

Second Mandibular Molar Roots in Relation to Mandibular Canal in Cone Beam Computed Tomography

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Summary

Trauma to the mandibular canal during endodontic treatment can cause permanent damage to the inferior alveolar nerve, ranging from sensory disturbances to tissue necrosis. The roots of the second molar are closest to the mandibular canal, which significantly increases the risk of iatrogenic injuries. The aim of the study was to evaluate the relationship of the roots of mandibular second molar to the mandibular canal in cone beam computed tomography (CBCT). A cross-sectional study was conducted including 200 patients, the analysed CBCT examinations were made for other diagnostic needs. A total of 375 teeth were evaluated in the research, including 193 left and 182 right second molars. The most common distance from the mandibular second molar to the mandibular canal was 1.01–3.00 mm, direct contact with the canal was observed in up to 21.1% of cases. Penetration of the root apex into the mandibular canal was observed in up to 1.2%. The most common location of the canal to the root apex was apical (84.2–97.5 %). When performing root canal treatment, the dentist must be especially careful to avoid iatrogenic injuries to the alveolar nerve, which can significantly reduce the patient's quality of life.

Keywords: second mandibular molar, mandibular canal, localisation of the roots, iatrogenic injuries, complications.

Introduction

The main goal of endodontic treatment is to prevent or treat bacterial pathologies in the root canal system of the tooth. The outcome of successful treatment depends on the doctor's knowledge of both the anatomy of the root canals of the tooth itself and the relationship of the tooth to the surrounding structures (Gambarini et al., 2011). The mandibular or inferior alveolar nerve, which is located in the mandibular canal, provides sensory innervation to teeth, mandible, lower lip and chin and motor innervation to mylohyoid muscle and anterior belly of the digastric muscle, therefore it is important to assess the relationship of the tooth roots to the mandibular canal before endodontic treatment of the mandibular teeth, especially molars (Norton, 2016). In the mandible, the localization of the mandibular canal is very variable, some patients have direct contact of the tooth roots with the mandibular canal, which significantly increases the possibility of iatrogenic injury to the alveolar nerve (Kim et al., 2016).

Complications arising from the extrusion of endodontic materials beyond the apex of second mandibular molars have become growing concern in endodontics. A study examining 831 endodontically treated molars found that extrusion of root canal filling materials occurred in 8.9% of mandibular second molars, highlighting the relevance of this issue (Çulha, 2023). Given the severity of the potential consequences, every dentist should be aware of the possible

variations in the localization of tooth roots in relation to the mandibular canal (Gambarini et al., 2011; Shin et al, 2016). Excessive, inadequate instrumentation, extrusion of the materials used outside the root canal system into the surrounding tissues and the inferior alveolar nerve, can cause complications such as paraesthesia, dysesthesia, chronic pain and even tissue necrosis, which can lead to the need for extensive surgical operations and significantly reduce the patient's quality of life (Gambarini et al., 2011; Olsen et al., 2014). Part of endodontic materials, such as sodium hypochlorite, calcium hydroxide and resin-based sealers, are neurotoxic to some extent and even in small amounts can lead to pain, paresthesia, anesthesia or dysesthesia of leave the mandibular nerve. If this type of complication is detected, diagnosed in a timely manner, and evacuation of extruded material is performed, it is still impossible to predict whether permanent consequences will be prevented (Byun et al., 2016; Pogrel, 2007).

Aim of the study

The purpose of this study was to evaluate the relationship of the roots of mandibular second molar to the mandibular canal, measured on cone beam computed tomography.

Materials and methods

A retrospective study was conducted including 200 patients (110 women and 90 men), aged 15 to 56 years, with a mean age of 35 years. The study group consisted of patients who were randomly selected according to the inclusion criteria, which were: bi/-unilaterally fully erupted second mandibular molars; formed tooth roots; anatomical structures required for CBCT images clearly visible, without artifacts. Exclusion criteria were periapical inflammation and teeth with apical root resorption.

