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Morphologic Characteristics of C-Shaped Root Canals in Mandibular Second Molars in a Rajshahi (Bangladesh) Population-An *In Vivo* Study

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ABSTRACT

Aim: *The aim of this study was to determine the frequency of C-shaped canals in mandibular second molars in a population in Rajshahi (Bangladesh) and to establish a correlation with a classification of Melton et al.*

Methodology: *2638 mandibular second molars scheduled for root-canal treatment were examined over a 5-year period. The C-shaped canals were detected by radiographic and clinical examination. Teeth with C-shaped canal systems were categorized by using a classification of Melton.*

Results: *Out of 2638 molars, 354 (13.41%) exhibited C shaped canals. 118 molars were classified as category I, and 70 were considered category II. The remaining 166 cases were classified as category III, with 36 in subdivision I, 51 in subdivision II, and the remaining 79 in subdivision III.*

Conclusion: *The C-shaped canals in mandibular second molars vary considerably in their anatomical configuration with the result that debridement, obturation, and restoration may be difficult.*

Keywords
C-shaped canal, Mandibular second molar.

Introduction
Acceptable outcome of the Root canal treatment need successful debridement and obturation of the root-canal system. A thorough knowledge of the anatomy of teeth regarding internal and external morphology is essential for successful debridement and obturation of the root-canal system. Recognition of unusual canal configurations and variations should be considered because it has been established that the root with a single tapering canal and apical foramen is the exception one [1]. A greater Variation in Canal configuration of the mandibular second molar can occur and C-shaped canals are common with the presence of a thin fin connecting the root canals being the main anatomical feature [2]. Once recognized, the C-shaped canal provides a challenge with respect to debridement and obturation, especially 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.

Hertwig's epithelial sheath determines the shape and the number of roots, which bends in a horizontal plane below the amelocemental junction and fuses in the centre leaving openings for roots [3]. Fused roots may form either by failure of Hertwig's epithelial sheath to develop or fuse in the furcation area or as a result of coalescence owing to cementum deposition with time. A C-shaped canal appears when fusion of either the buccal or the lingual aspect of the mesial and distal roots occurs. This fusion remains irregular, and the two roots stay connected by an interradicular ribbon [4]. The pulp chamber has a single ribbon-shaped orifice from the distal to mesial canal [5]. The floor of the pulp chamber is deep and has an unusual anatomical appearance [4]. Two or three canals may be found in the C-shaped groove, or the C-shape may be continuous throughout the length of the root.

The mandibular second molars with C-shaped canals vary in their configuration [6,7]. Clearly recognition of these configurations facilitates cleaning, shaping, and obturation [8]. Preoperative radiographs demonstrate close fused roots or images of two distinct roots. This occurs when the fin is thin and thus, not visible on the X-ray and makes clinical recognition of the C-shaped canal unlikely until access to the pulp chamber has been achieved.

Radiographs taken when negotiating the root-canal system may suggest such anatomy as they can reveal two characteristics: instruments tending to converge at the apex [8] or instruments appearing both clinically and radiographically to be centered and appearing to be exiting the furcation. This can cause confusion and initiate a search for a perforation [7].

Cooke & Cox first documented the C-shaped canals in three case reports [2]. Endodontic textbooks state that the C shaped canal is not uncommon [9] and this is confirmed by studies in which frequencies ranging from 2.7 to 8% have been reported [2,10]. These figures relate to teeth of Caucasoid origin with an absence [11-13] or near absence [10] of C-shaped canals. Root canal anatomy of mandibular second molars conducted on Japanese [14], Chinese [6] and Hong Kong Chinese [15] populations showed a high incidence of C-shaped canals (31.5%). It has thus been established that this particular anatomy is more frequent in Asians than in other racial groups [16]. Reported prevalence's have included 2.7%-8% for American [2,10,17], 19.1% for Lebanese [18] and 10.6% for Saudi Arabian [19]. No data are available on the incidence of this canal configuration in the Bangladeshi population. The purpose of this study was to determine the prevalence and distribution of C shaped canal anatomy in mandibular second molar in a Bangladeshi population.

