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Vol 10 No 1 (2022) DOI 10.5195/d3000.2022.361

Correlation between presence of radix entomolaris in mandibular first molars and C-shaped canals in mandibular second molars: a sample of CBCT scans in Taiwanese students

Magdalena Piskórz[2] , Ingrid Różyło-Kalinowska[2], Karolina Futyma-Gąbka[2], Zuzanna Aleksandrowicz[1], Anna Błaszczyk[1], Wiktoria Furmanek[1]

[1.] Student Research Group at the Department of Dental and Maxillofacial Radiodiagnostics, Medical University of Lublin, Poland
[2.] Department of Dental and Maxillofacial Radiodiagnostics, Medical University of Lublin, Poland

Keywords: Root canal anatomy, cone beam computed tomography, C-shaped root canals, Taiwanese, radix entomolaris

Abstract

Objectives: The anatomy of root canals is so complex that in many cases it is not sufficient to take an intraoral radiograph to diagnose the number and shape of root canals. Therefore, Cone Beam Computed Tomography (CBCT) facilitating diagnosis and treatment planning in endodontics is gaining more and more importance. Radix entomolaris is an extra root which is found in mandibular molars and located distolingually. C-shaped canal is most commonly found in mandibular second molars and can differ significantly in shape from the typical anatomy of lower molars. The aim of the study was to evaluate the correlation between presence of radix entomolaris in mandibular first molars and presence of C-shaped mandibular second molars in Taiwanese students based on CBCT scans.

Methods: The material consisted of 19 CBCT examinations taken in the Department of Dental and Maxillofacial Radiodiagnostics of the Medical University of Lublin.

Results: Among 19 CBCT examinations 5 cases of coexistence of additional root and C- shaped canals were found. Up to 80.0% of cases were bilateral. In the studied sample there was high coincidence of radix entomolaris in mandibular first molars and C-shaped mandibular second molars.

Conclusion: Knowledge of this correlation will prevent diagnostic errors during endodontic and surgical treatment planning.

Citation: Piskórz M, et al. (2022). Correlation between presence of radix entomolaris in mandibular first molars and C-shaped canals in mandibular second molars: a sample of CBCT scans in Taiwanese students. Dentistry 3000. 1:a001 doi:10.5195/d3000.2022.361
Received: June, 15, 2022
Accepted: June 23, 2022
Published: August 12, 2022

Email: lek.dent.karolina.futyma@gmail.com

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Introduction

Dental practitioners are aware of anatomical variations of dental roots and root canals. The anatomy of root canals is so complex that in many cases it is not sufficient to take an intraoral radiograph before planning endodontic treatment [1]. The number of Cone Beam Computed Tomography (CBCT) scans is increasing year by year. This novel diagnostic method is effective to reveal anatomical variation of teeth and coexistence of different variants [2]. CBCT examination allows to analyze a case in three dimensions: axial, coronal and sagittal. Being highly exposed to caries, the molars in particular have a higher demand for root canal treatment [3]. Lack of knowledge of its diversity may lead to endodontic failures such as broken endodontic instruments, perforations, instrument separation and apical displacement, injuries of periapical tissues, underfilling and overfilling of root canals and serious oral health problems, for example: internal resorption, abscesses, cysts, chronic periapical inflammation, pathological fractures and tooth loss [3-5].

For deeper understanding of the root anatomy Vertucci suggested root canal morphology classification, in which the following eight types can be distinguished [6]:

Type I- a single canal extends from pulp chamber to the apex

Type II- two separate canals leave the chamber of the pulp and join short of the apex to form single canal

Type III- one canal leaves the pulp chamber, divides into two within the root, and then joins to exit as one canal

Type IV- two separate and distinct canals extend from the pulp chamber to the apex

Type V- single canal leaves the pulp chamber and divides short of the apex into two separate and distinct canals with separate apical foramina

Type VI- two separate canals leave the pulp chamber, merge in the body of the root, and redivide short of the apex to exit as two distinct canals

Type VII- one canal leaves the pulp chamber, divides and then rejoins within the body of the root, and finally redivides into two distinct canals short of the apex

Type VIII- three separate and distinct canals extend from the pulp chamber to the apex

The first mandibular molars commonly have 2 roots and 3 to 4 canals [1] but in 1844 Carabelli noticed a common occurrence of a third root in these teeth [7, 8].

