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# Occurrence of C-Shaped Canal in Mandibular First and Second Molars in the Erbil Population using Cone Beam Computed Tomography

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## Abstract

**Background and objective:** Anatomy of the root canal system and determining the number and form of the canals are the most important steps for successful root canal therapy without post-operative complications. The objective of the current research was to apply cone beam computed tomography as a mean to investigate the occurrence and characteristics of C-shaped canals in mandibular 1st and 2nd molars of the Erbil citizens.

**Methods**: the study was done retrospectively in February 2023 to September 2023 at the Private Dental Center, Erbil, Iraq. A group of individuals who had cone-beam computed tomography examinations were chosen for the study. The cone-beam computed tomography examinations were conducted at three distinct axial levels, and based on the Fan criteria, the mandibular molars were categorized as C-shape. cone-beam computed tomography scans were utilized to determine the existence and features of C-shaped canals. The data were examined based on the status of unilateral or bilateral, gender, types of C-shaped configurations, and distribution across the root thirds.

**Result:** The analysis of 676 molars from 222 patients revealed low occurrence rates of this anatomic feature in mandibular first molars 3 cases (0.97%), but mandibular second molars exhibit a comparatively greater frequency 28 case (7.62%). The incidence of C-shaped canals varied by status of unilateral or bilateral, gender, types of C-shaped configurations, and their distribution across the root thirds. There was a significant difference between the total number of c-shaped canals found in mandibular second molars in the male and female, on the other hand there was no significant difference in the mandibular first molar.

**Conclusion:** The results in mandibular second molars demonstrated a greater frequency of C-shaped canals compared to mandibular first molars. Females exhibited a greater incidence of C-shaped canals, and bilateral cases were more frequent in females than males.

**Key Words**: CBCT, Fan criteria, Shaped-shaped canal

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## Introduction:

Evaluating the frequency and characteristics of C-shaped canals in mandibular molars is crucial for the efficacy of endodontic therapy. The purpose of this cone-beam computed tomography (CBCT) study was to determine the prevalence of C-shaped canals in the Erbilian mandibular 1st and 2nd molar. Several anatomical differences exist in root canal systems, some of which might greatly make obstacles to root canal therapy to be done smoothly. Before starting the treatment, learning a root canal system`s anatomy and morphology could enhance treatment quality and hence the endodontic treatment`s long-term prognosis.[1] The first documentation of this anatomical variation was provided in 1979 by Cooke and Cox.[2] The term BC-shaped was coined due to the resemblance of the root canal opening to the letter C in the axial plane, and occasionally, a web or fin might be seen linking the separate canals.[2] Typically, the orifices of the canal are situated under the cementoenamel junction (CEJ). They can take the form of a single ribbon-shaped aperture with a 180° arc connecting a ribbon-shaped arc or all of the primary canals connecting a mesial canal (the lingual or buccal) with the distal canal.[3] It is hypothesized that on the root surface of buccal or lingual, the non-fusion of the epithelial root sheath of Hertwig may give rise to the C-shaped canal formation.[4]The conventional inner morphology of mandibular molars exhibiting canals that are C-shaped is distinguished through a configuration whereby the distal, mesiobuccal, and mesiolingual canals are interconnected via slit-like anatomy, resulting in the formation of a 180˚ arc.[5] Roots with canals that are C-shaped normally have a conical or square form.[6] The C-shaped root canal architecture is linked to other tooth groups, despite being a clinical feature more often associated with mandibular second molars. This anatomical feature, which is more challenging to obturate, shape, and clean, is very significant.[7] The objective of the current research was to apply cone beam computed tomography as a means to investigate the occurrence and characteristics of C-shaped canals in mandibular 1st and 2nd molars of the Erbil citizens.

