The retromolar canal and its variations: Classification using cone beam computed tomography

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Objective: To determine the prevalence of the retromolar canal and its various patterns using cone beam computed tomography (CBCT). Method and Materials: CBCT images with the presence of mandibular third molars from August 2013 to May 2015 were retrospectively investigated. The presence of retromolar canal, its patterns, sides, as well as gender were evaluated by two observers. The pattern of retromolar canal was initially classified into three types: Type A, superior type; Type B, radicular-retromolar type; and Type C, dental type. During the investigation, two additional types were found and further classified: Type D, plexus type; and Type E, forward type. The distribution of retromolar canals between genders and sides was statistically analyzed with Pearson’s chi-square test. Results: A total of 201 mandibular sites in 156 subjects (99 women, 57 men) were included. Among them, 128 sites had retromolar canals (63.68%). The presence of retromolar canal was not statistically related to gender or side. Most of the retromolar canals were the radicular-retromolar type (Type B, 38.10%), followed by the superior type (Type A, 29.93%), dental type (Type C, 19.73%), plexus type (Type D, 6.80%), and forward type (Type E, 5.44%). Conclusion: There was a high frequency of retromolar canals and these could be classified into five patterns. The clinician should be aware of this anatomical structure when performing surgical procedures involving the retromolar area. (Quintessence Int 2018;49:61–67; doi: 10.3290/j.qi.a39224)

Key words: bifid mandibular canal, cone beam computed tomography, inferior alveolar canal, retromolar canal

The mandibular retromolar region is an intraoral donor site at which autogenous bone blocks are harvested for dental implant procedures. In this region, there is an anatomical variant of the inferior alveolar nerve canal (IAC) called the retromolar canal, which consists of nerve bundles, arterioles, and venules.1-3 This variation of the IAC is relevant to surgical procedures that take place in the retromolar area, such as surgical removal of an impacted third molar, bone harvesting from this area, and sagittal split osteotomy.4-6 If clinicians do not properly identify the course of the retromolar canal, complications could occur, such as traumatic neuroma, paresthesia, anesthesia, dysesthesia, unexpected bleeding, hemorrhage, and/or failure to achieve adequate levels of anesthesia.6,7 Another clinical importance of the retromolar canal is its association with the pain experienced during extraction or surgical removal of third molars.8,9

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of impacted mandibular third molars despite adequate local anesthesia, called the “escape pain phenomenon.” This escape pain is due to the nerve content in the retromolar canal, which innervates the retromolar triangle mucosa, buccal mucosa, and buccal gingiva of the mandibular premolar and molar regions.

Previous studies have reported a varying prevalence of the retromolar canal (3.0% to 72.0%) in different populations and study designs. Recently, retromolar canals were detected in only 3.0% of panoramic radiographs but were identified in 26.7% using cone beam computed tomography (CBCT). Thus, panoramic radiography has a limited ability to detect the retromolar canal. With the advent of CBCT, a three-dimensional (3D) imaging system, the prevalence of the retromolar canal has been determined to range from 5.4% to 65.3% among various populations.

Most studies have investigated and classified the retromolar canal as a type of bifid mandibular canal or as an accessory canal; for example, Type 3 in the classification of Carter and Keen, Type 1 in the classification of Langlais et al, Type 1 in the classification of Naitoh et al, and Type 4 in the classification of Kang et al. Most studies of the retromolar canal focused on only those that coursed posterosuperiorly. Moreover, the retromolar canal patterns were classified differently among the studies. To the present authors’ knowledge, no previous studies have offered a complete classification of retromolar canals. Therefore, the aim of this study was to evaluate the prevalence of the retromolar canal and its various patterns in Thai mandibles using CBCT.