In most cases the extra root is located distolingually, and is called radix entomolaris (EM) [1, 9]. If the root is located mesiobuccally, it is called radix paramolaris [8]. Previous studies showed that Chinese, Japanese, Korean and Taiwanese populations are more predisposed occurence of the first mandibular molars with the extra root in comparison to Europeans (frequency of an additional root in Taiwanese is around 24%, while in German is less than 4%) [10, 11]. Presence of an accessory root in mandibular first molars requires careful examination of CBCT scans [7].

The second mandibular molars usually have 2 roots and 3 canals [12]. It is possible to find the ‘C’ shaped canal configuration in these teeth [13]. This is an anatomical variation of root canal system and shape and its diagnosis is challenging based on conventional radiographs only. Depending on the population, C-shaped mandibular second molar canals may occur with various percentages (from 2.7 to 44.5%) [14-16]. It is widely known that most cases with this configuration

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are found in the population of Asia [14, 17-21].

According to studies, C-shaped root canals were located most frequently in the second mandibular molars [21, 22].

In 1991 Melton et al. [23] proposed the classification of C-canals based on their cross-sectional shape. It distinguished three types of appearance of C-shaped canals:

Category 1- the continuous C-shaped canal

Category 2- “semicolon” shaped canal (dentin separated one distinct canal from a buccal or lingual C-shaped canal)

Category 3- two or more discrete and separate canals

In 2004 Fan et al. [20] using micro-computed tomography demonstrated modified Melton’s classification and divided C-canals into five following categories:

Category I (C1) - the uninterrupted “C” shape of the canal with no division or separation (Fig. 1a)

Category II (C2)- the canal shape similar to “semicolon” resulting from a discontinuation of the “C” outline, but either angle ɑ or β (Fig. 2) should be no less than 60° (Fig. 1b)

Category III (C3)- two or three separate canals and both angles, ɑ and β (Fig. 3), were less than 60° (Fig. 1c, 1d)

Category IV (C4)- only one round or oval canal in that cross-section (Fig. 1e)

Category V (C5)- no canal lumen could be observed (which was usually seen near the apex only) (Fig. 1f)

CBCT is one of the best diagnostic modality which can be used to evaluate complexity of the root canal system [4, 21]. Without a doubt it is easier to visualize root canal anatomy due to using 3-dimensional (3D) images [24]. CBCT helps to identify canal morphology, numbers of canals and their relative positions [9, 24-30]. It is especially helpful in evaluating canals in teeth with radix ento- or paramolaris [24].

The aim of the study was to estimate the correlation between presence of radix entomolaris in mandibular first molars and presence of C-shaped root canals in mandibular second molars in a sample of CBCT scans of Taiwanese individuals.

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Fig. 1 - Classification of C-shaped canal configuration by Fan et al. [35]. Diagrams drawn according to the paper by Fan et al. [35].

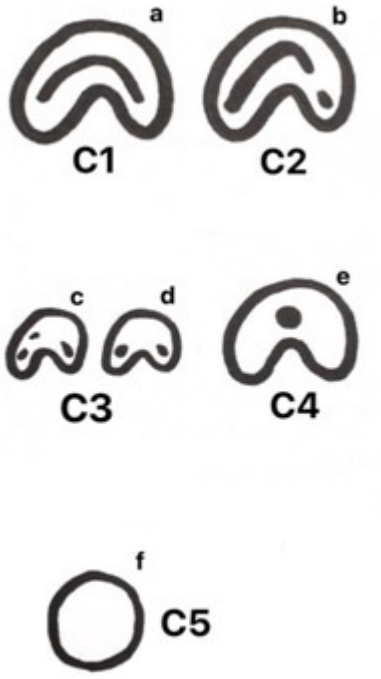

Figure 1

Fig. 2 - Measurement of angles for the type C2. Angle β is more than 60°. (A and B) - ends of one canal cross-section; (C and D) - ends of the other canal cross-section; M - middle point of line AD; α - angle between line AM and line BM; β - angle between line CM and line DM [35]. Diagrams drawn according to the paper by Fan et al. [35].

