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ORIGINAL ARTICLE


# Prevalence of Extra Root Canal Orifices of Maxillary First Permanent Molars in a Saudi Subpopulation Utilizing Microcomputed Tomography

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## ABSTRACT

**Aim:** To study the prevalence of additional root canal orifices of upper first permanent molars in Saudi subpopulation in Jeddah, Kingdom of Saudi Arabia, utilizing micro-computed tomography X-ray (micro-CT).

**Materials and methods:** One hundred extracted upper first permanent molars of Saudi patients were included in the study. Micro-CT was used to detect the prevalence of extra root canal orifices of the permanent upper first molars.

**Results:** The evaluation of three-dimensional (3D) images of this study showed that of 100 upper permanent first molars scanned and analyzed, 10.53% had 6 pulp canal orifices, 35.09% had 5 pulp canal orifices, 47.37% had 4 pulp canal orifices and 7.01% had 3 pulp canal orifices.

**Conclusion:** The current data showed the highest prevalence of 4 and 5 root canal orifices compared to 3 and 6 root canal orifices.

**Clinical significance:** The knowledge of anatomic variations of teeth before starting root canal treatment can help dentists to detect and manage all root canals successfully.

**Keywords:** *In vitro* study, Maxillary first molars, Microcomputed tomography (micro-CT), Root canal orifices.

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**Conflict of interest:** None

## INTRODUCTION

Recognition of all root canals for its sufficient cleaning is directly related to successful endodontic therapy. Understanding the difficulty of pulp canal system and designing the treatment relies on the examination of internal anatomy.[1,2] Many investigations were made to examine the configuration of root canal system using radiograph, decalcification, sectioning, replication and computerized-added techniques.[3]

New scientific knowledge is constantly developing to strengthen researches in endodontics. The X-ray micro-CT, which is the integration of X-ray microscopy and tomographical reconstruction, has been used as a strong aid for *in vitro* assessment of many endodontic treatment phases.[4-6] Accurate 3D the rebuilding of the complicated form of the root canal filling and specifics not detectable by 2D X-rays are demonstrated by the micro-CT technique.[7-9] Micro-CT gives very clear images that can be combined producing a 3D image that can be analyzed with modeling computer program. Micro-CT imaging can provide a comprehensive analysis of the endodontic morphology without damaging of specimens gave a novel view to endodontic studies. It has been successfully used to see root morphology difficulty, to examine canals instrumentation effectiveness and to assess the goodness of canal obturation in several aspects.[10-13]

Micro-CT has several advantages when compared to other methods, but at the same time, it has some restrictions. Confocal laser microscopy, scanning electron microscopy (SEM) and stereomicroscope can give surface anatomy but not 3D pictures without the need of specimens dividing. Besides, the little volume size of micro-CT (5 to 50 μm) results in increased resolution

in comparison with cone-beam computed tomography (CBCT). By the use of micro-CT, the same sample could be used for different tests without destruction. This allows the evaluation of root canal volume or is a pre-and post-treatment and quality of pulp canal obturation (PCO). More benefits of micro-CT are that image control can be done using a special computer program, and the scanning can be redone. Regarding micro-CT restrictions, there is a difficulty of using it in in vivo studies due to the radiation amount of subjection. Furthermore, micro-CT allows evaluation of small samples, which limits testing.[14-18]

Several elements participate to variations in pulp and root canal morphology including ethnic background, age, and gender of the examined community. Pulp canals variations and number among different people are investigated in many studies. Many of them concentrated on permanent molars, particularly first permanent molars due to their extensive differences from one community to another.[19-21]

Although the maxillary first permanent molars are important for the masticatory system, they are the most susceptible to dental decay due to their early eruption in the oral cavity, their function, size and shape which leads to endodontic treatment.[22,23]

It is commonly approved that maxillary first permanent molars have three or four pulp canals; mesiobuccal (MB/2 MB), distobuccal (DB) and palatal (P), however, previous researches reported extra canals in the P and DB roots. Several studies demonstrated the presence of 5, 6, 7 and 8 canals.[24-28]

Detection of the root canal orifices often difficult because of the dentine ledge that may cover it at the pulp chamber floor. Failure to locate root canal orifices and treat all root canals were related to recurrent failure of root canal treatment (RCT).

Fine details of the widespread presence of additional root canal orifices of permanent upper first molars in a Saudi community using micro-CT have not been investigated before. Therefore, the purpose of this study was to show the prevalence of extra root canal orifices, regardless of the type of the root canal, in permanent upper first molars in Saudi subpopulation in Jeddah, Kingdom of Saudi Arabia, utilizing micro-CT.

## MATERIALS AND METHODS

Ethical approval of the research protocol was obtained from the Research Ethics Committee at King Abdulaziz University Faculty of Dentistry (KAUFD), Jeddah, Kingdom of Saudi Arabia.

### Sample

One-hundred human permanent maxillary first molars extracted from Saudi patients due to severe caries or periodontal disease after obtaining informed consent were selected. The teeth were collected from pediatric dentistry and oral surgery clinics, KAUFD, Jeddah, Kingdom of Saudi Arabia. Allmolarshad no fractured or surgically separated roots and no previous root canal treatment.

