Assessment of the prevalence and configuration of middle distal canals in the mandibular molars in a Saudi subpopulation using Cone-Beam computed tomography

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Abstract
Purpose: The prevalence of the middle distal (MD) canal in the mandibular molar is significantly low among countries including the USA, Spain, Turkey, and Jordan; however, analysis of its prevalence and configuration has not been performed in Saudi Arabia. Therefore, we aimed to assess the prevalence and configuration of the MD canal in Saudi Arabia.

Methods: A retrospective analysis of 132 cone-beam computed tomography (CBCT) images was performed to evaluate the presence of the MD canal in patients visiting the Radiology Department
Assessment of the prevalence and configuration of middle distal canals in the mandibular molars in a Saudi subpopulation using CBCT.

1. Introduction

The primary purpose of root canal therapy is to shape and clean the entire root canal system before obturating it with a root filling material (Vertucci, 1974). The incomplete removal of pulp tissue and failure in eradicating microorganisms from the root canal systems are considered significant reasons for root canal treatment failure (Ricucci et al., 2009). Therefore, clinicians must have adequate knowledge of the root canal anatomy and its different anatomical variations to obtain a high level of treatment success (Baruwa et al., 2020).

Mandibular molars have a complex and varying root canal anatomy (Mannocci et al., 2005). The mandibular first and second molars generally have two roots (mesial and distal) with two mesial and one or two distal canals (Vertucci, 1984). Secondary dentin deposition has been reported to be a principal determinant in the form and number of root canals that cause a wide variation in root canals, which were primarily in simple form (Thomas et al., 1993).

The presence of an extra root canal in the distal root of the mandibular molars is called the middle distal (MD) canal (Gaéta-Araujo et al., 2019), which is rarely observed, and its occurrence ranges from 0% to 22.5% (Sperber and Moreau, 1998; Sert et al., 2004; Mukhaimer, 2014; Calişkan et al., 1995; Al-Qudah and Awawdeh, 2009; Ahmed et al., 2007; Filpo-Perez et al., 2015; Alashiry et al., 2020). Different methods have been used to detect the presence of MD canals, including radiography (Fabra-Compos, 1985; Cunningham and Senia, 1992), clearing (Sperber and Moreau, 1998; Sert et al., 2004; Calişkan et al., 1995; Al-Qudah and Awawdeh, 2009; Ahmed et al., 2007), cone-beam computed tomography (CBCT) (Fabra-Compos, 1985), and micro-computed tomography (Filpo-Perez et al., 2015; Alashiry et al., 2020).

The prevalence and configuration of MD canals have not been assessed in Saudi Arabia. Therefore, the present study aimed to evaluate the prevalence and configuration of the MD canals in a Saudi subpopulation using CBCT.

2. Materials and methods

2.1. Sample selection and study design

This study was approved by the Ethics Committee of College of Dentistry, King Saud University (IRB #E-18–3277). In total, 132 CBCT images were obtained from 132 patients (92 women and 40 men), aged 17 to 70 years who were sent to the Radiology Department for regular dental care between July 2018 and July 2019. The power analysis indicated that 102 cases were at least required to detect a group difference of at least 0.0% vs. 22% MD canal prevalence (Table 1) with a 95% confidence interval and 95% power in a z-test for independent proportions.

Each image included at least one sound mandibular right or left first and/or second molar with fully formed roots. CBCT images that were unclear or blurred, cases with previously initiated root canal treatment or treated teeth, cases with posts or crown reconstruction, periapical lesions, and any clinical or pathological mechanism such as open apex were all excluded. The final sample comprised of 145 mandibular molars (68 mandibular first molars and 77 mandibular second molars).

2.2. Image evaluation

The following data were evaluated and recorded: age, sex, molar type (first or second mandibular molar), presence/absence of an MD canal, and the anatomical configuration of the existing MD canal. The age of the patients was divided into four groups: group 1 (16–25 years), group 2 (26–35 years), group 3 (36–45 years), and group 4 (≥46 years).