## Materials and methods

The study employed a retrospective research design and took place within the Private Dental Center. It utilized cone-beam computed tomography (CBCT) scans to examine the presence of C-shaped canals within the mandibular molars. The article was approved by the ethical and Scientific Committee of the Kurdistan Higher Council of Medical Specialties. Data collection occurred at a radiology clinic located in the Private Dental Center in Erbil, Kurdistan region, Iraq, in February 2023 to September 2023. It's important to note that the sample selected for this study consisted of individuals of both male and female genders aged between (18-65 years old), qualifying it as a convenience sample. Images including mandibular first or/and second molars that had neither post-crown restoration nor root filling, images including mandibular first or/and second molars with a completely mature apex, Erbil cases over 18 years old. The population of Erbil city (1612737 inhabitants), a level of confidence of 95%, and a sample (margin) error of 5% were taken into account while estimating the size of the sample. To assess the frequency of C-shape canals among Erbil citizens, 139 CBCT scans were required as the sample size but, we increased the sample size to 250 CBCT images among Erbil city residents with CBCT testing as part of diagnosis or/and treatment planning over 2 years. We used Fan et al. classification Fan et al. in 2004 modified Melton's method into the following categories: Category I (C1): The shape exhibited an unbroken "C" form without any gaps or divisions. Category II (C2) refers to a


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canal shape that seems like a semicolon due to a break in the "C" outline. However, both angles should be > or = 60°.Category III (C3) refers to a condition when there are 2 or 3 distinct canals, and both angles and, are each smaller than 60°.Category IV (C4) refers to a cross-section that contains only one round or oval channel. Category V (C5) refers to a situation when no canal lumen is visible, typically only around the apex.(3),Figure(1).

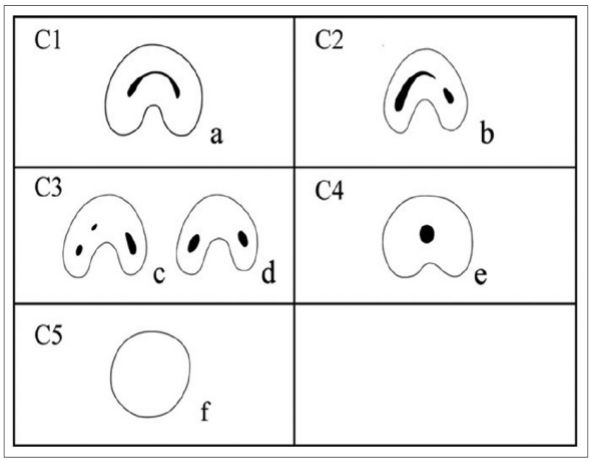


**Figure. (1):** Mandibular molar C-shape categorization in axial cross-section

There were 676 mandibular molars in total, including 367 mandibular second molars and 309 mandibular first molars. The sample consisted of 222 patients (28 patients were excluded), with 125 males and 97 females aged over 18 years. The CBCT images were examined by experienced endodontists who were blinded to the patient's details. The existence of C-shaped canals, their bilateral or unilateral frequency, and the distribution of C-shaped canals across root thirds were recorded. Additionally, various kinds of C-shaped configurations were identified and documented. Statistical analysis was performed using Paired t-test using SPSS.

## Results:

The results shed light on several important aspects, including gender differences, bilateral incidence, types of C-shaped configurations, and distribution across root thirds. The low frequency of C-shape canal (0.97%) in mandibular first molars, aligns with previous research findings, suggesting that this anatomical variation is relatively rare in this tooth. One case was identified in a female patient, while the remaining two cases were found in male patients. These findings imply that in mandibular first molars, clinicians may encounter C-shaped canals less frequently during endodontic procedures. Therefore, while clinicians need to be cautious about the possibility of anatomical feature in mandibular first molars, it might not be a routine consideration in treatment planning for this particular tooth, Table (1). In contrast, in the mandibular second molars, 28 cases (7.62%) of C-shaped canals were identified. This indicates that mandibular second molars are more likely to exhibit C-shaped canal configurations, emphasizing the importance of considering and identifying these canals during treatment planning and management. Regarding mandibular second molars, clinicians should be vigilant in detecting and addressing C-shaped canals to ensure successful endodontic outcomes. Among these cases, 15 were found in females and seven in males. In six female patients, bilateral C-shaped canals were present, Table (2). In both molars of the mandibular, the overall C-shaped canal frequency was 31 (4.58%). The analysis of gender-specific occurrence indicated that among 97 female patients, only one case (1.03%) had a C-shaped canal of unilateral, while among 125 male patients, two cases (1.60%) had unilateral C-shaped canals. In mandibular second molars, nine female patients had unilateral C-shaped canals, and six female patients had bilateral C-shaped canals. The frequency of C-shaped canals in females was 15 cases (15.46%) among 97 female individuals. Among 125 male patients, seven cases (5.6%) had unilateral C-shaped canals, and none had


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bilateral C-shaped canals. There was a significant difference between the total number of c-shaped canals found in mandibular second molars in the male and female, on the other hand there was no significant difference in the mandibular first molar.

