researching aims.

Imaging

The 3D Accuitomo® MST-1, Ex-2, RH 202 (Morita, Kyoto, Japan) CBCT apparatus was used with a 75 kV-voltage-current tube of 5 mA, for an exposure time of 17 s. The imaging area (field of view, FOV) of the 3D Accuitomo is a 30 mm height cylinder (240 voxels) with a diameter of 40 mm (320 voxels), resulting in an isotropic cubic voxel with 0.125-mm sides. Contiguous cross-sectional images in three directions, parallel to the dental arch, perpendicular to the dental arch and horizontal, were reconstructed from the projection data with a slice width of 0.5 mm. By viewing the contiguous sectional images using dedicated software (I-Dixel 3 DX®, Morita), we have analysed the images in each section on a cathode ray tube monitor.

Image evaluation

An oral clinician (A.F.) and oral radiologist (G.G.) evaluated the CBCT images independently for the presence or absence of a retromolar canal and foramen. Criteria for identifying the presence of an accessory canal have been established to be:

- a round radiolucent area in the retromolar area with a diameter ≥ 1 mm, indicating the retromolar foramen,
- a continuity solution in the upper cortex of the mandibular canal in the retromolar area as a sign of bifurcation of the principle bundle, and
- a radiolucent band connecting the first two points in the retromolar area, indicating the retromolar canal.

The actual presence of a retromolar canal was established only if all the three criteria were judged to be satisfied in the same case by both the assessors.

Results

Of the 233 CBCT examinations in 187 patients, 34 revealed the presence of a retromolar canal (14.6%). This anatomical variant was found in 30 out of 187 patients (16%). Only 46 patients underwent CBCT bilaterally and in these patients the retromolar canal was found in nine subjects (19.6) and was present bilaterally in four subjects (8.7%). These results are summarized in Table I.

Representative images of a case are shown in Figures 1,2,3,4.

Discussion

The mandibular canal runs from the mandibular foramen to the mental foramen and contains the inferior alveolar artery, vein and nerve. In medical images, it appears as a dark radiolucent ribbon between two white lines [11]. Significant variations in its course have been reported [11,20,21]. A single canal is found only in 60% of cases, with the nerves and vessels radiating in the bone [22]. Different classifications of the principal anatomical variants have been proposed, underlining the presence of supplemental branches, entering bone foramina, that may arise from different portion of the main

Table I. The occurence of retromolar canal considering the number of radiographic exams and the patients who received a bilateral CBCT.

	Cone beam CT	Patients undergone to bilateral CBCT	
Total number	233	46	
Number with at least 1 retromolar canal	34	9	
Number with bilateral retromolar canals			4
Percentage value	14.6%	19.6%	8.7%

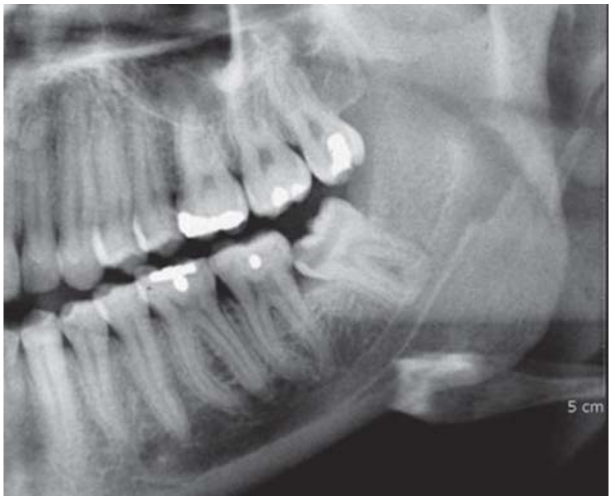

Figure 1. Panoramic image (particular) of the left mandible.

canal or originate with a new mandibular foramen in the ramus of the mandible [3,4,23].