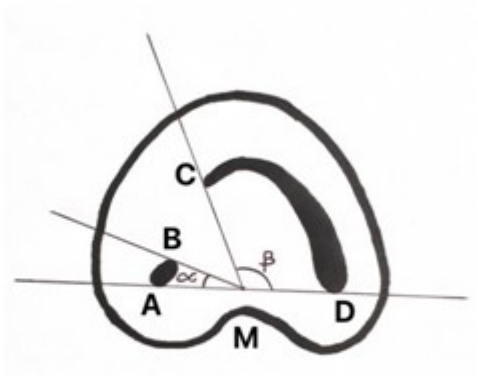

Figure 2

Fig. 3 - Measurement of angles for the C3 canal. Both angle α and angle β are less than 60°. (A and B) - ends of one canal cross-section; (C and D) - ends of another canal cross-section; M - middle point of line AD; α - angle between line AM and line BM; β - angle between line CM and line DM [35]. Diagrams drawn according to the paper by Fan et al. [35].

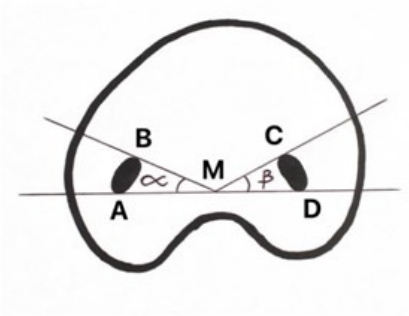

Figure 3

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Methods

Nineteen consecutive CBCT examinations retrieved from the database of the Department of Dental and Maxillofacial Radiodiagnostics, Medical University of …. were analyzed in order to assess the anatomy of the mandibular first and second molars. In the study group only teeth that meet the following criteria were included:

- mature (those at the stage H according to Demirijan's tooth formation stages)
- without any features of inflammation
- with no capping and motion artifacts (well taken CBCT scans)
- with any pathologies in the interested region
- without root canal treatment.

The examinations were taken with the use of VistaVoxS CBCT X-ray machine (Dürr Dental, Germany) with FOV size 130x85mm. The study group included eleven women and eight men, aged 21-53 years (mean 27.6). Only examinations of Taiwanese patients were evaluated. CBCT scans were analyzed in multiplanar reconstructions (MPR): coronal, axial and sagittal, by means of VistaSoft software on diagnostic radiological medical monitor Barco Coronis Fusion 4 MP (MDCC-4430, Belgium). The axial scans were used to evaluate root canals and configuration of roots in first and second mandibular molars. Presence of radix entomolaris in first mandibular molars and C-shaped root canal configuration in second mandibular molars was noted. The next step was to assess correlation between presence of radix entomolaris in mandibular first molars and presence of C-shaped root canals configurations in mandibular second molars.

Results

Among 38 first mandibular molars 13 teeth with radix entomolaris were found (34.2%)
(Tab. 1). Six cases were observed on the right side (46.2%) and seven on the left (53.8%). In five patients the occurrence was bilateral (Tab. 2). The gender predominance in occurrence of radix entomolaris was not noticed; six cases were found in women and seven in men (46.2%/53.8%). In all cases only a single root canal was found in the supernumerary root.Among 37 (one tooth was missing - no data in history of the patient) second mandibular molars, 21 teeth with C-shaped configuration of root canals were found (56.8%) (Tab. 1). Almost all finds were bilateral (10 people) (Tab. 2). Twelve cases were found in women (57.1%) and nine cases in men (42.9%). Table 3 presents the frequency of particular types of C-shaped canals in mandibular second molars.
Eventually, among all cases with radix entomolaris (36, 46) and C-shaped root canals (37, 47) we found 5 cases with both unusual anatomy (Tab. 4). Four cases presented bilateral occurrences of radix entomolaris and C-shaped root canals (80.0%). One case was partially bilateral (36 with radix, 46 without radix but 37 and 47 with C-shaped) (Tab. 5). Three cases were found in women and two in men. In men all cases were bilateral. Figures 4-6 present axial views of patients with radix entomolaris and C-canals.

