Global Journal of Medical Research: J
Dentistry & Otolaryngology
Volume 19 Issue 4 Version 1.0 Year 2019
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4618 & Print ISSN: 0975-5888

C-Shaped Canal System in Mandibular Second Molars Evaluated by Cone-Beam Computed Tomography in an Argentine Subpopulation

By Chaintiou Piorno Romina, Consoli Lizzi Eugenia Pilar, Saiegh Jonathan, Vázquez Diego Jorge, Gualtieri Ariel Félix & Rodríguez Pablo Alejandro

University of Buenos Aires

Abstract- Introduction: To evaluate cone-beam computed tomography (CBCT) images in order to determine the presence of mandibular second molars with C-shaped canal system and classify them.

Methods: 3035 CBCT images fulfilling the selection criteria were observed. Once established the presence of C-shaped canal system, they were classified according to the anatomic and radiographic classification of Fan et al. Data description was made by frequencies and percentages rates, with a 95% confidence interval (IC95) according to score method. Comparisons were assessed by means of the Chi-square test with a significance level equal to 5%.

Results: Of the 225 selected patients, 44 exhibited C-shaped canals (20%; IC95: 15% to 25%). 70% (IC95: 56% to 82%) of patients showed a bilateral C-shaped canal system pattern. Regarding to the axial plane - anatomic classification-, there was a significant association between the root third and the configuration (Chi-square=76.89; $p<0.05$): at the coronal third prevailed the C1 configuration (47%; IC95: 36% to 58%); at the middle third prevailed the C3d configuration (39%; IC95: 28% to 50%) and at the apical third, the C4 configuration (35%; IC95: 25% to 46%).

Keywords: C-shaped canal, dental anatomy, mandibular second molar, cone-beam computed tomography.

GJMR-J Classification: NLMC Code: WU 500

C-SHAPEDCANALSYSTEMINMANDIBULARSECONDMOLARSEVALUATEDBYCONE-BEAMCOMPUTEDTOMOGRAPHYINANARGENTINESUBPOPULATION

Strictly as per the compliance and regulations of:

C-Shaped Canal System in Mandibular Second Molars Evaluated by Cone-Beam Computed Tomography in an Argentine Subpopulation

Chaintiou Piorno Romina [α], Consoli Lizzi Eugenia Pilar [σ], Saiegh Jonathan [ρ], Vázquez Diego Jorge [Ѡ], Gualtieri Ariel Félix [¥] & Rodríguez Pablo Alejandro [§]

Abstract- Introduction: To evaluate cone-beam computed tomography (CBCT) images in order to determine the presence of mandibular second molars with C-shaped canal system and classify them.

Methods: 3035 CBCT images fulfilling the selection criteria were observed. Once established the presence of C-shaped canal system, they were classified according to the anatomic and radiographic classification of Fan et al. Data description was made by frequencies and percentages rates, with a 95% confidence interval (IC95) according to score method. Comparisons were assessed by means of the Chi-square test with a significance level equal to 5%.

Results: Of the 225 selected patients, 44 exhibited C-shaped canals (20%; IC95: 15% to 25%). 70% (IC95: 56% to 82%) of patients showed a bilateral C-shaped canal system pattern. Regarding to the axial plane -anatomic classification-, there was a significant association between the root third and the configuration (Chi-square=76.89; $p<0.05$): at the coronal third prevailed the C1 configuration (47%; IC95: 36% to 58%); at the middle third prevailed the C3d configuration (39%; IC95: 28% to 50%) and at the apical third, the C4 configuration (35%; IC95: 25% to 46%). In 72% (IC95: 61% to 81%) of the cases configuration changes were observed at different levels, while in 28% (IC95: 19% to 39%) the same configuration was observed in the three thirds. This difference was significant (Chi-square=14.52; $p<0.05$).

Conclusions: The present study contributes to the epidemiological information about an anatomical variable of the inner dental configuration and its extrapolation to clinical practice.

Keywords: C-shaped canal, dental anatomy, mandibular second molar, cone-beam computed tomography.

I. Introduction

One of the purposes of the endodontic treatment is the cleaning and shaping of the root canal system. Thus, it is imperative the understanding of the inner dental anatomy to ensure a successful treatment.

