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Correlation between the Middle Mesial Canal and Furcation Radiolucency in Mandibular Molars

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Introduction: The middle mesial canal (MMC) of mandibular molars is of particular interest in endodontics due to its complexity. This study investigated the association between MMC presence in first and second mandibular molars and the radiolucency in the furcation area using cone-beam computed tomography (CBCT) scans. **Materials and Methods:** CBCT scans of 400 patients referred to the largest radiology center in Kerman City from January 1, 2022, to January 1, 2023, were examined. All CBCT scans were assessed for radiolucency in the furcation area and the presence of MMC. Variables, including age, gender, tooth number, and MMC presence were recorded. Chi-squared tests and logistic regression analyses were employed to compare MMC frequency and its impact on furcation radiolucency. **Results:** Of 201 examined teeth, 37 (18.4%) had MMC, and 23 (11.4%) exhibited furcation radiolucency. However, teeth with a mesial canal showed a higher prevalence of furcation lesions compared to those without (38% *vs.* 5.2%) (P<0.001). A significant association was observed between a mesial canal and furcation radiolucency, with odds of furcation radiolucency at 12.7 after controlling for age and gender (P<0.001). **Conclusion:** A strong association exists between MMC presence in first and second mandibular molars and furcation radiolucency, unaffected by age and gender.

Keywords: Endodontics; Cone-beam Computed Tomography; Furcation Lesions; Middle Mesial Canal

Introduction

The anatomical complexity of mandibular molars, particularly their root canal systems, poses significant challenges in endodontic treatments [1, 2]. Among these complexities, the middle mesial canal of the first and second mandibular molars (MMC) has been particularly interesting, specifically in relation to furcation lesions [3-6].

Furcation lesions are characterized by the loss of bone and attachment in the area between the roots of teeth, posing challenges for traditional dental treatments. These challenges primarily stem from various factors related to tooth morphology, periodontal health, and endodontic conditions [7]. Several factors contribute to the development of furcation lesions, including root anatomy (such as divergence, fusion, and concavities), the length of the root trunk, the relationship between the crown and root, occlusal factors, age, habits like smoking, and the presence of endodontic or endoperiodontal issues [8, 9]. However, the specific role that MMCs may play in the development of these lesions remains unclear.

The critical nature of detecting and treating MMC has led to numerous research endeavors in recent times. Kuzekanani *et al.* [10] used CBCT imaging to investigate the presence of MMC in the first molars of the lower jaw. The prevalence of MMC was 8.1%, which was higher in women (10.0%) than in men (6.3%). Another study by Honap *et al.* [11] compared CBCT and dental microscopy in locating MMC in both the first and second molars of the lower jaw, revealing prevalences of 13.33% and 18.33%, respectively. This slight discrepancy underscores the need for careful evaluation before opting for CBCT scans. Aldosimani *et al.*

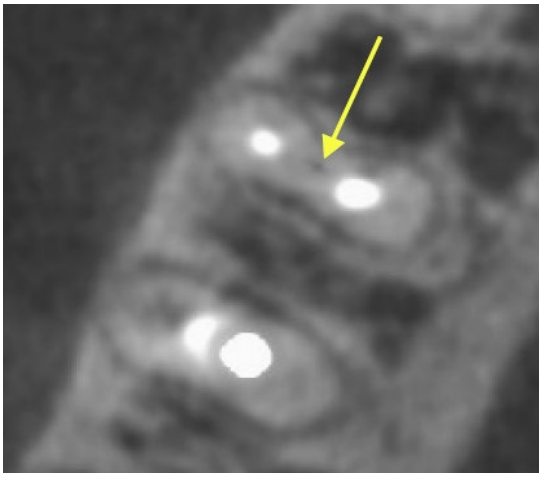

Figure 1. A cross-sectional view of a mandibular molar with MMC is highlighted (indicated by the yellow arrow) in the cone-beam computed tomography (CBCT) image