Ikeda et al. [24] distinguished three nerve branches in the mandibular canal: (1) the retromolar branch leaves the main trunk, runs parallel to it and then turns upwards to the third molar, (2) the second molar branch diverges from the main trunk and runs until it gives off the dental branches and (3) the third molar branch leaves the inferior alveolar nerve (IAN) immediately after entering the mandibular canal; otherwise, it enters the mandible via an independent foramen localized above and anterior to the mandibular foramen and passes through a retromolar foramen near the third molar [6]. The embryonic development of the inferior alveolar nerve (IAN) results in the fusion of three distinct nerve bundles, innervating the three groups of teeth, and incomplete fusion of the three nerves may explain the presence of duplications of the mandibular canal [25]. Auluck et al. [26] described the case of a triple mandibular canal where the third branch perforated the lingual cortex in the retromolar area.

Kaufman et al. [17] detected bilateral accessory canals, 1–2 mm in diameter, slightly anterior to the ascending ramus of the mandible. Several studies agree that the majority of foramina are concentrated in the posterior mandible [4,17,27]. The symmetry of the accessory canals and foramina is controversial [27,28]; we observed bilateral retromolar canals in four out of 46 patients (8.7%) who underwent bilateral CBCT examinations.

Several studies [5,10,23] have evaluated the location of bifid mandibular canals using panoramic images, reporting incidences from 0.08–8.3% [29,30] with no agreement between the various reports. Comparing anatomical and radiographic investigations, some authors believe that panoramic images under-estimate the incidence of this structure, because they are insufficient to detect all bifid canals [8,9,12]. This was consistent with our results as well as the results of a recent study about 31 retromolar canals [12]. Conversely, some authors state that all studies based on panoramic evaluations over-estimate the presence of these anomalies [11,31]. Regardless, routine two-dimensional investigations are not reliable for identifying these anatomical variants [11] and a three-dimensional image examination is the only means of diagnosing anatomical variants [31,32].

The most common three-dimensional diagnostic imaging modalities used to study jaw anatomy are multi-slice CT (MSCT) and CBCT [8,13–15]. Two studies stated that various mandibular anatomical structures can be assessed with equal accuracy using CBCT and MSCT [8,33]. CBCT appeared to be more effective for observing a bifid mandibular

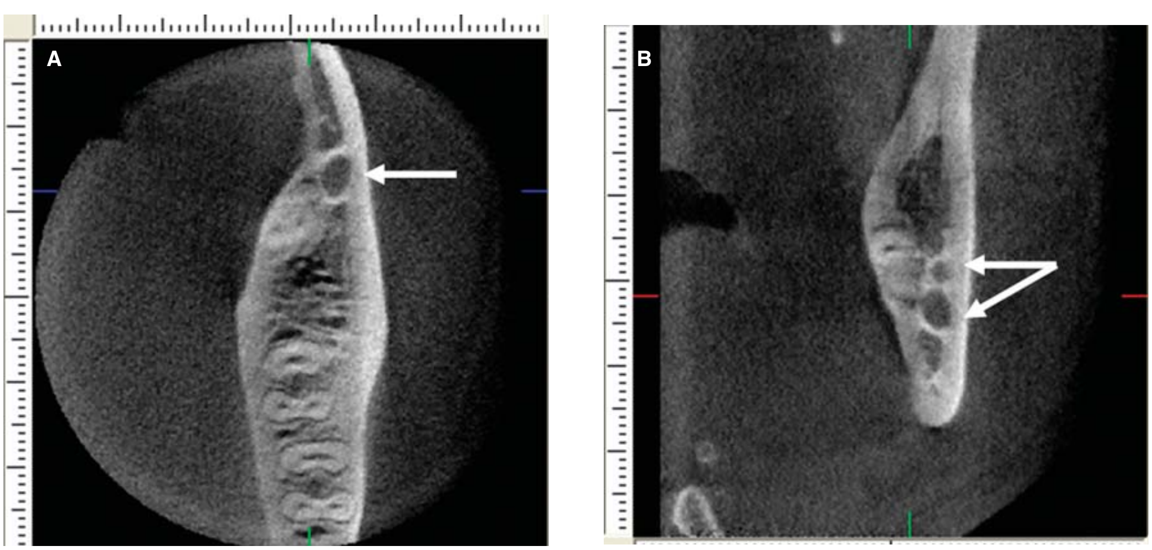

Figure 2. The cone beam CT images reveal a bifid mandibular canal in the retromolar area, arising from the principal alveolar canal. Assial (A) and coronal (B) plane slice.