Author α σ: DDS, Department of Endodontics, School of Dentistry, University of Buenos Aires, Argentine Republic.
e-mail: rominachp@hotmail.com
Author ρ Ѡ: DDS, Department of Diagnostic Imaging, School of Dentistry, University of Buenos Aires, Argentine Republic.
Author ¥: BS, PhD, Department of Biophysics and Biostatistics, School of Dentistry, University of Buenos Aires, Argentine Republic.
Author §: DDS, PhD, Department of Endodontics, School of Dentistry, University of Buenos Aires, Argentine Republic.

Numerous studies on the C-shaped root canals and their anatomical variations have been published. Historically, Keith & Knowles (1) were the first authors to depict the C-shaped root canals. This specific morphology was observed in cross-sections of mandibular second molars in a Neanderthal man. However, these authors have not assigned a specific terminology to the assessed anomalies.

The C-shaped root was first analyzed in detail by Nakayama (2), who gave it the name *"gutter-shaped root"*. Tratman (3) stated that the C-shaped root morphology can be frequently observed in mandibular second molars of Asian individuals, and he defined this shape as *"horse-shoe reduction form"*. Thirty years later, Cooke & Cox (4) reported a number of cases observed in clinical practice. Since then, the term *"C-shaped canal"* and *"C-shaped root"* have been widely employed by researchers and clinicians around the globe (5).

The main anatomical feature of the C-shaped roots is the presence of a fin or web connecting the individual canals. In this type of molars, the canal orifice is ribbon shaped describing an arc of 180º or larger, instead of the typical pulp chamber form with three root canals (6, 7).

It is postulated by Manning (8) that the failure of the Hertwig's epithelial root sheath to fuse on the lingual or buccal root surface causes this C-shaped root form, which always presents a C-shaped canal configuration.

The prevalence of C-shaped root systems in mandibular second molars is 2.7- 7.6% in the Caucasian population (4, 9), 10.6% in Saudi Arabians (10), 19.14% in Lebanese (11), being higher in Northeast Asia, 31.5% in Chinese (12) and 32.7% in Korean populations (13).

Melton et al. (14) proposed the earliest classification of the C-shaped root canals and later, Fan et al. (15, 16), based on the former one, introduced an anatomic and radiographic classification (7):

a) *Anatomic classification*

Category I (C1): The shape is an uninterrupted "C", with no separation or division.

Category II (C2): The canal shape resembles a semicolon, resulting from a discontinuation of a "C" outline.

Category III (C3): 2 or 3 separate canals.

Category IV (C4): Only one round or oval canal in the cross-section.

Category V (C5): No canal lumen can be observed, which is usually seen near the apex only.

b) Radiographic classification

Conical or square root with a radiolucent longitudinal line separating it into distal and mesial parts.

Type I: There is a mesial and a distal root canal merging into one before reaching the apical foramen.

Type II: There is a mesial and a distal root canal continuing their own pathway to the apex.

Type III: There is a mesial and a distal root canal. One canal curves as overlapping with the radiolucent line when reaching the apex and the other root canal appears to run its own pathway to the apex.

The C-shaped canals are not always to be continued from the entrance orifice of the root canal to the apical foramen with this "C". Usually, a tooth is defined as exhibiting a C-shaped canal system when its cross-section presents a C-shaped root.

The C-shaped canals have a high possibility of being divided into two or three canals (13). The root and the canal shape in the middle and the apical thirds cannot be predicted on the basis of the canal shape at the chamber floor level (15, 16). That is why studies are carried out with the aim of classifying them.

Many of the research works done on the anatomic features of the C-shaped canals are invasive studies conducted on extracted teeth. A non-invasive tri dimensional imaging (3D) technique as the cone-beam computed tomography (CBCT) has been reported to be sufficiently accurate for the morphologic analysis (17).

The CBCT images have been more routinely used than the conventional computed tomography (CT) due to its higher resolution, along with a reduction of the radiation dose and a shorter working time (18). The American Association of Endodontists (AAE) states that the CBCT imaging should be considered when the conventional dental radiography does not allow to set an adequate diagnosis (19).

The aim of this study has been to assess the CBCT scans taken at the Department of Diagnostic Imaging, School of Dentistry of the University of Buenos Aires (FOUBA) in order to determine the presence of second mandibular molars with C-shaped canals and classify them. This study has an epidemiological type of repercussion. There have not been found similar reports in the Argentine population.