**METHOD AND MATERIALS**

**Patient selection and imaging system**

The Faculty of Dentistry/Faculty of Pharmacy, Mahidol University institutional review board approved the study with a certificate of exemption (COE No. MU-DT/ PY-IRB 2015/018.0707). The CBCT images of patients aged ≥ 20 years recorded during August 2013 to May 2015 were retrieved. The inclusion criteria were CBCT images (field of view 6 x 6 cm, voxel size 0.125 mm) that covered the retromolar area, contained the third molar tooth, and revealed distinct borders of the IAC without evidence of jaw fracture or pathologic conditions.

All CBCT images were acquired with the 3D Accuitomo 170 machine (J. Morita) with exposure factors of 90 kVp, 5 mA, and 17.5 seconds. Sagittal, coronal, and axial images were reconstructed with i-Dixel imaging software (J. Morita) and were used to assess the retromolar canals. All CBCT images were displayed on a liquid crystal display monitor with a resolution of 2,560 x 1,600 (EIZO RX430; EIZO Nanao).

The CBCT images of 201 mandibular sites in 156 subjects (99 women, 57 men; aged 20 to 70 years, mean 35.14 years) were included in the study. The presence of a retromolar canal with its pattern and side, as well as the age and sex of the patients, was recorded. Two observers (an oral and maxillofacial radiologist and an oral implantologist) independently evaluated the CBCT images twice for the presence or absence of the retromolar canal.

**Classification of the retromolar canal**

The retromolar canal was classified into three types, as modified from Patil et al. For Type A (superior type), the retromolar canal branched from the IAC at an area distal to the third molar and coursed superiorly. For Type B (radicular-retromolar type), the retromolar canal coursed between the radicular portion of the third molar and the retromolar fossa. For Type C (dental type), the retromolar canal branched from the IAC distal to the third molar and coursed toward the third molar (Fig 1).

During the investigation, two additional types were found and classified into Types D and E. For Type D (plexus type), the retromolar plexus branched off the IAC distal to the third molar. For Type E (forward type), the retromolar canal branched off the IAC distal to the third molar and coursed forward at apical areas of the third molar. This Type E was further classified into E1 and E2. For Type E1 (forward, with no merging), the retromolar canal branched from the IAC and coursed forward for some distance. For Type E2 (forward, with merging), the retromolar canal branched from the IAC, coursed forward for some distance, and then merged with the IAC.
Figs 1a to 1c  Cone beam computed tomography images and diagrams of the retromolar canal patterns. (a) Type A: superior type. (b) Type B: radicular-retromolar type. (c) Type C: dental type.

In addition, combination patterns of retromolar canal Type B with other types were found and recorded.

Statistical analysis
Data were analyzed using descriptive statistics, calculating the percentages of the retromolar canal and its patterns. Intra-examiner and inter-examiner reliabilities were evaluated using the intraclass correlation coefficient (ICC). Pearson’s chi-square test was used to assess the distributions of the retromolar canals between the sexes and the different sides of the mandible by means of a standard statistical software package (SPSS version 18, IBM). A value of $P < .05$ was considered to indicate statistical significance.

RESULTS
The retromolar canals were found in 128 of 201 sites (63.68%) from 156 subjects (99 women, 57 men), as shown in Table 1. Intra-observer reliabilities were .979 and .957, respectively, and inter-observer reliability was .935. The retromolar canals were found in 75 of 127 sites (59.06%) in women and 53 of 74 sites (71.62%) in men. The difference in the prevalence of the retromolar canal between the sexes was not statistically significant ($P = .074$) (Table 1). According to side, the retromolar canal was found at 43 sites of the right mandible only (21.39%), 41 sites of the left mandible only (20.40%), and bilaterally at 44 sites (21.89%). The difference in prevalence of the retromolar canal between the right and left sides was not statistically significant ($P = .194$).

Regarding the retromolar canal patterns, the radicular-retromolar type was the most common (Type B, 38.10%), followed by the superior type (Type A, 29.93%), dental type (Type C, 19.73%), plexus type (Type D, 6.80%), and forward type (Type E, 5.44%) (Table 2). Type B retromolar canals were found in combination with other types in 19 of 201 sites (9.45%).

Among these 19 sites, Type B was combined with Type A at five sites (2.49%), with Type C at 11 sites (5.47%), and with Type D at three sites (1.49%).

