C Shaped Root Canals in Mandibular Second Molars in UAE Nationals

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ABSTRACT
The aim & objective of this study is to investigate the frequency and type of C-shaped root canals in mandibular second molars of the UAE population. The teeth with C-shaped canals were classified using Melton’s classification.

Method: Ninety-six mandibular second molars of patients aged between 20-45 years old, scheduled for endodontic treatment, were examined over a 2-year period in the Endodontic Department, Tawam Hospital, Dental Center, UAE. C-shaped canals were detected and counted. Two detection procedures, radiography and clinical examination, were used.

Results: Thirty three exhibited C-shaped canals (34.37%). Eleven molars presented a continuous C-shaped canal (11.4%), category I. Seven (7.2%) had a semicolon shape with a mesial canal located on the buccal or lingual side depending on where the fusion occurred, category II.

In many instances, this canal swung back and merged with the distal canal, thus yielding a single foramen, in the other cases, it remained distinct with its own portal of exit. Fifteen (15.6%) were considered as category III: Three for subdivision I, two for subdivision II, and ten for subdivision III. Conclusion: The frequency of C-shaped root canals in mandibular second molars is high in the UAE patients.

KEYWORDS
C-shaped canals, Endodontic treatment, Obturation.

INTRODUCTION
Knowledge of the anatomy of the root-canal system in teeth is essential for its successful debridement and obturation. With information gleaned from preoperative dental radiography, the clinician can assess, to a great extent, the anatomic challenges in each tooth.1 Of particular interest is the canal configuration of the mandibular second molar, as a great deal of variation can occur. The C-shaped canal system is an anatomic variation occurring mostly in mandibular second molars, especially in Asian populations, although it can also occur in maxillary and other mandibular molars.2-7 The main anatomic feature of the system is the presence of a fin or web connecting the individual root canals. The orifice may appear as a single ribbon-shaped opening with a 180º arc in the form of a band or a deep semi lunar groove connecting the distal, mesio-buccal and mesio-lingual canals8 (Figs 1, 2). The concavity of the C may be oriented buccally or lingually. In other cases, the orifice may take the form of an incomplete C, with union of the distal and mesio-buccal canals and the presence of an isolated mesio-lingual canal, giving the canals the appearance of a semicolumn.9,10 It may also present as a C-shaped canal with union of the distal and mesio-lingual canals with a separate mesio-buccal canal. It is important to emphasize that this C-shaped variation of the anatomy can occur throughout the length of the root canal, which complicates the stages of biomechanical preparation and obturation. Once recognized the C-shaped canal presents a challenge with respect to diagnosis, debridement, obturation and prosthodontic restoration8,11-16 because it is unclear whether the C-shaped orifice found on the floor of the pulp chamber actually continues to the apical third of the root.8

(Fig. 1) C-shaped chamber floor showing a complete C-shaped root-canal orifice in the form of a deep trough connecting the distal, mesio-buccal and mesio-lingual canal orifices

(Fig. 2) C-shaped chamber floor of mandibular second molar with mesial, distal and mid-buccal canal orifices after Obturation
Rice & Gilbert\textsuperscript{14} considered the interpretation of preoperative radiographs fundamental to the success of the endodontic treatment of C-shaped canals, since it can demonstrate the presence of atypical root configurations. The importance of good quality preliminary radiographs taken from at least two angulations cannot be overstated.

Melton \textit{et al.}\textsuperscript{12} proposed a classification based on the different configurations of the orifices in C-shaped canal systems. In all three classes, the "main" canals can be cleaned and shaped normally, however, the instrumentation of the isthmus that connects these canals requires care, because it may be very narrow.\textsuperscript{9,13} These areas are prepared using small sized endodontic instruments and copious amounts of irrigants.\textsuperscript{13} In this situation, the irrigation solutions assume a very important role. Sodium hypochlorite, with its capacity to dissolve organic material, is the solution of choice.\textsuperscript{13}

The aim of this study was to provide information on the distribution of C-shaped canal anatomy, to establish a classification for the most common configurations, and to determine its frequency in a sample representing the United Arab Emirates population.