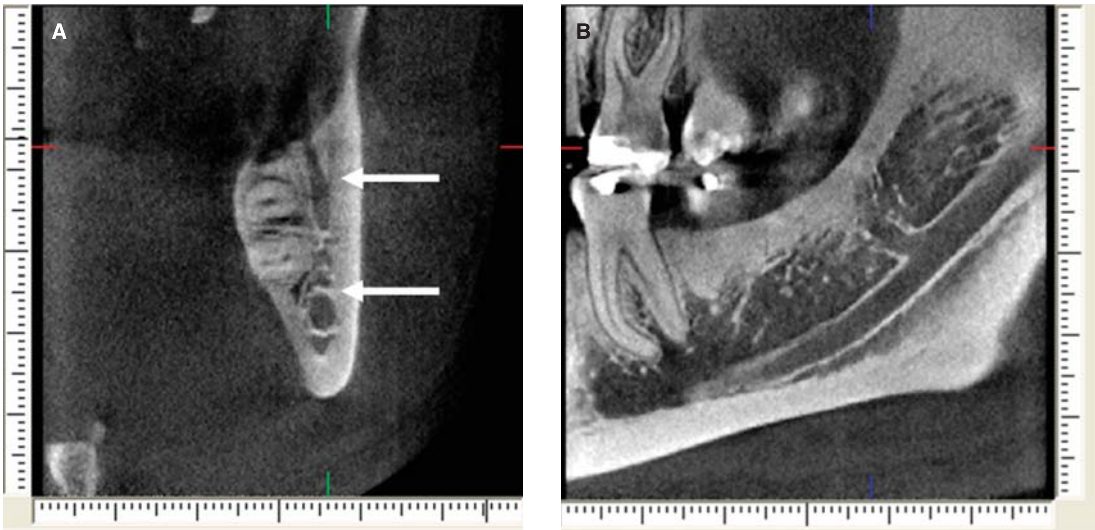

Figure 3. The cone beam CT images reveal a bifid mandibular canal in the retromolar area, arising from the principal alveolar canal. Assial (A) and coronal (B) plane slice.

canal in the mandibular ramus because four of 19 bifid canals observed in CBCT images were unclear in MSCT images [8]. Regarding the portion of the mandible distal to the second molar, it is worth noting that the pixel size and thickness in MSCT images were slightly larger than the narrow foramen, as the internal diameter of the retromolar foramen was reported to range from 0.2 to more than 1 mm [34]. The retromolar region is near the level of the occlusal plane and MSCT images are influenced by metal artefacts from metal restorations. CBCT images have a higher resolution and the absence of distortion and enlargement, with an error margin < 0.1 mm, while conventional MSCT has an error margin of 1–1.5 mm [8,19]. CBCT has further advantages compared with MSCT. The average exposure dose produced by a cone-beam scanner is ~ 12.0 μSv, which is 40–60-times less than with conventional MSCT [16,19]: the mA and kV, that are both directly proportional to the radiation dose, are lower in a CBCT than MSCT. The resolution of CBCT is inversely proportional to the FOV; the 3D Accuitomo® used in this study has a 30 × 40 mm FOV and obtained very detailed images, demonstrating its great usefulness in detecting this anatomical variant [8,13,16,19].

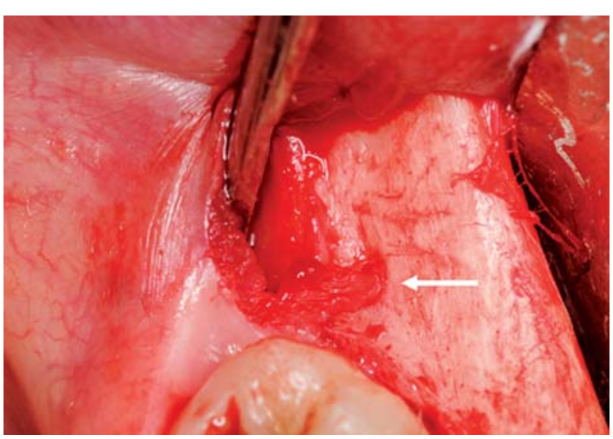

Figure 4. The clinical image of a retromolar bundle emerging from the bone pad of a retromolar area during surgical extraction of a left third molar.