DISCUSSION
This study showed that CBCT detected a high prevalence of retromolar canals (63.68%) in Thai mandibles. In previous cadaveric studies, the prevalence of the retromolar canal ranged from 12.9% to 72.0%.1,3,20
panoramic radiography studies, the prevalence of the retromolar canal was low, ranging from 3.0% to 8.8%.\textsuperscript{14,15,21} The diagnostic accuracy of panoramic radiography (3.0%) for predicting the presence of a retromolar canal was less than that for CBCT (26.7%) in the same population because of the limitation of the two-dimensional imaging technology of panoramic radiography.\textsuperscript{14}

CBCT is being increasingly used to evaluate the retromolar canal. The prevalence of retromolar canals detected using CBCT has ranged from 5.4% to 65.3%, as shown in Table 3.\textsuperscript{11-16,18,22-24} The lowest prevalence of the retromolar canal (5.4%) was reported by Kang et al,\textsuperscript{11} who defined it as one of the bifid mandibular canals: the branch arising from the main canal and opening at the retromolar foramen. Lizio et al\textsuperscript{12} also found a low prevalence of the retromolar canal (14.6%), likely because of their criteria for identifying it as a bifurcated canal in the retromolar area detected together with a retromolar foramen of diameter $\geq$ 1 mm. In contrast, Patil et al\textsuperscript{13} detected a high prevalence of the retromolar canal (65.3%) because of their inclusion criteria, which disregarded both the presence of a retromolar foramen and the diameter of the retromolar canal. The most common finding in their study was that, with the Type B retromolar canal, a thin radiolucent line coursed between the retromolar fossa and the radicular portion of the third molar, similar to the present Type B (radicular-retromolar type) (38.10%). Another factor that affects the high prevalence of the retromolar canal is the quality of the CBCT images, which directly depends on voxel size. The smaller the voxel size, the better the spatial resolution.\textsuperscript{25} In Patil’s study, the voxel size was 0.08 mm, compared with 0.125 mm in the present study. Hence, the prevalence of the retromolar canals is different according to the definition of the retromolar canal, method of study, inclusion criteria, imaging techniques, and image quality.

There was no difference in the prevalence of the retromolar canal with regard to sex or side of the mandible in the present study or in previous studies.\textsuperscript{13,15} The retromolar canal patterns were first classified by Ossenberg.\textsuperscript{19} Most researchers focused on the common type of retromolar canal (Type 1), proposed by Ossenberg, corresponding to Type A (superior type) in the present study, which was considered a type of bifid mandibular canal. Its prevalence was reported at 38.6% by Langlais et al\textsuperscript{17} and at 52.5% by Kang et al.\textsuperscript{11} Nevertheless, in the

\begin{figure}[h]
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\includegraphics[width=\textwidth]{Figs2a_2c}
\caption{Cone beam computed tomography images and diagrams of additional retromolar canal patterns. (a) Type D: plexus type. (b) Type E1: forward type with no merging. (c) Type E2: forward type with merging.}
\end{figure}
present study, Type A (superior type) was the second most frequently found (29.93%), similar to the 29.0% in the study of von Arx et al.\textsuperscript{15} and the 29.8% in the study of Naitoh et al.\textsuperscript{18}

Type B retromolar canal in the present study, the radicular-retromolar type, was most common (38.10%). It was also the most common type (56.7%) in the study of Patil et al.\textsuperscript{13} Type B was first described in 1977 by Sagne et al.,\textsuperscript{26} but most researchers still focused only on Type 1, proposed by Ossenberg.\textsuperscript{19} In 2013, Patil et al.\textsuperscript{13} suggested that Type B retromolar canal should be considered an additional individual type of retromolar canal because of its high prevalence. It generally appears as a fine canal (< 1 mm) that opens into the periodontal ligament space. In 2015, Sisman et al.\textsuperscript{14} classified it as another retromolar canal pattern (Type VII) with a prevalence of 7.5%. In the present study, 19 sites (9.45%) were found with a combination of Type B and other types (Types A, C, D). These combination patterns were also mentioned by Patil et al.\textsuperscript{13} as appearing with a prevalence of 7.6% in their study. Further studies are needed in additional samples to investigate these combinations and their effects on surgical complications.