### Methods

All molars were disinfected by immersion in 5.25% sodium hypochlorite (NaClO) for 24 hours and then kept individually in a labeled container with a normal saline solution during the study period at room temperature.

The setting of the right specifications for scanning was done, then each tooth was placed on the sample standard scanned using SkyScan, high-resolution desktop micro-CT scanner (SkyScan 1172, SkyScan, Bruker, Belgium). The micro-focus X-ray tube was set at 100 kV of acceleration voltage, 100 µA of beam current. Scanning was done at 13.4 µm resolution and 0.5 mm aluminum filter placed ahead of the radiation origin for altering the responsiveness of polychromatic radiation and the rotation step angle was 0.60° with about 1490 seconds camera exposure time positioned middle-far. The micro-CT scanning data produced for each sample was reconstructed to be displayed as 3D images by modeling software (SkyScan 1172, SkyScan, Bruker, Belgium) to obtain the complete configuration of the internal microstructure of each tooth. Data were evaluated using CT-analyzer (CTAn) computer program (SkyScan 1172, SkyScan, Bruker, Belgium) to observe the number of pulp canal orifices in each molar. The investigation of the cross-sectional images was performed at the same level of all teeth which is 135 slices from the cementoenamel junction (CEJ) of the tooth.

### Inter- and Intra-examiner Reliability

Two examiners investigated the 3D images of the scanned molars independently of one another. The examiners were faculty staff members from the Department of Pediatric Dentistry, KAUFD. The inter- and intra-rater agreement and correlation between the two examiners were calculated using Cohen's kappa coefficient. Intraexaminer reliability for each examiner was 0.950 and 0.964 respectively. Whereas, interexaminer reliability, was >0.985 indicating an almost perfect level of agreement. When there was no agreement between both evaluators, a discussion was undertaken until a consensus was reached.

## RESULTS

The current study showed the prevalence of extra root canal orifices using micro-CT. The evaluation of the 3D images showed that of the 100permanent maxillary first molars scanned and analyzed, 10.53% had 6 pulp canal orifices, 35.09% had 5 pulp canal orifices, 47.37% had

4 pulp canal orifices and 7.01%had 3 pulp canal orifices (Graph 1). The current data showed the highest prevalence of 4 and 5 root canal orifices compared to 3 and 6 root canal orifices. Figure 1 shows the representative images of 3D reconstructions of micro-CT scanned data. Figure 1A reveals 3 root canal orifices (MB, DB, P). Figure 1B reveals 4 root canal orifices (MB1, MB2, DB, P). Figure 1C shows 5 root canal orifices (MB1, MB2, MB3, DB, P) and Figure 1D shows 6 root canal orifices (MB1, MB2, DB1, DB2, DB3, P).

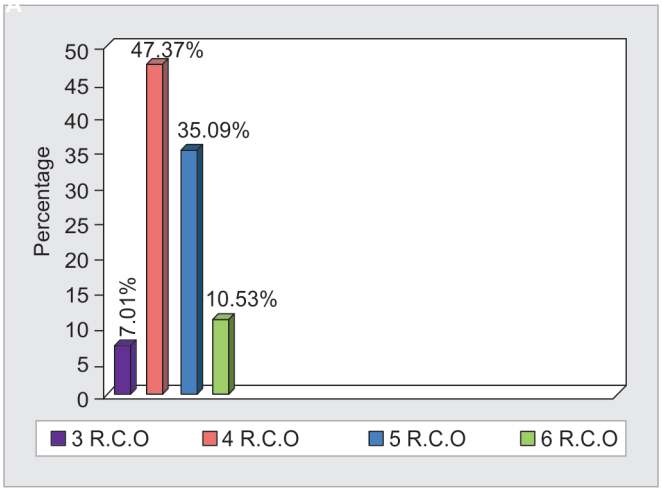
## DISCUSSION

The cornerstone for successful results of RCT is the sound understanding of the variation in pulp canal morphology and its possible differences before starting endodontic treatment.[29,30]

Effective dental pulp canal cleaning and a final 3D obturation of the pulp canal that allows good sealing of the accessible spaces are important foreffective RCT.[31] Therefore, it is important for the dentist to have a clear mental image of what they are going to inspect when starting RCT. This will result in an easier and more successful treatment rate.

Micro-CT is a new generation used to achieve the 3D structures of minor objects with a high spatial resolution allowing its usage in dentistry effectively for several years. It is an accurate and none-destructive method with shorted capture time in comparison to the other methods.[32,33] It can give images with higher resolution and higher precision.[34] Micro-CT enables evaluation of root canal count, canal volume, pre- and post- preparation volume changes and the existence of gaps and spaces in the obturation materials.[35]

In the current study, micro-CT was utilized to study the prevalence of extra pulp canal orifices in 100 maxillary first permanent molars in a Saudi subpopulation.

