

Assessment of Mandibular Root Morphology Using Cone Beam Computed Tomography in the Croatian Population

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Abstract

The objective of this research was to study the variation in the number of roots of mandibular teeth and to compare them with data from available literature. The retrospective study was conducted at the Department of Maxillo-facial Surgery at the University Hospital Centre Split by analysing Cone-Beam Computed Tomography (CBCT) scans of patients' lower jaws. Out of 145 CBCT scans of the lower jaws, 114 were valid and entered in the Excel table for statistical analysis. Three hypotheses have been put forward: (1) lower incisors, canines and premolars have one root; (2) lower molars have two roots; (3) supernumerary root is the most common variation in lower molars. Data collected from 114 participants, i.e. CBCT scans, were analysed in the STATISTICA 11.0 programme package and every side of a group of teeth was analysed separately. Lower incisors, canines and premolars are, in the largest percentage, single-rooted teeth (two-rooted teeth vary from 0 to 4 per cent), whereas molars are, the most, two-rooted teeth (one-rooted teeth vary from 2 to 5 per cent, while three-rooted teeth stand at about 3 to 6 per cent). The most frequent anatomical variation observed was the presence of a supernumerary root in the mandibular third molar. This research confirmed the hypotheses and obtained data on the number of dental roots in all teeth of the lower jaw, in accordance with data from the literature.



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Introduction

Endodontics is a branch of dental medicine focusing on the morphology, physiology, pathology, diagnosis, and treatment of the dental pulp and periapical tissues. A thorough understanding of tooth anatomy, especially the endodontic area, is essential for high-quality dental treatment. Endodontic procedures involve creating access openings, instrumentation, and filling of root canals, aimed at preserving the tooth for as long as possible. Failure to locate root canal entrances, improper instrumentation, or inadequate filling often leads to treatment failure.¹

Besides clinical examination, radiographic analysis plays a crucial role in treatment planning.¹ Cone-beam computed tomography (CBCT) is a recent imaging technique that offers detailed three-dimensional views of teeth and adjacent anatomical structures, allowing precise identification of root and canal numbers.^{1,2}

Several studies worldwide have investigated root morphology variations in mandibular teeth, especially premolars and molars. Most studies^{3–10} are consistent with the literature on the number of roots in mandibular teeth. The opposite results appear in the study by Guo *et al.*¹¹ who reported a higher incidence of single-rooted second molars. Research¹² in the Bosnia and Herzegovina population reported predominantly double-rooted lower third molars.

Assessing root morphology is critical.¹ This study provides new data on mandibular tooth root morphology in the Croatian population, where only studies conducted 40 years ago exist.^{13–15} The aim was to determine the frequency of variations in the number of mandibular tooth roots by analysing CBCT images. Three hypotheses were tested: (1)

mandibular incisors, canines, and premolars have one root; (2) mandibular molars have two roots; (3) supernumerary roots are the most common variation in mandibular molars.

Materials and Methods

This retrospective study was conducted at the Department of Maxillo-facial Surgery at the University Hospital Centre Split. 145 CBCT images of patients from the Department of Oral Surgery and the Department of Dental Medicine at the University Hospital Centre Split were retrospectively analysed using the Sectra program (Sectra AB, Linköping, Sweden). Images were examined in sagittal, frontal, and transverse planes. Nine edentulous images and 22 partial jaw images were excluded, leaving 114 images for analysis. Data on the number of roots per tooth were recorded in Microsoft Excel Office 2019. The study received ethical approval from the University Hospital Centre Split Ethics Committee (Class: 500-03/21-01/34; No.: 2181-147-01/06/M.S.-20-02). Statistical analysis was performed using STATISTICA 11.0 software. Descriptive statistics and frequency tables were generated for each tooth type, separately for right and left sides. Results are presented in tables and figures. There was a single observer, which can be considered a limitation of the study.

Results

A total of 1401 mandibular teeth were analysed on CBCT images, including central and lateral incisors, canines, first and second premolars, and first, second, and third molars (441 incisors, 224 canines, 376 premolars and 360 molars). The number and distribution of roots by tooth type and side are summarised in Table 1.