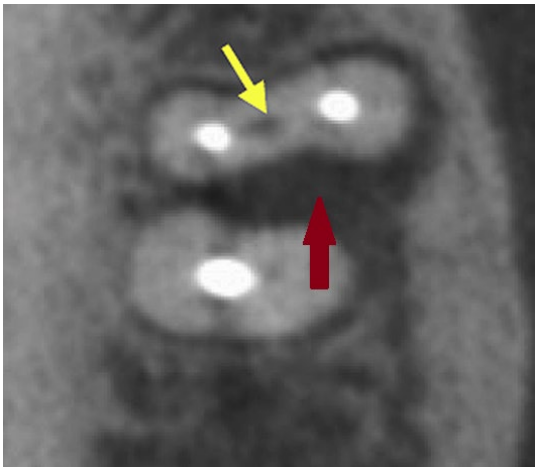

Figure 2. A cross-sectional view of a mandibular molar with the MMC (the yellow arrow) with furcation radiolucency (the red arrow) highlighted in the cone-beam computed tomography (CBCT) image

[12] in Saudi Arabia in 2021 also studied the prevalence of MMC in an Arab population, showing a low occurrence and no notable influence from gender, tooth side, or age group. Meanwhile, in a 2022 study in Brazil, Barros-Costa *et al.* [13] explored the prevalence of middle mesial root canals and their association with tooth anatomy, finding a higher prevalence in the first molars of the lower jaw compared to second molars, with certain anatomical features aiding in canal identification. While much research has focused on the prevalence and detection of MMCs, less attention has been given to their potential role in contributing to pathological conditions such as furcation lesions

Although CBCT has revolutionized the detection of anatomical anomalies such as MMCs [7, 8], there is still uncertainty regarding whether the presence of MMCs is associated with increased susceptibility to furcation lesions. This represents a critical gap in the current understanding of MMCs and their broader clinical implications. Therefore, this study investigated the association between the presence of the MMC in the first and second mandibular molars and the development of radiolucency in the furcation area using CBCT scans.

Materials and Methods

Study design and study population

In this cross-sectional study, CBCT scans of patients referred to the largest radiology center in Kerman City were examined. The CBCT scans were conducted for diagnostic and treatment planning purposes during routine dental examinations from January 1, 2022, to January 1, 2023. All the CBCT scans were obtained from a single oral radiology center, and the institutional review board reviewed and approved the project protocol.

The sample size was calculated based on the study by Honap *et al.* [11], which reported a 13% prevalence of the MMC. Therefore, 87% of the cases did not have MMC. Considering a significance level (α) of 0.05, a power (β) of 0.8, an odds ratio of 3, and a case-control ratio of 1:5, a minimum of 32 cases and 161 controls were required, as calculated using GPower 3.1 software (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany).

Inclusion criteria

1. First and second molar teeth of the lower jaw with root canal treatment
2. Presence of dental restorations

Exclusion criteria

1. Teeth with an undetectable mesiobuccal or mesiolingual canal
2. Teeth with root fractures
3. Teeth with internal or external resorption
4. Teeth with primary periodontal lesions
5. Teeth without full eruption
6. Teeth with recurrent caries

Data collection

Images with a field of view (FOV) of 8×8 cm, a resolution of 0.2 mm, a slice thickness of 0.3 mm, and a slice interval of 0.5 mm were used, with optimal exposure settings for each patient. MMC was identified if a clear round or oval radiolucency was observed between the mesiobuccal and mesiolingual canals in the axial view. Each tooth examined in the CBCT scans was assessed for radiolucency in the furcation area, and the presence of MMC was identified if a clear round or oval radiolucency was observed between the mesiobuccal and mesiolingual canals in the axial view (Figures 1 and 2).

To evaluate CBCT images, a postgraduate endodontics student received training from an endodontist and an oral and maxillofacial radiologist to identify lesions and MMC. Subsequently, the student evaluated 10 random images under appropriate lighting conditions (in a dimly lit room), all of which were assessed correctly. After this initial phase, the postgraduate student independently evaluated the study's CBCT scans. To assess inter-rater reliability, we employed Cohen's kappa statistic. A subset of 20 images was randomly selected for independent evaluation by the postgraduate student and an experienced endodontist. The inter-rater agreement for lesion identification between the two raters was calculated using kappa, with a kappa value of 1, indicating perfect agreement. Additionally, all the CBCT scans evaluated by the postgraduate endodontics student were checked and confirmed by an experienced endodontist.