**Table (1):** Demographic characteristics of participants with C-shaped canals in mandibular first molars, particularly exploring the distribution based on bilateral or unilateral involvement and gender.

| | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| Unilateral – Left Side | .01031 | .10153 | .01031 | -.01015 | .03077 |
| Total | .010 | .102 | .010 | -.010 | .031 |

**Table (2):** Demographic characteristics of participants with C-shaped canals in mandibular second molars, particularly exploring the distribution based on bilateral or unilateral involvement and gender.

| | Mean | Std. Deviation | Std. Error Mean | | 95% Confidence Interval of the Difference | |
|---|---|---|---|---|---|---|
| | | | | | Lower | Upper |
| Unilateral – Left Side | -.01031 | .10153 | .01031 | -.03077 | .01015 | -1.000 |
| Unilateral - Right Side | .010 | .102 | .010 | -.010 | .031 | 1.000 |
| Bilateral | .06186 | .24214 | .02459 | .01305 | .11066 | 2.516 |
| Total | -.082 | .277 | .028 | -.138 | -.027 | -2.938 |

Various kinds of C-shaped configurations were distributed variably between the second molars and the mandibular first. Among the mandibular first molars, one case exhibited the C1 configuration Figure (2), one case had the C3 configuration Figure (3), and one case had the C4 configuration Figure (4). In mandibular second molars, the C1 configuration was observed in 10 cases Figure (5), the C2 configuration in 9 cases Figure (6), and the C3 configuration in nine cases, Figure (7). However, no cases with the C4 configuration were detected.

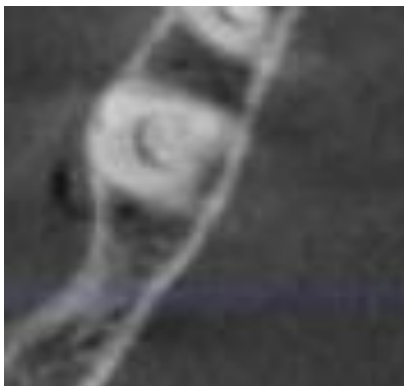

**Figure (2):** CBCT image of the C1-shaped image of canal in the mandibular first molar the (mid-axial section)

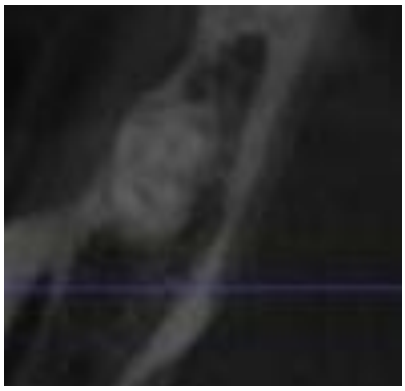

**Figure (3):** CBCT image of the C3-shaped canal in the mandibular right first molar (mid-axial section)

**Figure (4):** CBCT C4- shaped canal in mandibular right first molar (Coronal- axial section)



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**Figure (5):** CBCT image of the mandibular left second molar`s C1-shaped canal.