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Table 1

Prevalence of radix entomolaris in mandibular first molars (n=38) and C-shaped canals in mandibular second molars (n=37) examined in terms of presence.

Radix entomolaris	**n**	**%**
Present	13	34.2
Absent	25	65.8

C- shaped canals	**n**	**%**
Present	21	56.8
Absent	16	43.2

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Table 2

Prevalence of radix entomolaris in mandibular first molars (n=13) and C-shaped canals in mandibular second molars (n=21) examined in terms of lateralisation.

Radix entomolaris	**n**	**%**
Unilateral	3	23.1
Bilateral	10	76.9

C-shaped canals	**n**	**%**
Unilateral	1	4.8
Bilateral	20	95.2

Table 3

Prevalence of particular types of C-shaped canals in mandibular second molars (n=21).

Type of C-shaped canal	**C1**	**C2**	**C3**	**C4**	**C5**
n	4	6	11	0	0

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Table 4

Prevalence of coexistence of radix entomolaris in mandibular first molars and C-shaped canals in mandibular second molars in patients in terms of presence (n=19).

Radix entomolaris and C-shaped canals	**n**	**%**
Present	5	26.3
Absent	14	73.7

Table 5

Prevalence of coexistence of radix entomolaris in mandibular first molars and C-shaped canals in mandibular second molars in patients in terms of lateralisation (n=5).

Radix entomolaris and C-shaped canals	**n**	**%**
Unilateral	1	20.0
Bilateral	4	80.0

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Fig. 4a - CBCT axial view- bilateral occurrence of C-shaped canals in teeth no. 37 (C2), 47 (C1), unilateral presence of radix entomolaris in tooth no. 36.

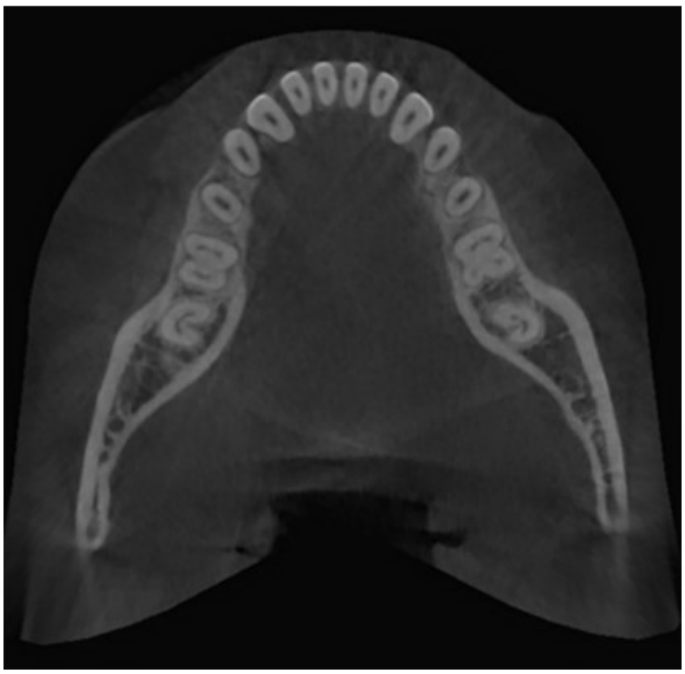

Figure 4a

Fig. 4b - Panoramic radiograph - no radiological signs of radix entomolaris and C-shaped configuration of root canals in the mandibular molars.

Figure 4b

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Fig. 5a - CBCT axial view- bilateral occurrence of C-shaped canals in teeth no. 37 (C3), 47 (C2) and bilateral occurrence of radices entomolaris in teeth no. 36, 46.