Variables such as age, gender, tooth number, and the presence of MMC were recorded. The chi-squared test was used to compare the frequency of the MMC between the two groups. Logistic regression analysis was employed to assess the impact of variables such as age, gender, tooth number, and the presence of the MMC on the presence of furcation radiolucency. Previous studies revealed that the prevalence of MMCs varies with age and sex [14-18]. Previous studies revealed that the prevalence of MMCs varies with age and gender. Therefore, we considered these variables as potential confounders. The significance level for this study was set at 5%.

Results

In this study, CBCT scans of 400 patients were evaluated. A total of 124 images and 201 teeth meeting the inclusion criteria were selected. Among the patients investigated, 85 were female and 39 were male. The age range was 22–71 years, with a mean age of 43.7 (SD=11.29).

Of the teeth analyzed, 31.5% were right first molars, 24.5% were left first molars, 19% were left second molars, and 25% were right second molars, with no significant difference between them (P=0.099).

Of the 201 examined teeth, 37 (18.4%, 95% CI=13%, 23.8%) had a mesial canal, and 23 (11.4%, 95% CI=7%, 15.9%) had furcation radiolucency. The prevalence of furcation lesions and mesial canals did not differ significantly between the two sexes (P=0.879 and P=0.069, respectively). There were no significant associations between age and furcation radiolucency or the presence of mesial canals (P=0.749 and P=0.198, respectively).

The prevalence of furcation lesions in teeth without a mesial canal was 5.2% (95% CI=2.9%, 9.2%), and in teeth with a mesial canal, it was 38% (95% CI=21.4%, 54.2%) (P<0.001). Univariate analysis revealed that the odds of furcation radiolucency were 10.4 times higher in cases where a mesial canal was present (P<0.001). However, after controlling for the effects of age and gender, the odds of furcation radiolucency in the presence of a mesial canal increased by 12.7 times (P<0.001). Additionally, age and gender did not significantly impact the odds of furcation radiolucency in both univariate and multivariate analyses (Table 1).

Discussion

The primary aim of this study was to investigate the relationship between the presence of the MMC in the first and second mandibular molars and the development of radiolucency in the furcation area using CBCT scans. The results demonstrated a strong association between the presence of a furcation radiolucency and the presence of a middle mesial canal. Furthermore, this relationship was independent of age or gender.

Furcation lesions primarily result from perforations, accessory canals, and mesial roots [19]. In this study, teeth with perforations were excluded, and accessory and mesial canals were considered the remaining factors. Limited studies are available on the prevalence of accessory canals in the furcation area. A study conducted in Turkey on 200 molar teeth showed that furcation lateral canals were present in 24% of the first upper molars, 16% of the second upper molars, 24% of the first lower molars, and 20% of the second lower molars [20]. Another study examining 102 teeth found that 25.5% of molar teeth had accessory canals in the furcation area. [21]. Hence, furcation lateral canals are anticipated to have a notable prevalence in the furcation area. The advancement of periodontal disease can expose accessory canals to bacterial contamination, a phenomenon more frequently observed in the apical third and furcation area of the tooth [22-24]. It is also conceivable that bacterial contamination of accessory canals may result in bacterial leakage into the furcation area, leading to lesions. However, given the location of the mesial root, it might exert a more significant influence on bacterial transmission. Therefore, untreated mesial canal infections are highly likely to contribute to the development of lesions in the furcation area.