The analysed CBCT examinations were made for other diagnostic needs with the i-Cat Next Generation device (Kavo, voxel size 0,300mm). A total of 375 teeth were evaluated in multiplanar reconstruction view, including 193 left and 182 right second molars. Permission from the Research Ethics Committee (Nr. 2-4/459/2023). Data processing with *MS Excel* and *IBM SPSS*.

To facilitate data analysis and to make the results more understandable, five categories were created for the distance from the apex of the tooth root to the mandibular canal:

- a. direct contact with the mandibular canal or 0 mm;
- b. distance to the mandibular canal 0.01–1.00 mm;
- c. distance to the mandibular canal 1.01–3.00 mm;
- d. distance to the mandibular canal 3.01–5.00 mm;
- e. distance to the mandibular canal 5.01 mm and more.

It is important to note that the CBCT voxel size of 0.300 mm limits the precision of distance measurements, particularly in the sub-millimetre range. Therefore, measurements below or near the voxel resolution should be interpreted with caution. Similar grading has been used by Wang et al (2017), but they distinguished only two extremely dangerous distances: 1.00–2.00 mm and less than 1.00 mm.

When examining the localization of the mandibular canal relative to the root apices, three localizations were distinguished: buccal, lingual and apical.

Results

In total 375 teeth were evaluated. Of the 193 left molars, 173 cases (89.6%) had the most common root anatomy, namely a tooth with two roots, 17 cases (8.8%) had a tooth with one root, while in three cases (1.6%) a tooth with three roots was found – two mesial and one distal. Of the 182 right mandibular second molars, 162 (89.0%) had two roots, 19 (10.4%) had one root, and one case (0.6%) also had three separate roots.

When evaluating each root separately according to the distance from the root apex to

the borders of the mandibular canal, the following results were obtained: for the mesial root of d37, out of 173 measurements, 33 were in direct contact with the mandibular canal (19.1%), 23 measurements were up to 1 mm (13.3%), 48 cases were from 1.01 to 3.00 mm (27.7%), 41 measurements were from 3.01 to 5.00 mm (23.7%), while 5.01 mm and more were in 28 cases (16.2%). Accordingly, for this root, the most common distance from the root apex to the mandibular canal was from 1.01 to 3.00 mm. The remaining data are presented in Figure 1.

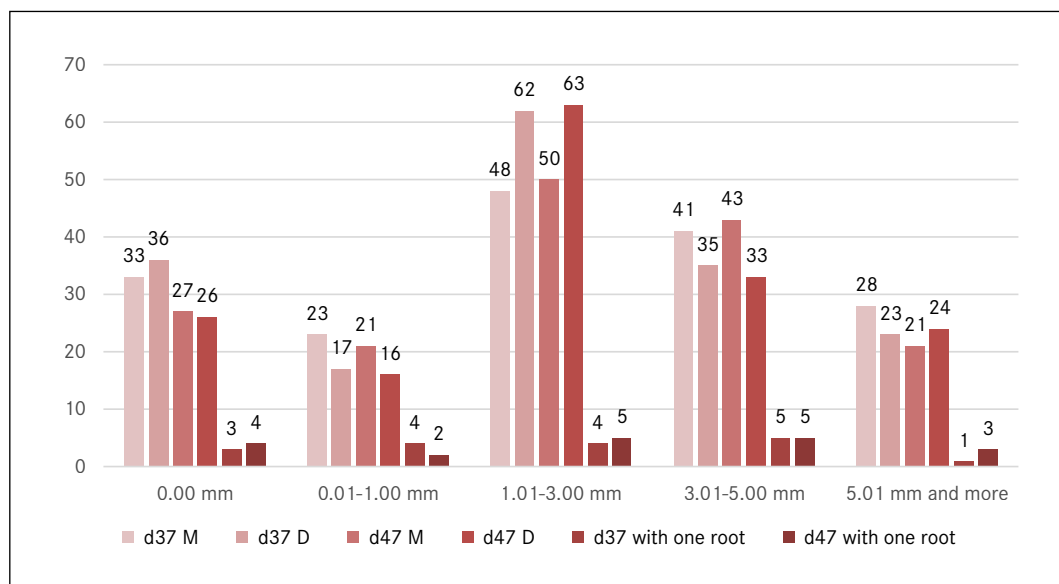


Figure 1. Frequency distribution of the distance from the root apex of second mandibular molars to the mandibular canal in categories.