Materials and Methods

Two thousand six hundred thirty-eight mandibular second molars scheduled for root-canal treatment were examined over a 5-year period from January 2013 to December 2018 in the Endodontic Department, Dental Unit Rajshahi Medical College, and Rajshahi Bangladesh. The incidence of C-shaped canals was revealed following radiographic and clinical examination. Three preoperative radiographs were taken at a constant target-film distance and angulation by utilizing the extension cone-paralleling device (Rinn Corp., Elgin, and III, USA): one with a 90-degree angulation to the tooth in a bucco-lingual direction and another two at a mesial and distal angulation of approximately 20 degree to allow better visualization of the bucco-lingual anatomy. The radiographs were examined on a viewer using a peripheral block and a 6x magnifying lens. The number and the position of root canals were noted. Three postoperative radiographs using the same exposure geometry were taken to confirm canal configuration. Clinical examination of the pulp chamber and canal orifices was carried out and root canals were investigated with size 10 K-files (Kerr Co., Romulus, MI, USA); radiographs were taken to confirm canal morphology. Once C-shaped anatomy was recognized, teeth were categorized using a classification of Melton et al in 1991 [10]. (a) Category I: continuous C-shaped canal running from the pulp chamber to the apex. (b) Category II: 'semicolon' (;) shaped orifice in which dentine separated a main C-shaped canal from one mesial distinct canal. (c) Category III: subdivision i, C-shaped orifice in the coronal third that divided into two or more discrete and separate canals that joined apically; Subdivision ii, C-shaped orifice in the coronal third that divided into two or more discrete and separate canals in the mid-root to the apex; and subdivision iii, C-shaped orifice that divided into two or more discrete and separate canals in the coronal third to the apex.

Results

Of the 2638 molars, 354 (13.41%) exhibited C-shaped canals (Table 1). 118 molars presented a continuous C-shaped canal (category I), and 70 had a semicolon shape (Category II) with a mesial canal located on the buccal or lingual side (depending on where the fusion occurred) (Table 2). In 22 instances, this canal swung back and merged with the distal canal, thus yielding a single foramen; in the other 48 cases, it remained distinct with its own portal of exit (Table 2). The 166 cases were considered as category III, amongst those: 36 were subdivision I; 51 were subdivision II; and the remaining 79 one were subdivision III (Table 2).

Number of tooth	Frequency of C shaped canal	Percentage
Mandibular 2nd molar 2638	354	13.41%

Table 1: Number and percentage of C shaped mandibular 2nd molar out of 2638 molars.

Category of C-shaped canals	Frequency				Percentage
Category I	118				33.33 %
Category II	70				19.77 %
Category III	166	Subdivision	Frequency	Percentage	46.89 %
		Subdivision i	36	21.68%	
		Subdivision ii	51	30.72%	
		Subdivision iii	79	47.59%	100%
		Total	166	100%	
Total	354				100%

Table 2: Distribution of C shaped canal anatomy in mandibular second molar.

Discussion

Root-canal anatomies of mandibular second molars differ from race to race and with geographical variation. Two rooted mandibular second molars predominantly found in a Caucasian population [10-13] whereas single-rooted mandibular second molars are common in Asian or Mongoloid population [14,15].

Weine et al. found 1 single canal and two C-shaped canal in a radiographic study of three single- rooted specimens [17]. Walker showed the complex anatomy characteristic of single-rooted specimens in photographs of selected specimens that were cleared. In the current study, a variety of canal types was found, with category I representing almost one-third of the sample [15]. Cooke & Cox stated that it was impossible to diagnose C-shaped canals on the preoperative radiograph [2]. In this study, almost all preoperative radiographs of category I, II, and III (subdivision I) showed a common characteristics that provided a typical image and allowed identification of this anatomical condition. In fact, most radiographs revealed radicular fusion or proximity, a large distal canal, a narrow mesial canal, and a blurred image of a middle third canal.

Weine et al. advised placing files in the canals to determine canal configuration of the mandibular second molar by using a radiograph [10]. Sometimes it was difficult to distinguish between C-shaped canal and one with single or three canals joining apically then it was necessary to confirm the diagnosis by exploring the access cavity. Two types of root-canal orifices were observed. 1. A complete C-shaped orifice located either on the buccal or lingual aspect of the floor that extended from the usual location of the distal canal to the usual location of the mesial canals. 2. Two or three orifices: a C-shaped orifice extending from distal to mesiobuccal in a buccal position separated with dentine from an independent mesiolingual orifice, or from distal to mesiolingual in a lingual position with an independent mesiobuccal orifice. Some teeth had one mesial and one distal orifice, and one orifice between the two. In the present study, all root canals that diagnosed C-shaped root canals by preoperative radiograph, Pulp chamber examination for root canal orifice and radiograph with file placing with in the root canal.

The study of the incidence of C-shaped canals in the mandibular second molars using radiographic techniques might appear to have certain disadvantages. Only a 2D image of the tooth is seen and conceivably both roots and root canals can be missed. However, clinically it remains the only non-invasive method available, and by strictly adhering to the radiographic criteria for determining the incidence of C-shaped canals in the mandibular second molars, the findings of this study were in good accord with those of other recent studies using various techniques [20].

The frequency obtained in this study (13.41%) lies between the 31.5% frequency reported [6] by Yang et al. and the 2.7% frequency reported [10] by Weine et al. The geographical position of Bangladesh in particular and the South Asia, in general, may be the explanation for this phenomenon. However, further studies would be necessary to confirm this phenomenon.

Conclusions

Mandibular second molars with C-shaped canals vary in canal configuration. The early recognition of these configurations facilitates cleaning, shaping, and obturation of the root-canal system. The possibility of C Shaped canals has to be considered during the clinical and radiographic examination of the patient.

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