Table 1. Association between the presence of middle mesial canal, age, gender, and furcation radiolucency

Variable	Crude OR	*P*-value	95% CI (crude OR)	Adjusted OR	*P*-value	95% CI (adjusted OR)
Middle mesial canal (presence, absence)	10.4	<0.001	(4.07, 26.97)	12.7	<0.001	(4.62, 35.03)
Age	0.9	0.647	(0.94, 1.03)	0.9	0.71	(0.94, 1.03)
Gender (female *vs.* male)	2.1	0.088	(0.89, 5.32)	2.6	0.055	(0.97, 7.40)

CI, confidence intervals; OR, odds ratios

This study revealed that the relationship between the presence of the mesial canal and furcation lesions remains unaffected by age and gender. Age serves as a surrogate variable for the time until the occurrence of the outcome. Similarly, there was no significant difference in age between the two groups, justifying this result. Likewise, the presence of lesions and canals in both genders is not expected to significantly impact the relationship. In this study, the prevalence of the middle mesial canal among the examined teeth was 18.4%. However, the prevalence of the middle mesial canal can vary depending on the study and the population under investigation. For example, in a multinational cross-sectional study with meta-analysis, the overall prevalence of MMC was estimated to range between 1% and 23% worldwide, with an average estimate of 7% [18]. A systematic review and meta-analysis of studies revealed that the global prevalence of the middle mesial canal in the first molar was 4.4% [25]. A study conducted on CBCT scans in a southern Chinese subpopulation revealed that the incidence of the middle mesial canal was 9.03% [26]. In an in vivo survey of lower jaw molars, the middle mesial canal was found in 42 out of 91 teeth, corresponding to a prevalence of 46.2% [16]. Another study demonstrated that the prevalence of the middle mesial canal in the first molar was 26%, while in the second molar, it was 8% [15]. A study analyzing data from 1000 lower jaw molars revealed that the incidence of the middle mesial canal was 32.1% in patients under 20 years of age, 23.8% in patients aged 21–40 years, and 3.8% in patients over 40 [27]. Considering the range of reported prevalence or incidence values for this condition, the prevalence of the middle mesial canal in this study falls within the range reported in other studies.

In the present study, CBCT scans were evaluated to determine the presence of the MMC and associated lesions. This method proved effective in diagnosing the MMC. The findings underscored the utility of CBCT imaging in MMC diagnosis, demonstrating that troughing, magnification, and CBCT could significantly enhance MMC identification [28]. A comparative analytical study reported that CBCT achieved a sensitivity of 100% in diagnosing periapical lesions, whereas two-dimensional techniques (periapical radiography and panoramic radiography) exhibited a sensitivity of 82% [29]. Another study revealed that CBCT exhibited a false positive rate of 42% in diagnosing periapical lesions [30]. An in vivo study demonstrated that the prevalence of MMCs identified using CBCT was 13.33%, which was lower than the prevalence diagnosed using dental microscopy (18.33%) [31]. In this study, alternative methods for identifying the MMC were not feasible. Nonetheless, given that CBCT scans were examined by both a postgraduate endodontic student and an experienced endodontist, it is anticipated that diagnostic errors related to MMC and furcation radiolucency were minimized. However, it is crucial to consider potential false positive findings associated with CBCT. It is unlikely that any errors in MMC diagnosis would strongly correlate with the presence of lesions, which might explain the observed relationship.

In the present study, a strong relationship was observed between the presence of mesial roots and furcation lesions. The odds ratio was used to determine association, which typically portrays the relationship's strength as larger than the risk ratio. Despite this bias associated with using the odds ratio, the observed relationship still indicates a strong association.

The limitations of this study include its single-center nature. Therefore, it is recommended that future multi-center studies be conducted on this topic to enhance generalizability. Additionally, the sample size of this study is limited, suggesting that future studies should be conducted with a larger sample size to improve statistical power. A large, multi-center study within a 5-year birth cohort of a population can investigate the relationship longitudinally with risk ratio indices. In such a study, biases related to the odds ratio would also be significantly reduced.

Conclusion

A strong association exists between the presence of middle mesial canals and radiolucency in the furcation area of the first and second mandibular molars, and this relationship remains unaffected by age and gender.

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Conflict of interest

None.

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Authors' contributions

Conceptualization: AS; Methodology: AS; Formal Analysis and Investigation: MK, AS, RF, HE, AHN, SA, SR; Writing-Original draft preparation: MK, AS, RF, HE, AHN, SA, SR; Writing-review and editing: MK, AS, RF, HE, AHN, SA, SR; Supervision: RF. All authors read and approved the final manuscript.

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