Table 1: Frequency and percentage of subjects with respect to the number of roots for the left and right sides of the lower jaw

Tooth	Side	1 root N (%)	2 roots N (%)	3 roots N (%)
Central incisor	R	112 (100%)	0 (0%)	0 (0%)
	L	107 (100%)	0 (0%)	0 (0%)
Lateral incisor	R	111 (99.1%)	1 (0.9%)	0 (0%)
	L	109 (99.1%)	1 (0.9%)	0 (0%)
Canine	R	111 (97.4%)	3 (2.6%)	0 (0%)
	L	106 (96.4%)	4 (3.6%)	0 (0%)
First premolar	R	98 (95.1%)	5 (4.9%)	0 (0%)

Second premolar	L	94 (94.9%)	5 (5.1%)	0 (0%)
	R	87 (97.7%)	2 (2.3%)	0 (0%)
First molar	L	83 (97.6%)	2 (2.4%)	0 (0%)
	R	0 (0%)	53 (94.6%)	3 (5.4%)
Second molar	L	0 (0%)	57 (95%)	3 (5%)
	R	2 (2.7%)	69 (92%)	4 (5.3%)
Third molar	L	2 (2.6%)	68 (89.5%)	6 (7.9%)
	R	3 (6.4%)	37 (78.7%)	7 (14.9%)
	L	6 (13.05%)	34 (73.9%)	6 (13.05%)

N = number of participants, % = percentage of participants, R = right, L = left

The distribution of root number by tooth type is shown in Figure 1. A clear predominance of single-rooted teeth was observed in incisors, canines, and

premolars, while molars, especially third molars, exhibited greater variability, including a significant proportion of three-rooted third molars.

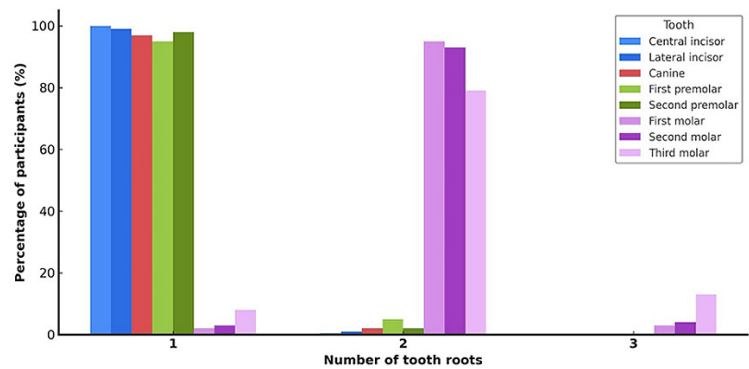


Fig. 1: Root number variation in mandibular teeth (in percentages)

Figures 2 and 3 show CBCT scans of the same patient, demonstrating bilateral two-rooted morphology of the lower premolars. On both the right

and left sides of the mandible, the premolars clearly exhibit two distinct roots, indicating a symmetrical anatomical variation.

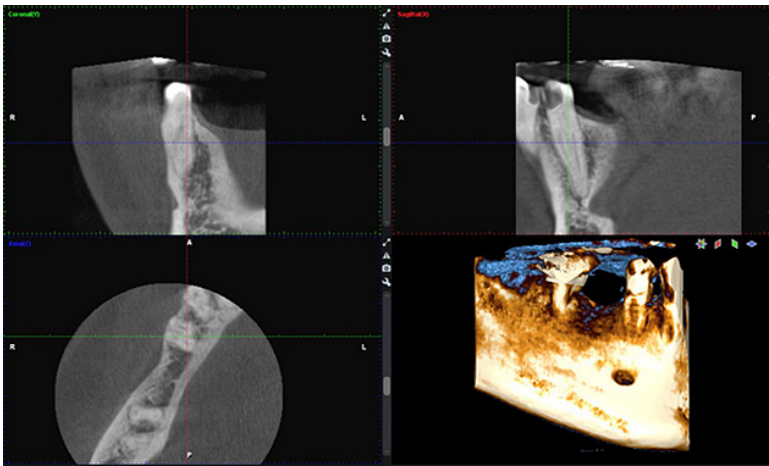


Fig. 2: CBCT scan of the right lower mandible showing a two-rooted premolar

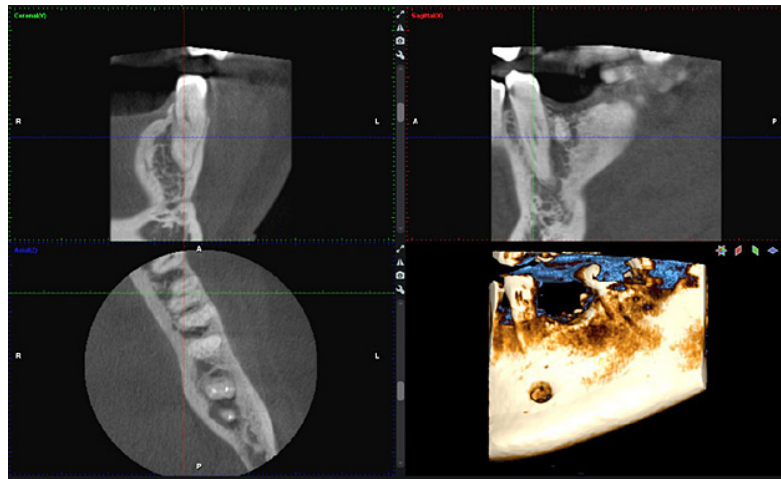


Fig. 3: CBCT scan of the left lower mandible showing a two-rooted premolar

Discussion

All analysed lower central incisors were single-rooted, consistent with Krishnan *et al.*⁵ (Indian population), as well as several other studies.^{4,16,17} Lateral incisors were predominantly single-rooted, with two roots found in fewer than 1% of cases, supporting findings by Mashyakh and Gambarini.¹⁷