II. Materials and Methods

A retrospective, observational, cross-sectional and descriptive study. On a database of 5514 PDFs, resulting from 3035 CBCT images of patients, taken with a CBCT unit in the timeframe between September 2016 and April 2018, 225 PDFs were selected fulfilling the following criteria:

a) Inclusion criteria

- Mandibular tomography, in which both second molars can be observed.
- Mandibular second molars with developed apices.

b) Exclusion criteria

- Crown-root decay involving pulp chamber floor.
- Previous endodontic treatment.
- Root resorptions.
- Crown post/core and/or crown.
- Images that cannot be correctly visualized.

Ethical considerations have been taken into account. All the patients participating in this study signed the informed consent form which stated that the information and the imaging studies could be used with academic or scientific purposes, being his/her identity preserved by FOUBA (Resolution (CD) N° 983).

The assessed images have been acquired with a Kodak 9000c 3D CBCT system, with 70 Kv and 10 mA, exposure time from 10.8 to 32.4 seconds depending on the extension -either the hole dental arch or half of the dental arch- and at a voxel size of 200 μm x 200 μm x 200 μm. The above studies have been requested by different clinicians for the diagnosis and resolution of preexisting pathologies that have not been the motive of the present research.

CBCT images have been examined by two endodontists from FOUBA, trained on the observation of tomography slices and updated by means of the continuous critical reading of scientific reports related to the subject matter of this work. To measure the inter-observer agreement, the Cohen's kappa unweighted coefficient was used. The kappa coefficient (κ) with a 95% confidence interval (IC95) was obtained. A Z test was applied to analyze the difference between the coefficient obtained and the zero value, with a significance level of 5%: a $p<0.05$ value indicates that the Cohen's kappa coefficient differs significantly from zero. The Cohen's kappa coefficient value was computed according to the criteria proposed by Altman (20). The assessment was done in software R version 3.5.1 (21): packages "irr" (22) and "psych" (23) were used. When the inter-observer agreement was estimated between the observers who collected the data, it was found that both professionals agreed in all cases. The formal analysis showed a significant and very good agreement for evaluating the presence of C-shaped canals (κ=1; IC95: 1 to 1; Z=6.3; $p<0.05$; n=40) and C-shaped type of canal according to axial orientations (κ=1; IC95: 1 to 1; Z=11.4; $p<0.05$; n=40) and sagittal (κ=1; IC95: 1 to 1; Z=8.2; $p<0.05$; n=40).

The information was collected by direct observation of the complete volumes with the Extraoral Imaging System software, Carestream Health Inc, Rochester, NY, USA.

One and a half-hour a day shift was arranged to avoid visual strain and the misinterpretation of images. The collected data were entered into specific data recording sheets for this report.

The definition of the C-shaped root canal system in the mandibular second molars requires that all the teeth exhibit the following three features: (I) fused roots, (II) a longitudinal groove on the lingual or the buccal surface of the root and (III) at least one cross-section of the canal should belong to the C1, C2, or C3 configuration. The C3 type can show two or three separate orifices, but an isthmus connecting them can be seen. The round or oval type, which can be encountered near the apex, must be considered as C4 when another part of the canal is C-shaped (15).

The anatomic classification was established performing three axial slices at different levels in accordance with the pertinent root third: "Coronal", 2 mm apical to the canal entrance orifices at the chamber floor; "Apical", 2 mm above the apex; "Middle", average distance between "coronal" and "apical". A sagittal slice was used for the radiographic classification.

Data description was achieved by absolute frequencies and percentages with 95% confidence intervals. The IC95 was obtained by the Wilson *score* method (24). A spreadsheet was used to calculate them, based on the resource ICPROPORCION.xls (25). The Chi-square test was used for the comparison of frequencies, which was implemented in the Infostat software, version 2018p (26). The significance level chosen was set up at 5%.

III. Results

Out of a total of 5514 PDFs, belonging to 3035 CBCT images of patients, 225 corresponded to patients meeting the selection criteria requirements. Out of these 225 patients, 44 showed C-shaped canals, that is to say, a 20% (IC95: 15% to 25%).