**MATERIALS & METHODS**

Ninety-six mandibular second molars in patients aged 20-45 years scheduled for endodontic treatment were examined over a 2-year period in the Endodontic Department at the Dental Center, Tawam Hospital, UAE. C-shaped canals were detected and counted. Two detection procedures, radiography and clinical examination, were used. Two preoperative radiographs were taken utilizing the extension cone-paralleling device (Rinn Corp., Elgin Ill, USA): One with a 90° angulation to the tooth in a buccolingual direction and another at a mesial angle of 20° to allow better visualization of the buccolingual anatomy. The radiographs were examined on a viewer using a peripheral block and a 6× aspheric magnifying lens. The number and position of root canals were noted. Two postoperative radiographs using the same incidence were taken to confirm canal configuration. Clinical investigation was done by scrutinizing the pulp chamber and canal entrance. While probing root canals with K-file #10 (Maillefer, Baillaigues, Switzerland), radiographs were taken to confirm canal morphology.

Once C-shaped anatomy was recognized, teeth were classified using a Melton-like\textsuperscript{12} classification pattern of three categories:

- **Category I:** Continuous C-shaped canal running from the pulp chamber to the apex (Fig 3).
- **Category II:** The canal orifices resemble a semicolon (;) (Fig 4), where a C-shaped canal is present buccally or lingually separated from another distinct canal by a dentine wall (Fig 5).

\section*{Figures}

(Fig. 3) \textbf{Category I a:} Preoperative radiograph of the mandibular second molar showing fused roots and \textbf{b:} Completed root canal filling using lateral condensation of gutta-percha showing true C-shaped canal

(Fig. 4) \textbf{C-shaped chamber floor of mandibular second molar with mesial, distal and mid-buccal canal orifices are seen}

(Fig. 5) \textbf{Category II a:} Preoperative radiograph showing a radicular fusion, a large distal canal, a narrow mesial canal and a blurred image of a third canal in the center. \textbf{b:} Postoperative radiograph: Note the presence of dentine separating a mesial canal from the rest of the C-shaped canal

(Fig. 6) \textbf{Category III Subdivision I a:} Preoperative radiograph of a mandibular second molar and \textbf{b:} Postoperative radiograph: Note the main C-shaped canal splits in the coronal third into three canals and joined at one apical foramen

(Fig. 7) \textbf{Category III Subdivision III a:} Preoperative radiograph of a mandibular second molar and \textbf{b:} Postoperative radiograph: Note the main C-shaped canal splits in the coronal third into three canals foramen
• Category III:
  - Subdivision I: C-shaped orifice in the coronal third that is divided into two or more discrete and separate canals that join apically (Fig 6).
  - Subdivision II: C-shaped orifice in the coronal third that is divided into two or more discrete and separate canals in the mid-root to the apex.
  - Subdivision III: C-shaped orifice that is divided into two or more discrete and separate canals in the coronal third to the apex (Fig 7).

RESULTS
Of the 96 treated molars, thirty three (34.37%) exhibited C-shaped canals. Eleven (11.4%) molars presented a continuous C-shaped canal (category I) and seven (7.2%) had a semicolon shape with a mesial canal located on the buccal or lingual side depending on where the fusion occurred (category II).

In many instances, this canal swung back and merged with the distal canal, thus yielding a single foramen; in the other cases, it remained distinct with its own portal of exit. Fifteen (15.6%) represented category III: Three for subdivision I, two for subdivision II and ten for subdivision III.

DISCUSSION
C-shaped canals in mandibular second molars are rarely found in Caucasians. They have a relatively high prevalence in mandibular second molars of Chinese and Lebanese populations.\textsuperscript{10,16-19} This anatomy is much more common in Asians than in Caucasians.\textsuperscript{20} Studies on mandibular second molars have shown a high incidence of C-shaped root canals in the following populations: Chinese 18%, Hong Kong Chinese 30%, Lebanese 19%, Saudi Arabian 11%, Turkish 8%, Greek 5%, Korean 45%, Burmese 10% and Thai 10%.\textsuperscript{10,17,19,21-26} These studies indicate that C-shaped canals are more frequent in Asians, especially from the Far East.