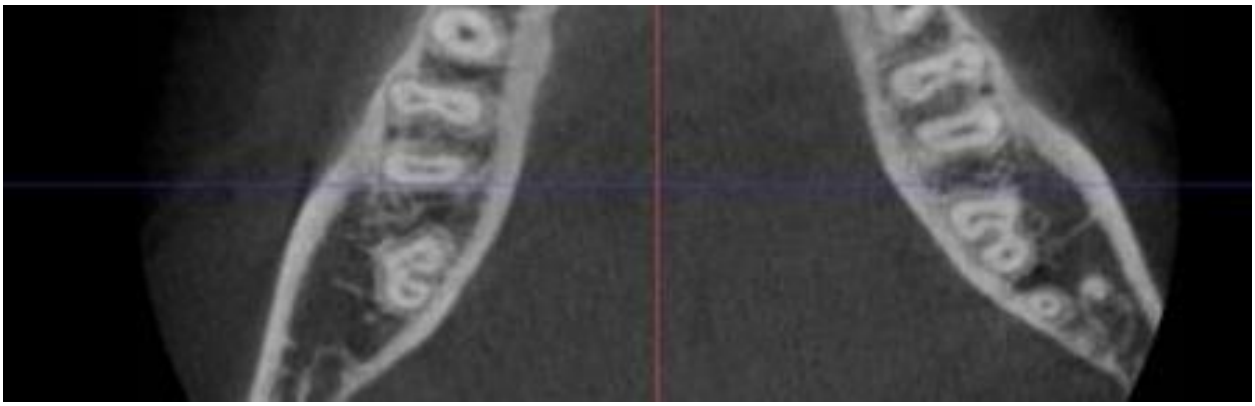

**Figure (6):** CBCT image of the mandibular second molars` C2-shaped canal (Bilateral)

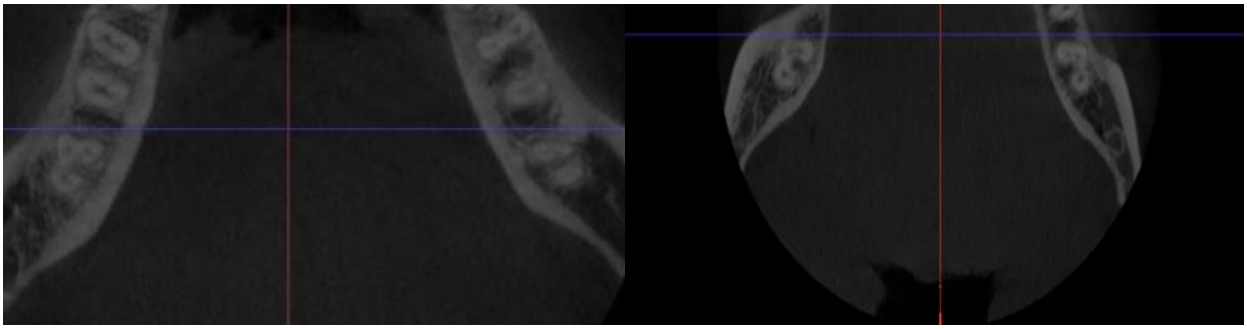

**Figure (7):** CBCT image of the mandibular second molar C3-shaped canal.

**Table (3):** Frequency of the various types of C-shaped configurations (mandibular first and second molars)

| Tooth | C1 | C2 | C3 | C4 |
|---|---|---|---|---|
| 36 | | | | 1 |
| 46 | 1 | | 1 | |
| 37 | 8 | 4 | 3 | |
| 47 | 2 | 5 | 6 | |
| Total | 11 | 9 | 10 | 1 |

Analysis of distributing C-shaped canals across the root thirds revealed that in mandibular first molars, one canal was identified in the coronal third and two canals were identified in the middle third. Two canals were detected in mandibular second molars in the coronal third, ten canals in the apical third, and seventeen canals in the middle third, Table(4).



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**Table (4):** Frequency of the C-shaped canals per third of the roots (mandibular first and second molars)

| Tooth | Coronal | Middle | Apex |
|---|---|---|---|
| 36 | 1 | 0 | 0 |
| 46 | 0 | 2 | 0 |
| 37 | 2 | 8 | 5 |
| 47 | 0 | 9 | 5 |
| Total | 3 | 19 | 10 |