The female sex prevailed. Out of 44 patients, 28 were women (64%; IC95: 49% to 76%) and 16 were men (36%; IC95: 24% to 51%): this difference was not significant (Chi-square=3.27; p=0.07) (Fig. 1A).

Out of 44 patients, 31 showed bilateral pattern of C-shaped canals (70%; IC95: 56% to 82%) while 13 patients presented unilateral C-shaped canals (30%; IC95: 18% to 44%) (Fig. 1B, 1D y 1E): This was a significant difference (Chi-square=7.36; p<0.05).

The prevalent tooth was the 4.7 when the unilateral pattern was showed. The tooth 4.7 was found in 9 patients out of 13, presenting unilateral C-shaped canals (69%; IC95: 42% to 87%) and the tooth 3.7, was found in 4 patients (31%; IC95: 13% to 58%) (Fig. 1C): the difference was not significant (Chi-square=1.92; p=0.17).

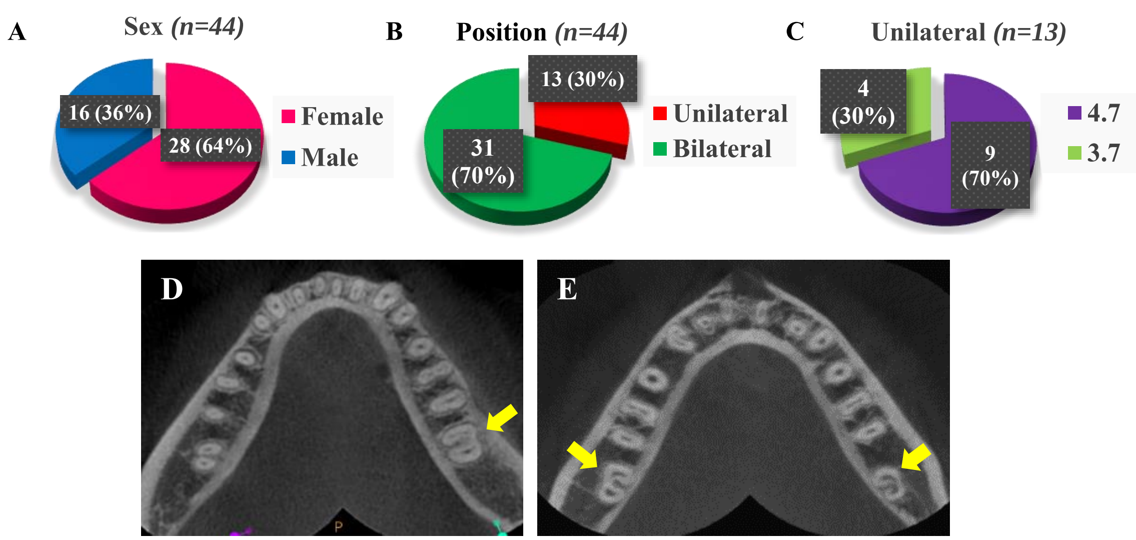

Figure 1: Prevalence of C-shaped canals according to (*A*) sex, (*B*) position, uni or bilateral and, (*C*) tooth 3.7 or 4.7, when were unilateral. CBCT axial slices in which the presence of unilateral *(D)* and bilateral *(E)* C-shaped canals is shown with yellow arrows.

As far as the anatomical classification -axial plane-, there was a significant association between the radicular third and the configuration (Chi-square=7. 89; p< 0.05): in the coronal third prevailed the C1 configuration (47%; IC95: 36% to 58%); in the middle third, C3d (39%; IC95: 28% to 50%); and in the apical third, C4 (35%; IC95: 25% to 46%) (Table 1 and Fig. 2).

Table 1: Frequency C1, C2, C3c, C3d, C4, C5 as per coronal, middle and apical thirds.