A classification similar to the one proposed for middle mesial canals by Pomeranz et al. (1981) has been used for the MD canal by replacing the mesial canal with the distal canal. The classification was described as follows: type I “fin”: the file passes freely between the main canals and the extracanal (transverse anatomies), type II “confluent”: the extracanal originates as a separate orifice but apically joins to one of the main canals, and type III “independent”: the extracanal originates as a separate orifice and terminates as a separate apical foramen. Moreover, measurements for the distance between the orifice of the MD canal and main distal canals and from the cementoenamel junction (CEJ) up to the detection of the MD canal orifice were also recorded (Fig. 1).

Two endodontists analyzed the images of this retrospective CBCT using Planmeca ProMax 3D (PLANMECA, Roselle, IL, USA) with a voxel size of 90–300 μm. The imaging factors were constant for all CBCT scans as follows: field of view 170 × 120 mm, 90 kv, 5–8 mA, and 15 s exposure time. Serial buccolingual, mesiodistal, and coronoapical CBCT sections of the molar were evaluated continuously by moving the toolbar from the pulp chamber floor to the apex to determine the pre-
ence or absence of the MD canal and its canal configuration. After determining an MD canal, a maxillofacial radiologist confirmed whether it was a true canal or an isthmus.

2.3. Statistical analyses

To ensure the reliability of the study findings, 10 CBCT images were randomly selected to assess the inter-examiner reliability by reporting the presence and orientation of the MD canals in the mandibular molars. After 1 week, the intra-examiner reliability was tested using the same images. The interclass correlation coefficient (ICC) was used to measure both inter- and intra-examiner reliability (ICC). To achieve data reliability, an intra-examiner calibration based on the anatomical diagnosis of the CBCT images was performed before the experimental reading. Using the Statistical Package for the Social Sciences (SPSS), the ICC was calculated to determine the reliability of the measurement.

### Table 1
Prevalence of the middle distal canals in the mandibular first and second molars in different populations.

| Author                  | Year  | Population    | Technique | Number of teeth examined | MD canals (%) |
|-------------------------|-------|---------------|-----------|--------------------------|---------------|
| Fabra-Compos, 1985      | 1985  | Spain         | Radiography | 145 (1st)                | 0.6           |
| Cunningham and Senia, 1992 | 1992 | United States | Radiography | 60 (1st)                 | 1.7           |
| Calişkan et al., 1995   | 1995  | Turkish       | Clearing  | 100                      | 1.7           |
| Sperber and Moreau, 1998 | 1998 | Senegalese    | Clearing  | 480                      | 0.2           |
| Sert et al., 2004       | 2004  | Turkish       | Clearing  | 200                      | 1             |
| Ahmed et al., 2007      | 2007  | Sudanese      | Clearing  | 100 (1st)                | 3             |
| Al-Qudah and Awawdeh, 2009 | 2009 | Jordanian     | Clearing  | 330 (1st)                | 0.3           |
| Mukhairer, 2014         | 2014  | Palestinian   | CBCT      | 320 (1st)                | 0.0           |
| Filpo-Perez et al., 2015 | 2015 | Brazil        | Micro-CT  | 100 (1st)                | 8             |
| Alashiry et al., 2020   | 2020  | Egypt         | Micro-CT  | 240                      | 22.5%         |
| Current study           | 2020  | Saudi         | CBCT      | 68 (1st)                 | 0.7           |
|                         |       |               |           | 77 (2nd)                 | 0.0           |

*Fig. 1* CBCT of mandibular first molar. (a) Axial view measuring the distance between the orifice of MD canal and main distal canals. (b) Sagittal view measuring the distance from CEJ to the MD canal orifice. CBCT: Cone-beam computed tomography, MD: Middle distal, CEJ: Cementoenamel junction.
and tooth clearing techniques (Neelakantan et al., 2010). In
uate the root canal system similar to modified canal staining
ment (Vertucci, 2005; Allen et al., 1989).
that contribute to the failure of the primary root canal treat-
Missed untreated root canals are considered as a major cause
examination is essential to detect such possible variations.
thus, this variation should always be considered at the start
of root canal therapy. A thorough clinical and radiographic
lation was observed in an 18-year-old female patient. The
distance between the DB and MD canal was 1.9 mm, the dis-
tance between the DL and MD canal was 1.4 mm, and the dis-
tance from the CEJ to the orifice of MD canal was 3.1 mm.
Another MD canal was excluded by the maxillofacial radiolo-
gist because it was not a true MD canal.