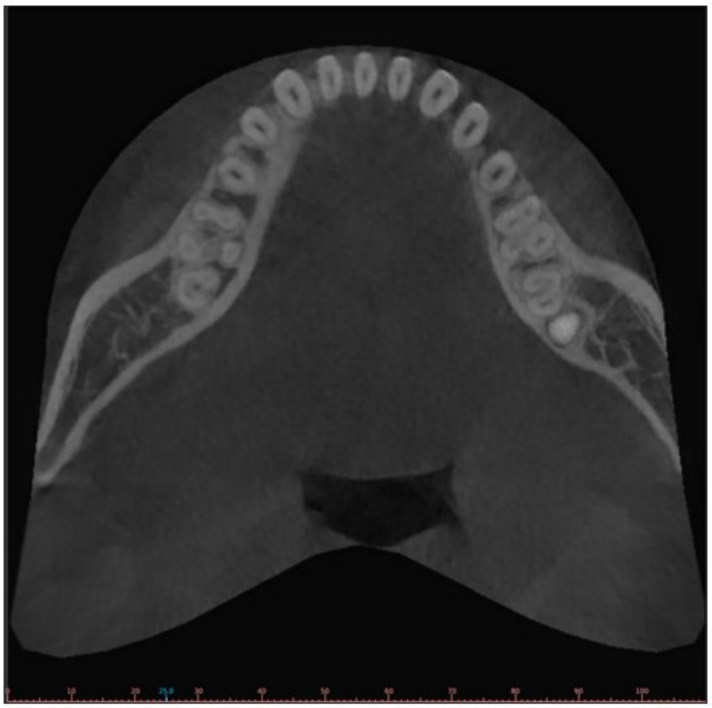

Figure 5a

Fig. 5b - Panoramic radiograph - no radiological signs of radix entomolaris and C-shaped configuration of root canals in the mandibular molars.

Figure 5b

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Fig. 6a - CBCT axial view- bilateral occurrence of C-shaped canals in teeth no 37 (C2), 47 (C2) and bilateral occurrence of radices entomolaris in teeth no. 36, 46.

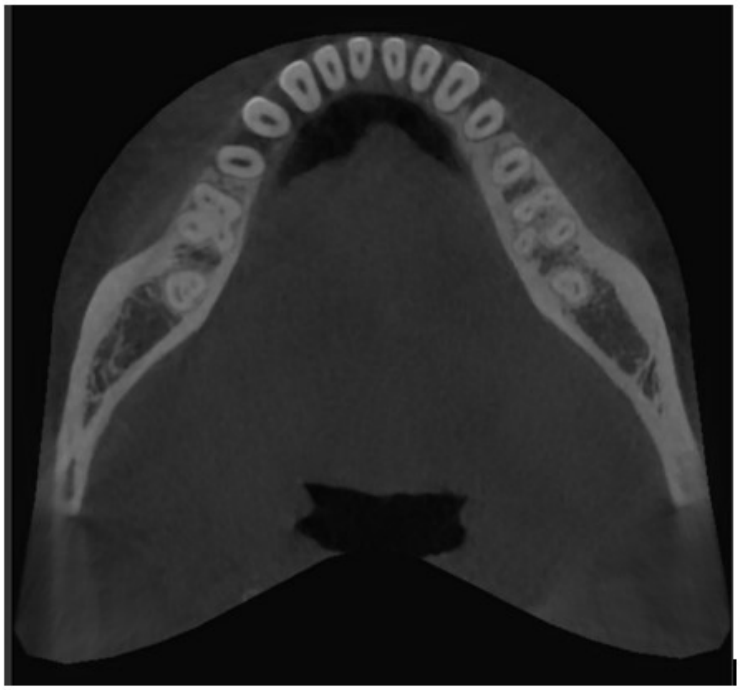

Figure 6a

Fig. 6b - Panoramic radiograph - no radiological signs of radix entomolaris and C-shaped configuration of root canals in the mandibular molars.

Figure 6b

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Discussion

The statement that the most common or typical morphology of the first mandibular molar is the two-rooted configuration is often challenged. There are many factors that affect the results of research studies. First and the most important is the population group, second is the type of examination that we rely on.

Our study revealed that among 38 first mandibular molars 34.2% had an accessory distolingual root, which is similar to prevalence reported with the use of CBCT by Zhang et al. (29.0%) in Taiwanese population [31]. On the contrary, the occurrence of the radices entomolares reported by Ming-Gene et al. [32] was lower in Taiwanese population (21.09%) compared to the results of this study. The obtained results might have been biased by using only 2D examinations (periapical radiographs) which are not as precise as CBCT in demonstrating three-dimensional anatomy of teeth. Prevalence of an accessory distolingual root was 22.8% in the Korean population based on CBCT scans, which is close to our findings [33].