Patil et al.\textsuperscript{13} did not classify or detect the prevalence of Type C (dental type), although they noted that they found this type during their study. Naitoh et al.\textsuperscript{18} classified this dental type as a type of bifid mandibular canal and reported its frequency at 8.8% of all bifid mandibular canals. The present Type C was found at 29 mandibular sites (19.73%), making it the third most common type.
Therefore, it can be suggested that this Type C (dental type) should be considered a retromolar canal pattern. Type D (plexus type) was found in 7 of 147 retromolar canals (4.76%). The present plexus type was similar to Type II (4.35%), a retromolar canal branch with a vertical course and an additional horizontal branch, and Type IX (5.14%), a retromolar canal running anteriorly for some distance and then coursing posterosuperiorly toward the retromolar foramen with an additional horizontal branch foramen, as described by Sisman et al.14 The present plexus type, however, showed more complicated branches than those of Types II and IX in Sisman et al’s study.14

Type E (forward type) was found in 8 of 147 retromolar canals (5.44%), which was the smallest proportion in the present study. This type is similar to Type 3 in the classification of the bifid mandibular canal by Naitoh et al.18 They classified this forward type into two patterns: with confluence and without confluence. Their study included all posterior mandibular regions, whereas the present study considered only the origin of the canal in the retromolar area. The present study subclassified the forward type, a retromolar canal that branched off the IAC distal to the third molar and courses forward at apical areas of the third molar, into Type E1 (forward canal without merging) and Type E2 (forward canal with merging). This forward canal type was the most common type (59.6%) found by Naitoh et al,18 especially the canal without confluence (55.3%). The present study, in contrast, found the forward canal with merging at only one site (0.68%).

A recent meta-analysis considered the retromolar canal to be a variation of the mandibular canal. The overall prevalence of bifurcated mandibular canals when assessed by CBCT was 16.25%.27 This result is in contrast with the high prevalence of retromolar canals in the present study, even though their bifurcated mandibular canals included both retromolar canals and bifid mandibular canals. This low percentage could be explained by their inclusion criteria considering the

<table>
<thead>
<tr>
<th>Method of study</th>
<th>Study</th>
<th>Year</th>
<th>No. of studied samples</th>
<th>Ethnicity</th>
<th>Prevalence (%)</th>
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<td>121</td>
<td>Swiss</td>
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<td>Capote et al21</td>
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<td></td>
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CBCT, cone beam computed tomography; PAN, panoramic radiography.
studies with a minimum population of 300 subjects, and the present Type B retromolar canals (the radicular-retromolar type) was not included. The retromolar canal is important because of the elements in the canal, which include a nerve, one or more arterioles, and one or more venules. Complications could thus occur when performing surgical procedures in the retromolar area (ie, excessive bleeding, hematoma, paresthesia, inadequate anesthesia). The limitations of the present study were small sample size and the lack of relations between various types of retromolar canal and their individual, associated complications. Future studies should investigate the relations between the various retromolar canal patterns and the occurrence of complications during or after surgery.

CONCLUSION

In the present study, the results reveal that the retromolar canal (the IAC branching from the retromolar area) could be classified into five patterns: Type A (superior type); Type B (radicular-retromolar type); Type C (dental type); Type D (plexus type); Type E (forward type). A high prevalence of the retromolar canal (63.68%) was observed in the examined Thai mandibles. The most common retromolar canal pattern was Type B (radicular-retromolar type), which was also found in combination with other types. Thus, the retromolar canal is not a rare anatomical variation of the IAC. Clinicians should be aware of the retromolar canal when performing surgical procedures in the retromolar area, such as removing an impacted third molar or harvesting a retromolar block bone graft.

REFERENCES