4. Discussion

Our objective was to investigate the prevalence and configura-
tion of the MD canal in a Saudi subpopulation. The preva-
ence of the MD canal in Saudi Arabia was found to be
significantly low at 0.7%. The canal was closer to the DL canal
and away from the CEJ by 3.1 mm.
The root canal system has different anatomical variations;
thus, this variation should always be considered at the start
of root canal therapy. A thorough clinical and radiographic
examination is essential to detect such possible variations.
Missed untreated root canals are considered as a major cause
that contribute to the failure of the primary root canal treat-
ment (Vertucci, 2005; Allen et al., 1989).
CBCT imaging was reported to be an accurate tool to eval-
uate the root canal system similar to modified canal staining
and tooth clearing techniques (Neelakantan et al., 2010). In
the current study, CBCT images were used to evaluate the
presence of the MD canals in the mandibular first and second
molars. The proportion for the number of root canals in the
mandibular first molars in a Saudi subpopulation were
reported to be in the range of 1.7% for two canals, 42.23%–
73% for three canals, and 25.3%–57.76% for four root canals
(Mashyakhly et al., 2019; Al-Nazhan, 1999). The prevalence
rate of the MD canals in this study was 0.7%, which was
higher than that of a previous study (0.0%) by Mukhaimer
(2014) using CBCT. Other studies had varying prevalence rates
of the MD canals due to different methodologies and races in
these prior studies (Sperber and Moreau, 1998; Sert et al.,
2004; Fabra-Compos, 1985; Cunningham and Senia, 1992;
Calışkan et al., 1995; Al-Qudah and Awawdeh, 2009;
Ahmed et al., 2007; Filpo-Perez et al., 2015; Alashiry et al.,
2020).
Different studies have emphasized that the root canal sys-
tem changes are associated with age as old patients have less
number of canals due to dentinal metamorphosis; a better
understanding of these changes influences the provision of
restorative and endodontic care (Walton, 1997; Smith et al.
1993; Murray et al., 2002; Dammaschke et al., 2003;
Basmadjian-Charles et al., 2002). The results of the current
study further reinforce these findings and show distinct devel-
opmental patterns of canal morphology, especially in young
women. It has been reported that women had greater incidence
of the presence of five root canals (both roots combined) than
men in the mandibular first molars (Kim et al., 2013).
Gupta et al. (2012) have reported that the MD canals were
found to be confluent with their respective distobuccal canal at
the junction of the middle and apical one-thirds. It is inconsis-
tent with our findings in that the MD canal was closer to the
distolinguinal canal orifice compared to the distobuccal canal
orifice (distance = 1.4 mm and 1.9 mm, respectively). It is dif-
ficult to determine the possible reason for our recent findings
because Gupta et al.’s study was a single case report and we
found only one case in a large sample size in our study.
This study has a limitation in that this was a retrospective
CBCT study. A study using micro-CT would show a more
accurate internal anatomy, and the prevalence of the MD
canal might become higher due to its higher resolution
(Alashiry et al., 2020). Although the sample size analysis
requires at least 102 cases, we cannot perform a statistical anal-
ysis on only one case compared to the remaining cases, which
would make it statistically biased. Therefore, a multicenter
study should be conducted to determine more cases, perform
a statistical analysis, and identify associated variables.

5. Conclusion

Considering the limitation of this study, the prevalence of the
MD canal in a Saudi subpopulation is significantly low. CBCT
is one of the most important tools that can be used to explore
the complex root canal anatomy, especially with the use of
small field of view with high resolution for dose reduction
and accuracy. Careful evaluation of radiographic images and
access cavity will provide clinicians with adequate knowledge
on the anatomical variations of the root canal of the teeth,
which will subsequently improve the outcomes of endodontic
treatment.

Ethical Statement

This study was approved by the Ethics Committee of College
of Dentistry, King Saud University (IRB #E-18-3277)

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Appendix A. Supplementary material

Supplementary data to this article can be found online at
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