Naitoh et al. [35] observed a bifid mandibular canal in the mandibular ramus region on 65% of CBCT images.

Kuribayashi et al. [10] reported that 47 out of 301 (15.6%) subjects studied with CBCT had bifid mandibular canals: 10 of the 47 bifid canals were classified into four types according to Nortjé et al. [5] and the incidence of type IV, which has a course more similar to a retromolar canal, was only 1.7%. In CBCT images, a bifid mandibular canal was observed on 18 of 38 sides and a retromolar canal was seen in three canals (7.9%) by Naitoh et al. [8]. Actually, in the literature the criteria for a precise radiological classification of a bifid canal as a retromolar canal are no clear. It has been reported that a radiological incidence of the anatomical variance was specifically called ‘retromolar canal’ [8], but only one study focused on the radiological detection and incidence of the retromolar canal by CBCT. This recent study of Von Arx et al. [12] describes in detail courses, morphologies and dimension of 31 retromolar canals on 121 mandibular sides (25.6%) of 100 patients and a bilateral presence of this structure in 19%. The minor incidence of retromolar canals in our study with respect to that reported by Von Arx may be explained with the restriction of inclusion criteria to the presence of a retromolar radiolucent image of ≥ 1 mm of diameter as a retromolar foramen, associated to the other radiological variables. We decided to apply this dimensional limit, considering that the reported widths of retromolar foramina in previous anatomical studies ranged from 1.5–4.35 [12,36] and that only a structure with such an entering or exiting bone foramen might be considered clinically relevant. Furthermore, in this study we established neat imaging parameters to be suitably attributed to the retromolar canal. Anyway, our radiological incidence of this particular type of bifid canal resulted higher than that reported in the literature based on cadaver studies.

In anatomical studies of dry skulls and cadavers, the incidence of a retromolar canal and foramen ranged from 1.7–25% [3,37], while Schejtman et al. [28] reported a 72% incidence, with 27% bilateral, although the sample size was small. The incidence of the retromolar foramen only goes from 12.7–17.8 [38,39].

Some studies reported myelinated nerve fibres, striated muscle fibres, venules and a muscular artery with a 122–130 μm lumen in the retromolar canal [3,7]. The nerves are derived from IAN and the artery branches from the inferior alveolar artery [34]. In one dissection, retromolar nerves were seen branching to the buccal mucosa and gingiva in the mandibular molar and premolar regions [34]. Anderson et al. [7] reported that these fibres innervate part of the temporalis and buccinator muscles, the retromolar trigone and the pulp of the third molar. Furthermore, it has been reported on an aberrant course of the buccal nerve, originating from the inferior alveolar nerve within the ramus, running through the retromolar canal and entering through the retromolar foramen [39].

Generally, bifid mandibular canals have important clinical implications. Inadequate anaesthesia is possible with any type of bifurcation, but especially when there are two mandibular foramens [3,10]. The presence of a retromolar canal may result in difficulty obtaining anaesthesia of retromolar and buccal mucosa as well as damage to an undetected supplementary artery with marked bleeding during surgery. Injury to the supplemental nerve fibres may result in altered sensation, including temporary or permanent paraesthesia or anaesthesia of the retromolar trigone, involving a 1-mm area in the posterior buccal mucosa. Moreover, nerve damage may result in a traumatic neuroma and a supplemental canal may be a route for spread of a tumour or infection and may interfere with implant insertion [3]. Particularly with third molar extraction, injury to the retromolar bundle during the incision is often unavoidable, as it must be made in the middle of the retromolar pad or while detaching the vestibular flap or during an osteotomy or odontotomy.

This study highlights the frequency of the retromolar canal. CBCT is the best method for identifying this anatomical variant and may be useful when a preliminary radiographic survey shows no clear relationship between the IAN and the other anatomical structures in mandibular molar area.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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