	C1	C2	C3c	C3d	C4	C5	Total
Coronal	*35*	9	16	15	0	0	75
Middle	18	9	19	*29*	0	0	75
Apical	15	5	6	22	*26*	1	75

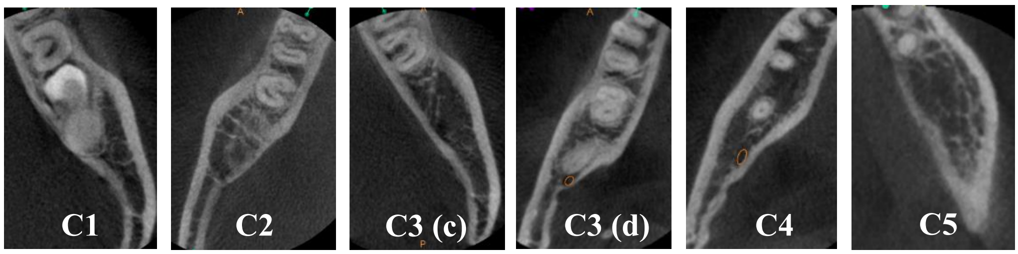

Figure 2: CBCT images of axial slices in which the different categories are shown in accordance with Fan et al. classification.

There was no significant association between the tooth and the radiographic classification -*sagittal plane*- (Chi-square=0, 99; p=0, 61): The type I prevailed in both teeth, 4.7 (58%; IC95: 42% to 71%) and 3.7 (66%; IC95: 49% to 79%) (Table 2 and Fig. 3).

Table 2: Frequency in the sagittal plane. Type I, II, and III.

	Type I	Type II	Type III	Total
4.7	23	12	5	40
3.7	23	7	5	35

Figure 3: CBCT images of sagittal slices in which the different categories are shown according to the Fan et al. Classification.

In 72% (IC95: 61% to 81%) of the cases, configuration changes have been observed at different levels. In 28% (IC95: 19% to 39%) the same configuration was observed in the three thirds (Table 3 and Fig. 4): this difference was significant (Chi- square=14.52; p<0.05).

Table 3: Configuration in the three-thirds of teeth with C-shaped canals.

Configuration in the three thirds (coronal, middle and apical thirds) of teeth with C-shaped canals	Teeth with C-shaped canals (n=75)
Configuration has no changes	21
Configuration changes	54

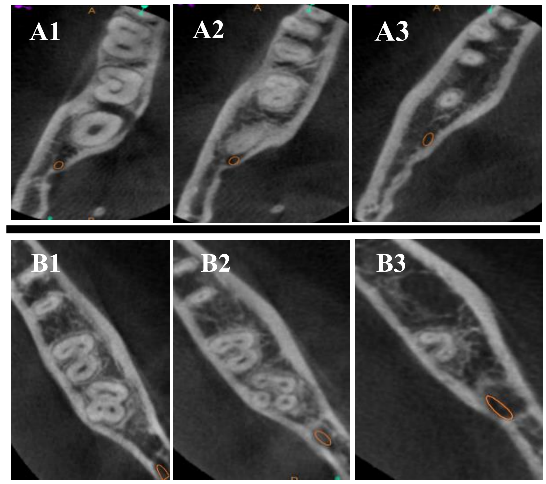

Figure 4: CBCT images showing the C-shaped canal configuration: *(A)* changes *or (B*) no changes. *(A1* and *B1),* coronal third; *(A2* and *B2),* middle third; *(A3* and *B3)*, apical third.

IV. Discussion

The C-shaped canal system has been the subject of many research works performed *in vivo* and *ex vivo* for its study. The literature points out that the presence of C-shaped canals is higher among the East Asian population, exhibiting China the highest prevalence (44%) (12). In European countries, such as Spain and England the prevalence rate varied between 7.8% and 11% (12), whereas studies in Italy reported a 6.2% (27), an 8.5% in Portugal (28), and a 10.7% in Belgium (29). A study performed in Brazil indicates a 3.6% (30) prevalence, whereas another study reports a 6.8% (12). As regards the American population, von Zuben et al. (12) were the first to investigate the C-shaped canals prevalence using CBCT imaging, obtaining a result of 11.3% that was higher than the 7.6% described in prior studies (9). On the other hand, von Zuben et al. reported a 9.3% prevalence in South Africa and a 14.2% prevalence in Mexico (12). Another study conducted on panoramic radiographs in Mexico reports a 36.8% prevalence (31). At the time this work was performed, similar reports were not found regarding the Argentine population.

Earlier reports show that sex has no significant influence on the C-shaped canal prevalence (27, 32, 33); in the present study, even though a higher percentage in women appeared, this difference was not significant. Martins et al. (28) report that women show a higher prevalence, as well as Kim et al. (34) and von Zuben et al. reports do (12).