Mandibular canines, in most cases, have one long and voluminous root, and since the small number of teeth analysed the percentage of 3.1% of lower canines with two roots is significant.¹⁶ Literature¹ reports two-rooted lower canines in up to 10% of cases, including studies by Shrestha *et al.*⁴ and Magat and Uzun¹⁸. Pan *et al.*¹⁹ found 1.2% two-rooted canines in a Malaysian population, in line with our data.

Lower first premolars were mainly single-rooted, with 5% showing two roots, similar to previous studies.^{5-8,13,20,21} In an older study by Trope *et al.*²² two populations were analysed and a higher frequency of double-rooted premolars was observed in one population. In a study by Gündüz *et al.*,²³ conducted on the Turkish population, out of a total of 988 analysed lower first premolars, 89.9% had one root, 9.7% had two roots, and 0.4% had even three roots.

Mandibular second premolars were also mostly single-rooted, with rare two-rooted cases, consistent with literature.^{5-8,13,20} Some studies^{16,17,19} have found that all lower second premolars analysed are teeth that have only one root. As with the lower first

premolars, the study by Almehrzi *et al.*⁷ reported that the lower second premolars are single-rooted teeth with a lower proportion of fused shapes (the letter "C" shape). Gündüz *et al.*,²³ out of a total of 974 teeth studied, also found lower second premolars with three roots in 0.3% of cases.

The lower first molars are mostly two-rooted teeth, but they can also have a supernumerary root (*radix entomolaris* or *radix paramolaris*), as shown by the results of our study. Similar results have been reported by other studies.^{14-16,24} Analyzing 1174 lower first molars, Qiao *et al.*⁹ reported in their study that 23.85% of the teeth had a supernumerary roots.

When it comes to lower second molars, this study found that these teeth are most often two-rooted, but in 10% of cases they can have one or three roots, which is largely confirmed by previous study.^{11,16,25,26} The study by Najžar-Fleger and Šutalo¹⁴ also recorded a fourth root. Kato *et al.*²⁷ gave different results by analysing 22 lower second molars, in which the highest percentage had one root (64%), a slightly lower percentage had two roots (32%), and the lowest percentage had three roots (0.35%).

The lower third molars are the most variable teeth missing in the subjects in this study. The majority are two-rooted third molars, while the remaining proportion is single-rooted and three-rooted teeth, which is consistent with the available data from previous study.¹²

Taking into account the limiting factors of this study, namely the small number of samples and data processing from only two departments of the Clinical Hospital of Split, recorded over a period of one year, there is a need for further analysis of as many samples (CBCT scans) as possible throughout the Republic of Croatia.

Conclusion

Dental practitioners must be familiar with possible morphological variations in tooth roots to ensure successful endodontic therapy. Based on the results of the study, reading 114 CBCT images, it is concluded that the number of roots of all teeth in the lower jaw is largely consistent with the data from the literature on the stated number of roots. All three hypotheses were confirmed:

- Lower incisors, canines and premolars are single-rooted teeth in the highest percentage.
- Molars are mostly double-rooted teeth.
- The most common type of variation is the supernumerary root of the lower third molar.

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Conflict of Interest

The authors do not have any conflict of interest.

Data Availability Statement

This statement does not apply to this article.

Ethics Statement

This retrospective study was approved by the Institutional Ethics Committee of the Split Clinical Hospital (Class: 500-03/21-01/34; Reg. No.: 2181-147-01/06/M.S.-20-02). The requirement for informed consent was waived due to the retrospective design and use of fully anonymized CBCT data.

Informed Consent Statement

This study did not involve human participants, and therefore, informed consent was not required

Clinical Trial Registration

This research does not involve any clinical trials.

Permission to reproduce material from other sources

Not Applicable

Author Contributions

- **Lucija Kustra:** Conceptualization, Methodology, Data Collection, Analysis, Writing – Original Draft.
- **Ivana Medvedec Mikic:** Analysis, Writing – Review & Editing.
- **Kristina Gorseta:** Conceptualization, Writing – Review & Editing, Supervision.

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