## Discussion:

In the endodontic literature, for the first time in 1979, Cooke and Cox described the anatomy of a C-shaped canal. The failure of either the lingual or buccal root surface to exhibit fusion of the epithelial root sheath of Hertwig is the most commonly recognized explanation for the creation of such a peculiar ribbon-shaped canal A two-dimensional radiograph cannot reveal information regarding the root canal system's cross-sectional anatomy. As a result, C-shaped canals could be complicated to detect on a radiograph of two-dimensional. The patients in this study needed the CBCT for a variety of genuine diagnostic or therapeutic reasons, such as assessing preimplant bone mass and ectopic impacted teeth. In these situations, the standard CT examination can result in a greater radiation dose; hence, CBCT was a possible substitute. Employing micro-CT to evaluate the system of C-shaped canals and revising the system's categorization, the following three characteristics have to be present in this form of canal system: More than one canal cross-section with the C1, C2, or C3 configuration, a longitudinal groove on the root`s buccal or lingual surface, and fused roots are all examples of possible root conditions. It is revealed that while the C3-type orifice might appear to have two or three distinct orifices, an isthmus connecting them is frequently observed. There is cross-sectional categorization, and the definition of C-shaped follows Fan's approach.[10]Other than mandibular second molars, C-shaped canals are hardly ever detected in teeth. C-shaped canals are explained in certain case reports and research in maxillary first molars, mandibular premolars, third molars, and mandibular first molars.[9]A total of 234 first molars as well as 226 second molars were examined by Silva et al., and they determined that 1.7% of first molars in the Brazilian population had C-shaped canals. Shemesh et al.[9], in the Israeli population, found that within the first and second mandibular molars, 0.16 and 4.6% of the canals were C-shaped. A high frequency of C- C-shaped canals was revealed by Shemesh et al. [9] and Zhang et al.[10] Zheng et al. [11] found a frequency of 36.4% in males and 41.6% in females in the C-shaped canal. These outcomes are comparable to our findings, which imply that clinicians in mandibular first molars may encounter C-shaped canals (0.97%) less frequently during endodontic procedures. Therefore, while physicians should be mindful of the likelihood of mandibular first molars` C-shaped canals, it may not be a routine consideration in treatment planning for this particular tooth. In a study by Al Omari et al. [12] that aimed to assess the occurrence and anatomical characteristics of C-shaped root canals in mesial roots of mandibular second molars (MSMs) across different regions (coronal, middle, apical) of the teeth, they revealed that the prevalence of C-shaped canals in millimeters (mm) was determined to be 12% within the Jordanian subpopulation. Based on research by Feghali et al.[13] the frequency of a c-shaped canal in the mandibular first and second molars among the Lebanese population ranges from 1.01% to 9.09%, respectively. The substantial disparity can be attributed to factors such as ethnic background, discrepancies in sample numbers, and variances in study methodologies.[15]Hence, precise probing with a fine file and the meticulous creation of a deep access cavity would lead to enhanced


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precision in the detecting configuration of a C-shaped root canal. The most prevalent forms observed in the coronal third were C1, whereas C3b forms in the apical and middle thirds, were the most frequently observed. Given the increased difficulty in cleaning forms of C1 and C2 root canals compared to C3 and C4 forms, it is suggested that alternate procedures, such as the ultrasonic technique, may offer greater efficacy in the cleaning of the coronal third of root canals of C-shaped.[14]In contrast, in mandibular second molars, C-shaped canals were found to be considerably higher (7.62%). This indicates that mandibular second molars are more likely to exhibit configurations of C-shaped canals, emphasizing the importance of considering and identifying such canals during treatment planning and management in mandibular second molars. Clinicians should be vigilant in detecting and addressing C-shaped canals to ensure successful endodontic outcomes. There was not any relationship between the frequency of C-shaped canals and gender in research by Khidir et al.[13] These results are analogous to those of Zheng et al.[10] and Shemesh et al.[9], who mentioned no statistically significant gender differences. However, these data contradict our findings and those of Sert and Bayirli [16] and Martins et al. [17] who claimed that gender should be taken into consideration when evaluating channel morphology prior to the treatment of root canals. Despite that, our study didn't include the maxillary first and second molar but the study by Suha et al., in the same geographic area found that the mentioned teeth didn't have c-shaped canals.[18]In the current research, the utilization of (CBCT) proved to be highly valuable for the characterization and detection of C-shaped canals. Cone beam computed tomography provides detailed three-dimensional imaging, facilitating accurate visualization and diagnosis of complex root canal morphology. Incorporating CBCT into routine clinical practice can enhance the detection and management of C-shaped canals, ultimately improving treatment outcomes and reducing procedural complications. Nevertheless, it is critical to recognize the study's limitations. A relatively small sample size and concentration on a particular population in Erbil were limitations. Therefore, we should be careful when generalizing the outcomes to other populations. Further investigations with more diverse and larger samples are necessary to obtain a more comprehensive understanding of the occurrences and properties of C-shaped canals among various populations and geographic regions.

## Conclusion:

In sum, this research gives useful information about the incidence and features of C-shaped canals in mandibular first and second molars (0.97 % and 7.62% respectively) in the Erbil population. Further investigations are required to explore the factors contributing to gender distinctions, the significance of different c-shaped configurations, and the optimal management strategies for these variations.

## Conflict of Interest:

No conflict of interest.

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