The presence of the bilateral C-shaped canals had a higher representation than the unilateral pattern in previous reports (12, 32, 34), as well as in the present work.

The tooth position, either right or left, would not influence the prevalence of the C-shaped canals (12, 28, 32, 33); this study is in line with the reports of these authors.

The C1 configuration prevailed in the coronal third, the C3d configuration type was prevalent in the middle third, and the C4 was prevalent in the apical third. Zheng et al. (32) reported that the prevailing type of configuration in the coronal third was C1, in the middle third was C3d and apical was C3c. Similar results were reported by Fan et al. (15). Kim et al. (34) encountered that the C1 configuration predominated at the canal entrance orifices level, in the coronal third predominated the C3 configuration as much as in the middle and apical thirds.

Along the canal, in 72% of the cases, configuration variations at the three-thirds have been observed, while 28% kept the same configuration along the root. Zheng et al. (32) observed that in the highest percentage of the teeth there was a variation from coronal to apical. Only in 5.5% there was no variation.

No studies evaluating the radiographic classification *-sagittal plane-* in cone- beam tomographies were found.

Regardless of the different configurations found along the root, the incidence of 20% of the C-shaped canals in the Argentine Republic can be explained from a genetic and ethnic perspective of the population, which is diverse and heterogeneous (35).

Argentina is considered to be an “immigration country” in the sense of the major impact that different migratory flows have had on the ethnic composition of its population.

V. Conclusion

The classification and the percentages obtained in the present research work contribute to the theoretical understanding and its extrapolation to the clinical field based on an anatomical variable of the inner teeth configuration. It is of paramount importance that the endodontist considers the C-shaped canal as a complex configuration of canals, but not as an unusual one, so that suitable procedures can be applied, leading to a successful treatment. Unquestionably, CBCT imaging is a substantial tool for diagnosing and planning a predictable treatment *in vivo*.

Acknowledgments

The authors deny any conflicts of interest related to this study.