In Our study, the incidence of C-shaped canals is high (34.73%) compared to other Middle East areas such as Saudi Arabia and Lebanon.\textsuperscript{19,21} Haddad et al.\textsuperscript{19} examined 94 mandibular second molars in the Lebanese population. They used two detection procedures: Radiography and clinical examination. They noted that true C-shaped canals with category I in mandibular second molars were the exception rather than the rule. Gulabivala et al.,\textsuperscript{25} using a canal staining and tooth clearing technique in Burmese patients, observed that inter-canal communications were quite common in these patients. Gulabivala et al.\textsuperscript{26} noted the prevalence of 10% in Thai population. The configuration of the canals in one third of the roots was type I (one canal), another one third had type IV canals (two canals), and the remainder had 3 to 4 or 2 to 3 configurations. At the same time, Al-Fouzan\textsuperscript{27} concluded that all patients showing category III configuration were less than 40 years of age.

This is in contrast to the observation of Manning\textsuperscript{16} that age-related deposition of dentine formed separate canals. Manning also reported that category III (subdivision III) systems are the most frequent, which is in agreement with Al-Fouzan. C-shaped canals, which have semicolon and continuous shape at the orifice level, have a high possibility of dividing into 2 or 3 canals in the apical region, which is important in endodontic treatment according to Seo and Park\textsuperscript{27} and Yang et al.\textsuperscript{10}

At the same time, Fan et al.,\textsuperscript{8} by anatomic evaluation, indicated that a majority of teeth with C-shaped canal system showed an orifice with an uninterrupted “C” configuration found within 3mm below the cemento-enamel junction. Another study by Fan et al.,\textsuperscript{15} suggested that it was possible to predict the presence and the configuration of C-shaped canal system by the radiographic appearance.

Cimilli et al.,\textsuperscript{22} using spiral computed tomographic imaging, concluded that Vertucci type I canals were the most frequently seen in these C-shaped molars.

In a study performed by using serial axial computed tomography images, Jin et al.,\textsuperscript{24} reported that continuous C-shaped canal was the most frequently found (Fig 8) and the separated canal was the least (Fig 9). In addition, the thinnest remaining tooth structure in the groove area of the C-shaped molar was not different from that of the danger zone of normal ones.

In this study, the frequency of C-shaped root canals in second mandibular molars in the United Arab Emirates population was high and mainly as category III with subdivision I which is in agreement with the other Middle East studies.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig8}
\caption{Preoperative radiograph of a mandibular second molar and \textbf{b}: Postoperative radiograph: Note the apical fusion of the three canals}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig9}
\caption{Preoperative radiograph of a mandibular second molar and \textbf{b}: Postoperative radiograph: Note the main C-shaped canal splits near the orifice into three or four canals}
\end{figure}
Although using radiographic techniques might appear to have certain disadvantages, being two dimensional, and conceivably both roots and root canals can be missed. However, clinically it remains the only non-invasive method available. Spiral CT images and micro-computed tomography scans (micro-CT) can show 3-dimensional images and, thus, much more detail. For this reason, CT has been used as a useful tool for diagnosing the morphology of mandibular molars and evaluating the morphological changes in the root canal shape before and after instrumentation, however, the radiation risk involved must be considered.

The frequency of C-shaped root canals in the United Arab Emirates with 34.73% is high. Further studies would be necessary to confirm this result with the use of CT images.

**CONCLUSION**

The possibility of C-shaped canals in second lower molars is high in UAE and has to be taken into consideration during the clinical and radiographic examination of the patient.

The clinical challenges are to find all the canals, and also to try and clear all the pulp and necrotic tissues along the fins and isthmuses to ensure endodontic success. Strip perforation during instrumentation is also highly possible because of the thin walls. Modification of procedures at all stages of the treatment and new resources is recommended for successful endodontic treatment. The magnification provided by the Dental Operating Microscope is a great aid in the interpretation of the anatomy of the floor of the pulp chamber, thus, facilitating effective access to the canal system. Fiber-optic trans-illumination can assist in the identification of the anatomy of the root canal system. Ultrasonic instrumentation and devices for thermo-plasticization of gutta-percha assist greatly with debridement and obturation. Technique modification may be required for restoration of C-shaped root canals. Placing pre-fabricated post in these teeth is highly risky because of the thin walls.

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