When evaluating the contact with the mandibular canal, in the case of the d37 mesial root, in 31 cases out of 173 measurements the root was in direct contact (17.9%), while in 2 cases it completely penetrated the canal (1.2%). As for the distal root, there was direct contact in 35 cases (20.2%) and penetration in one case (0.6%). For the right mandibular second molar, the mesial root showed direct contact in 26 cases (16.1%) and penetration in one case (0.6%), while the distal root had direct contact in 24 cases (14.8%) and penetration in two cases (1.2%). For single-rooted second molars, penetration was not observed, however, direct contact was noted in 17.6% of d37 cases and 21.1% of d47 cases. See Table 1.

Table 1. Contact of the root apices of second mandibular molars with the mandibular canal.

	No contact (%)	Direct contact (%)	Penetration (%)
d37 M	140 (80.9)	31 (17.9)	2 (1.2)
d37 D	137 (79.2)	35 (20.2)	1 (0.6)
d47 M	135 (83.3)	26 (16.1)	1 (0.6)
d47 D	136 (84.0)	24 (14.8)	2 (1.2)
d37 with one root	14 (82.4)	3 (17.6)	0 (0.0)
d47 with one root	15 (78.9)	4 (21.1)	0 (0.0)

The position of the mandibular canal relative to the root tips of the second mandibular molars was examined. Obtained results see in Table 2.

Table 2. The position of mandibular canal in relation to the apices of second mandibular molar roots.

	Apical (%)	Buccal (%)	Lingual (%)
d37 M	168 (97.1)	4 (2.3)	1 (0.6)
d37 D	162 (93.6)	8 (4.6)	3 (1.7)
d47 M	158 (97.5)	3 (1.9)	1 (0.6)
d47 D	155 (95.7)	4 (2.5)	3 (1.9)
d37 with one root	15 (88.2)	2 (11.8)	0 (0.0)
d47 with one root	16 (84.2)	3 (15.8)	0 (0.0)

The distance from the root apex to the mandibular canal between genders was evaluated using the Mann-Whitney U-test and the following results were obtained: the distribution of the distance between the root apex of the tooth and the mandibular canal for the mesial root of d37 is statistically significantly different between genders ($U=4474.5$, $p=0.005$), with the median for women being 1.77 mm (IQR 0.00–3.42) and for men 2.72 mm (IQR 1.52–4.70).

This distance is also statistically significantly different for the distal root of the same tooth ($U=4509.5$, $p=0.009$), with the median for women being 1.65 mm (IQR 0.00–3.35), and the median for men being 2.47 mm (IQR 1.23–3.96). The obtained data are summarized in Table 3.

Table 3. Mann-Whitney U-test: distance from root apex to the mandibular canal by gender.

	Gender	Count	x (SD), mm	Me (IQR), mm	Amplitude, mm	p value
d37 M	woman	99	2.26 (2.25)	1.77 (0.00–3.42)	0.00–10.36	0.005
	man	74	3.11 (2.22)	2.72 (1.52–4.70)	0.00–9.31	
d37 D	woman	99	2.15 (2.18)	1.65 (0.00–3.35)	0.00–10.42	0.009
	man	74	2.90 (2.14)	2.47 (1.23–3.96)	0.00–9.02	
d47 M	woman	90	2.54 (2.15)	2.34 (0.89–4.11)	0.00–9.62	0.431
	man	72	2.86 (2.31)	2.49 (0.91–4.22)	0.00–9.62	
d47 D	woman	90	2.31 (1.98)	1.96 (0.61–3.66)	0.00–8.49	0.103
	man	72	2.92 (2.29)	2.47 (1.29–4.45)	0.00–9.61	
d37 with one root	woman	8	2.23 (1.62)	2.11 (0.91–3.49)	0.00–4.84	0.815
	man	9	2.51 (2.66)	2.01 (0.30–4.48)	0.00–7.89	
d47 with one root	woman	9	2.55 (2.03)	2.47 (0.81–4.38)	0.00–5.73	0.661
	man	10	2.39 (2.56)	1.90 (0.00–4.03)	0.00–7.82	