References Références Referencias

1. Keith A, Knowles FH. A description of teeth of Palaeolithic man from Jersey. J Anat Physiol 1911; 46(Pt 1), 12.
2. Nakayama A. Gutter shaped root in human mandibular molars. Kokubyo Gakkai Zasshi. 1941; 15: 275–81. [in Japanese]
3. Tratman E K. A comparison of the teeth of people; Indo-European racial stock with the Mongoloid racial stock. The Dental Record 1950; 70: 63-88.
4. Cooke H G, Cox F L. C-shaped canal configurations in mandibular molars. JADA 1979, 99: 836-9.
5. Kato A, Ziegler A, Higuchi N, Nakata K, Nakamura H, Ohno N. Aetiology, incidence and morphology of the C-shaped root canal system and its impact on clinical endodontics. Int Endod J 2014; 47: 1012-33.
6. Gulabivala K, Opasanon A, Ng Y L, Alavi A. Root and canal morphology of Thai mandibular molars. Int Endod J 2002; 35: 56-62.
7. Jafarzadeh H, Wu Y N. The C-shaped root canal configuration: a review. J Endod 2007; 33: 517-23.
8. Manning S A. Root canal anatomy of mandibular second molars: Part II C-shaped canals. Int Endod J 1990; 23: 40-5.
9. Weine F S. The C-shaped mandibular second molar: incidence and other considerations. J Endod 1998; 24: 372-5.
10. Al-Fouzan K S. C-shaped root canals in mandibular second molars in a Saudi Arabian population. Int Endod J 2002; 35: 499-504.
11. Haddad G Y, Nehme W B, Ounsi H F. Diagnosis, classification, and frequency of C-shaped canals in mandibular second molars in the Lebanese population. J Endod 1999, 25: 268-71.
12. Von Zuben M, Martins J N, Berti L, Cassim I, Flynn D, Gonzalez J Á, Marques M S. Worldwide prevalence of mandibular second molar C-shaped morphologies evaluated by cone-beam computed tomography. J Endod 2017; 43: 1442-7.
13. Seo M S, Park D S. C-shaped root canals of mandibular second molars in a Korean population: clinical observation and in vitro analysis. Int Endod J 2004; 37: 139-44.
14. Melton D C, Krell K V, Fuller M W. Anatomical and histological features of C- shaped canals in mandibular second molars. J Endod 1991; 17: 384-8.
15. Fan B, Cheung GSP, Fan M, Gutmann J L, Bian Z. C-shaped canal system in mandibular second molars: Part I-anatomical features. J Endod 2004; 30: 899- 903.
16. Fan B, Cheung G S, Fan M, Gutmann J L, Fan W. C-shaped canal system in mandibular second molars: Part II—Radiographic features. J Endod 2004; 30: 904-8.
17. Zhang R, Wang H, Tian Y Y, Yu X, Hu T, Dummer PMH. Use of cone-beam computed tomography to evaluate root and canal morphology of mandibular molars in Chinese individuals. Int Endod J 2011; 44: 990-9.
18. Patel S, Dawood A, Ford T P, Whaites E. The potential applications of cone beam computed tomography in the management of endodontic problems. Int Endod J 2007; 40: 818-30.
19. AAE and AAOMR. Joint position statement on the use of cone-beam-computed tomography in endodontics. 2015. http://www.aae.org/guidelines/
20. Altman D G. (1991). Practical statistics for medical research. Londres: Chapman & Hall.
21. R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R- project.org/
22. Gamer M, Lemon J, Singh IFP. (2012). irr: Various Coefficients of Interrater Reliability and Agreement.
23. Revelle W. (2018) psych: Procedures for Personality and Psychological Research, Northwestern University, Evanston, Illinois, EUA.
24. Agresti A, Coull B A. Approximate is better than "exact" for interval estimation of binomial proportions. The American Statistician 1998; 52: 119-26.
25. Newcombe R G, Merino Soto C. Intervalos de confianza para las estimaciones de proporciones y las diferencias entre ellas. Interdisciplinaria 2006; 3: 141-54.
26. Di Rienzo J A, Casanoves F, Balzarini M G, Gonzalez L, Tablada M & Robledo C W. Info Stat versión 2018. Grupo InfoStat, FCA, Universidad Nacional de Córdoba, Argentina. Año 2018. URL http://www.infostat.com.ar
27. Plotino G, Tocci L, Grande N M, Testarelli L, Messineo D, Ciotti M, Gambarini G. Symmetry of root and root canal morphology of maxillary and mandibular molars in a white population: a cone-beam computed tomography study in vivo. J Endod 2013; 39: 1545-8.
28. Martins J N, Mata A, Marques D, Anderson C, Caramês J. Prevalence and characteristics of the maxillary C-shaped molar. J Endod 2016; 42: 383-9.
29. Torres A, Jacobs R, Lambrechts P, Brizuela C, Cabrera C, Concha G, Pedemonte M E. Characterization of mandibular molar root and canal morphology using cone beam computed

tomography and its variability in Belgian and Chilean population samples. Imaging Sci Dent 2015; 45: 95-101.
30. Silva EJNL, Nejaim Y, Silva A V, Haiter-Neto F, Cohenca N. Evaluation of root canal configuration of mandibular molars in a Brazilian population by using cone-beam computed tomography: an in vivo study. J Endod 2013; 39: 849-52.
31. Ávila-Gómez J A, Vega-Lizama E M, López-Villanueva M E, Alvarado-Cárdenas G. Bilateralidad de segundos molares mandibulares con conductos en C. Rev Odontol Latinoam 2012; 4: 33-6.
32. Zheng Q, Zhang L, Zhou X, Wang Q, Wang Y, Tang L, Huang D. C-shaped root canal system in mandibular second molars in a Chinese population evaluated by cone-beam computed tomography. Int Endod J 2011; 44: 857-62.
33. Helvacioglu-Yigit D, Sinanoglu A. Use of cone-beam computed tomography to evaluate C-shaped root canal systems in mandibular second molars in a Turkish subpopulation: a retrospective study. Int Endod J 2013; 46: 1032-8.
34. Kim S Y, Kim B S, Kim Y. Mandibular second molar root canal morphology and variants in a Korean subpopulation. Int Endod J 2016; 49: 136-44.
35. Chaintiou Piorno R, Consoli Lizzi E, Lenarduzzi A, Rodriguez PA. Reto de la Endodoncia: Conducto en “C”. Rev. Fac. de Odon. UBA 2018; 33: 5-9.