On the other hand, a study by Rahimi et al. [22] on Iranian population using CBCT showed a prevalence of 3.10% with an extra distolingual root, which is significantly less than our results. The prevalence of radix entomolaris in the first mandibular molars among Saudi subpopulation was low (4.2%) [1]. The present study detected more radices entomolares among men (53.8%) but in Saudi subpopulation more three-rooted mandibular first molars were found in women (61.9%) than in men (38.1%) [1]. These results are in agreement with the study conducted on Taiwanese population by Ming-Gene et al. (57.14% for women) [32]. However, there were no significant differences in the prevalence of radix entomolaris in mandibular first molars between men and women [1, 22, 34].
The numbers of bilateral cases were lower in Saudi (32.3%) [1], Iranian (33.3%) [22] and Korean (17.64%) [33] subpopulations in comparison to our study in a sample of Taiwanese individuals (76.0%). Present findings are consistent with results by Ming-Gene et al. [32], who also examined Taiwanese population (68.57% bilateral cases).

According to our findings, the prevalence of the accessory distolingual radix in the first mandibular molars is comparable on both the right (46.2%) and left (53.8%) side.
More radices entomolares were found on the right side in Malaysian (54.4%) [34] and Turkish (60.0%) subpopulations [35]. In agreement with these studies, Sin-Young Kim et al. [33] and Ming-Gene et al. [32] reported more radices entomolares detected on the right side.
One of the unusual forms of root canal configuration are the C-shaped canals, which are mostly found in mandibular second molars because these teeth are prone to root fusion [34].
In our study based on Taiwanese patients more than a half had C-shaped canals (56.8%) that is comparable to Malaysian subpopulation (48.7%) [34]. Findings reported by Zhang et al. [31] indicate that the Chinese population also has a high prevalence of C-shaped second mandibular molars (29% C-canals in 157 examined teeth). C-canals are not often found in Caucasian populations [31]. Studies in Iranian population indicated a relatively low appearance of C-shaped root canals in second mandibular molars (17.6% by Madani et al.[4]

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and 9.2% by Donyavi et al. [3] Shemesh et al. [2] reported even lower prevalence of C-canals in Israeli population (4.6%). Similarly, the prevalence of C-shaped root canals in mandibular second molars in Turkish subpopulation was low (10.7% in study by Kaplan et al. [36], 10.6% by Helvacioğlu-Yiğit et al. [37] and 8.0% by Cimilli et al. [38].

According to previous studies, there is no significant difference between genders and prevalence of C-shaped canals [2, 12], whereas the present study reported that more C-canals were found in women (57.1%). Our results are similar to studies in Malaysian and Iranian population [4, 34] and consistent with the results in Turkish subpopulation reported by Kaplan et al. [36]. Bilateral occurrence of C-shaped canals was present almost in all cases (95.2%) in contrast to Israeli population that has prevalence of asymmetry (55.0% unilateral cases) [2]. Kaplan et al. [36] also reported a lower percentage of bilateral C-shaped root canals in the second mandibular molars in Turkish subpopulation, which was 50%. On the other hand, findings by Tassoker et al. [14] showed a comparable percentage of symmetrical presence of C-canals in the second mandibular molars (88%) as in our study.

The present study reported that the coexistence of C-canals in mandibular second molars and radix entomolaris in first mandibular molars is more frequent in Taiwanese population (26.3%). In the majority of our cases there was bilateral occurrence of both C-shaped root canals and radices entomolares (80.0%) and there is no significant correlation between them and gender of the patients.

The main limitation of our study was a small examined sample but more advanced research is planned with more CBCT examinations included.

Conclusions

The results of this study revealed a high percentage of coexistence between presence of radix entomolaris in mandibular first molars and C-shaped mandibular second molars in a sample of CBCT scans in Taiwanese individuals.

List of abbreviations:

CBCT - Cone Beam Computed Tomography

Conflicts of interest:

There is no conflicts of interest

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