Discussion

Based on the data available in the literature, the tooth with the shortest distance between the root apex and the mandibular canal is the second mandibular molar, therefore it was chosen for the study (Byun et al., 2016; Kovisto et al., 2011).

Summarizing the results obtained in the study on the distance from the root apex of the mandibular second molar to the mandibular canal, it was found that the most common distance category is 1.00–3.01 mm. These data are closely comparable to those of Byun et al. publication, where the distance from the root apex to the border of the mandibular canal varied from 0.77 to 3.01 mm (average 1.36 mm) (Byun et al., 2016). In the study by Bürklein et al., this distance was slightly larger, averaging 3.5 mm for the mesial root of d37 and 3.4 mm for the mesial root of d47, while for the distal roots of d37 and d47, respectively, 2.7 and 2.9 mm (Bürklein et al., 2015).

When evaluating the contact of the tooth root with the mandibular canal, it was concluded that

direct contact with the mandibular canal was detected in up to 21.1% of cases. In addition, up to 1.2% of cases were cases where the root of the tooth had not only touched, but had already completely penetrated the mandibular canal, which means that the risk of complications during root canal treatment for such teeth is very high. Similar results were obtained in a study by Nair, et al: in the case of d37, direct contact of the root apex with the mandibular canal was observed in 13.6% and in the case of d47, 20.4% (Nair et al., 2013).

When analysing the obtained data on the distance from the roots of the second mandibular molar to the mandibular canal depending on gender, a statistically significant difference was obtained in the case of double rooted d37, respectively, in women this distance is more likely to be smaller (closer to 0.00 mm), while in men it is more likely to be larger (3.01 mm and more). This coincides with Bürklein et al. obtained results, where in women the distance from the root apex to the canal border is also slightly smaller, and direct contact is more often observed. For other variations of the mandibular second molars (teeth with one root and d47 in the case of two roots), such a statistically significant difference was not obtained, and these different results can be explained by the fact that in our study the patient groups were smaller than, for example, Bürklein et al., where 508 mandibular second molars were examined. Such a gender-related difference can be observed because in men the body structures themselves are larger than in women, therefore the distance between the mandibular nerve and the root apex of the mandibular teeth is also greater (Bürklein et al., 2015).

Accurate assessment of the relationship between the roots of second mandibular molars and the mandibular canal is essential for minimizing the risk of iatrogenic complications during endodontic procedures. From a prophylactic standpoint, the use of CBCT in complex or high-risk cases allows for more informed treatment planning, reducing the likelihood of over-instrumentation or material extrusion and thereby enhancing patient safety. If a preoperative periapical radiograph suggests that the mandibular canal is in close proximity to the roots of a mandibular second molar, the clinician should carefully evaluate the need for CBCT examination to obtain more accurate information and reduce the risk of complications. The primary limitation of periapical radiographs is their two-dimensional nature, this can create the false impression that the mandibular canal is in direct contact with the tooth roots, when in fact it may be located buccally or lingually, out of the plane of the image.

Conclusions

- Direct contact between the apex of the root of the second mandibular molar and the mandibular canal is a relatively common.
- In majority of cases, the distance between root apices and the canal is less than 3.00 mm.
- In 16.1–21.1% of cases direct contact with the canal is observed, while penetration is noted in up to 1.2% of cases.
- The risk of complications can be minimized through:
 - Careful preoperative assessment of anatomical structures;
 - Proper instrumentation and obturation techniques;
 - Use of appropriate imaging, such as CBCT when indicated.

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