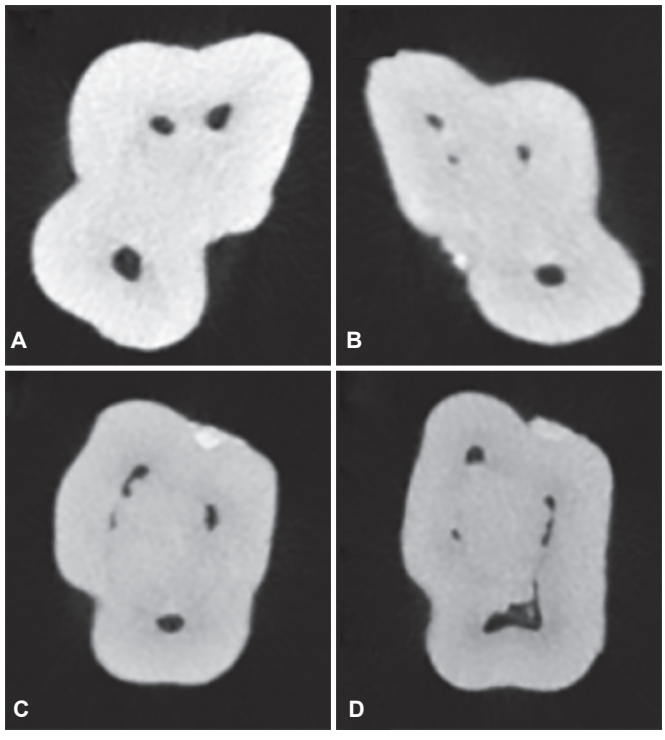



**Graph 1:** The prevalence of extra root canal orifices of maxillary first permanent molars

Permanent upper first molars were selected study because the majority of these molars are badly decayed and in need of RCT.[22] The results demonstrate that permanent maxillary first molars analyzed have an increased incidence of 4 and 5 pulp canal orifices more than 3 and 6 pulp canal orifices.

These study results are in agreement with the research done by Ahmad and Al-Jadaa,[36] who presented 2 cases of maxillary first permanent molars. One case was a nonsurgical RCT using an optical dental microscope and the other case was a removed permanent upper first molars canned by an X-ray microtomography and reconstructed 3D with a computer program. They revealed the presence of three canals in the MB root, whereas the DB and P roots had a single canal. Furthermore, the results are in accordance with Al-Habboubi and Al-Wasi,[37] who reported a case of Saudi male with an anatomical variation of having six root canals. The scans revealed 3 MB, 2 DB, and one palatal canal that were confirmed with CBCT.

Our results are in contrast with AlFouzan et al.,[38] and Alrahabi and Sohail Zafar,[39] however, they did not use micro-CT in their evaluations. They examined the anatomy of the permanent upper first molar in a Saudi population using conventional X-rays. Two mesial pulp canals and only 1 distal and palatal canals were reported. They concluded that the incidence of having three canals




**Figs 1A to D:** Illustrative images of 3D reconstructions of micro-CT scanned data showing the number of root canals orifices in the permanent maxillary first molar: (A) Three root canal orifices (MB, DB, P); (B) Four root canal orifices (MB1, MB2, DB, P); (C) Five root canal orifices (MB1, MB2, MB3, DB, P); (D) Six root canal orifices (MB1, MB2, DB1, DB2, DB3, P)

in the mesial root and two in the distal root in a Saudi citizen wasn't reported. Moreover, Al-Shehri et al.,[40] used CBCT images to study the pulp and pulp canal form of upper permanent first molars in Saudi residents. They revealed that the morphological configurations of the root canal of upper first molars showed that the majority had three roots and four canals. The extra 4th pulp canal was found in the MB root.

The present study revealed that most of the extra canal orifices were discovered at a slightly deeper level than the original canal orifices. These results amplify the importance of knowledge and realization of the differences found in the pulp canal system, also highlighting the great advantage of proper examination of the floor of the pulp chamber and the appropriate troughing or countersinking using the appropriate ultrasonic tips.

Micro-CT has some limitations such as greater complexity in equipment construction and the necessity of long exposure times may be a problem, high radiation dose and the high cost of the scans, scatter due to metallic objects, beam hardening and cupping artifacts. Also, it is not recommended at present for *in vivo* studies or routine clinical practice due to a high level of radiation exposure, and there is also specimen size limitation which may be a problem with a certain analysis.

## CONCLUSION

There is an increased prevalence of 4 and 5 pulp canal orifices and a decreased number of 3 and 6 pulp canal orifices in permanent maxillary first molars among Saudi subpopulation in Jeddah city.

Constantly dentists must expect the occurrence of additional pulp canals in permanent upper first molars and utilize all the accessible equipment to detect and manage these canals.

Micro-CT as a characteristic tool is suggested for the efficient endodontic research *in vitro*.

Application of this study on a large sample with correlation to gender and age is recommended.

## CLINICAL SIGNIFICANCE

The knowledge of anatomic variations of teeth before starting RCT can help dentists to detect and manage all root canals successfully.

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