Original Research
Endodontic Therapy

# Internal configuration of maxillary molars in a subpopulation of Brazil's Northeast region: A CBCT analysis

**George Táccio de Miranda CANDEIRO**[a]
**Samilla dos Santos GONÇALVES**[a]
**Luiza Lassi de Araújo LOPES**[a]
**Ilana Thaís de Freitas LIMA**[a]
**Phillipe Nogueira Barbosa ALENCAR**[a]
**Elaine Faga IGLECIAS**[b]
**Paulo Goberlânio Barros SILVA**[a]

[a]Centro Universitário Christus - Unichristus, Post-graduation Program of Dental Sciences, Fortaleza, CE, Brazil.

[b]Universidade de São Paulo – USP, School of Dentistry, Department of Restorative Dentistry, São Paulo, SP, Brazil.

**Declaration of Interests:** The authors certify that they have no commercial or associative interest that represents a conflict of interest in connection with the manuscript.

**Corresponding Author:**
George Táccio de Miranda Candeiro
E-mail: georgecandeiro@hotmail.com

https://doi.org/10.1590/1807-3107bor-2019.vol33.0082

Submitted: April 8, 2019
Accepted for publication: June 25, 2019
Last revision: July 31, 2019

**Abstract:** The present study aimed to evaluate the internal configuration of the maxillary molars of a population from the Northeast region of Brazil. Cone-beam computed tomography (CBCT) exams from 512 patients (1501 teeth) were evaluated regarding the anatomical configuration of the root canal system, according to Vertucci's classification. The images were obtained using a Prexion 3D scanner operating at 90 kVp and 4 mA. The voxel size was 0.125 mm and the cut thickness was 1 mm. The images were then analyzed in the Prexion 3D Viewer software. The data were analyzed statistically by Pearson's chi-square test, with 5% of significance. The first and second molars presented three roots in 99.14% and 87.27% of the cases, respectively. In relation to the number of canals, the first and second molars had a significantly higher frequency of three and four root canals respectively, presenting a higher prevalence of types I and II ($p < 0.001$). The second mesiobuccal canal (MB2) was observed in 48.21% and 22.72% of the first and second molars, respectively ($p < 0.001$). The identification of the MB2 canal was greater in young and adult patients ($p < 0.001$), presenting a higher prevalence in male patients ($p < 0.001$). The internal configuration of the MB root was influenced by gender and by age, presenting a higher prevalence of the MB2 in male patients younger than 50 years of age.

**Keywords:** Endodontics; Anatomy; Cone-Beam Computed Tomography.

## Introduction

The success of endodontic treatment relies on the correct cleaning and shaping of the root canal systems with subsequent obturation, avoiding recontamination.[1] However, in maxillary molars, the complex internal root canal anatomy contributes to the failure of the endodontic treatment.[2,3]

Anatomical differences in the root canal are genetically determined and have been frequently reported in several studies, allowing for the identification of root canal anatomy in different ethnic populations.[4,5,6,7,8,9] Recurrently, the first maxillary molars present three roots and four canals and a second mesiobuccal canal (MB2) is present in approximately 50% of cases.[5,6,7]

Some ex vivo methodologies may be used for the study of internal dental anatomy, such as diaphanization,[8] cross-section methods,[9] and

computed microtomography (micro-CT).[10] These methods may only be used to evaluate extracted teeth, making it difficult to correlate anatomy with gender and with age.[11] Among the *in vivo* methods to assess the anatomy of root canals, cone-beam computed tomography (CBCT) has been widely used in several studies.[1,5,6,7,12,13,14,15]

To date, there are some studies have evaluated the internal anatomy of teeth in the Brazilian population by using CBCT.[12,13,14,16] Since Brazil represents an extensive geographic area, different ethnicities, and great miscegenation, some anatomical differences between regions may occur. In view of the absence of previous studies, the aim of the present study was to evaluate the internal configuration of the mesiobuccal root of the first and second maxillary molars in a subpopulation of the Northeast region of Brazil, using CBCT. The experimental hypothesis was that there are significant difference between gender and age on morphologies of first and second maxillary molars.

## Methodology

This project has been approved by the Research Ethics Committee of Christus University Center (Fortaleza, Brazil) (CAAE 66524917.7.70000.5049).

The present study evaluated CBCT scans of 512 patients from a database of a private oral radiology clinic (Perboyre Castelo Clinic) in Fortaleza, Brazil. The patients' ages ranged from 10 to 80 years old. All images were obtained for reasons unrelated to the research, with the main indications being dental rehabilitation with implants, diagnosis of fractured roots, and location of impacted teeth. The selected patients had at least one erupted maxillary molar, teeth with fully formed apices, and teeth with no fractures, root resorption, or calcification. Teeth with intra-radicular metal posts and extensive metallic restorations were excluded from the study.

The images were obtained using a Prexion 3D imaging device (Prexion, Inc., San Mateo, USA) operating at 90 kVp and 4 mA. The voxel size was 0.125 mm and the cut thickness was 1 mm. The scans were acquired according to the manufacturer's instructions, with the minimum radiation exposure required to obtain an image of adequate quality. The CBCT images were analyzed by an experienced endodontist who had been previously trained regarding the methodology. The Prexion 3D Viewer software (Prexion, Inc., San Mateo, USA) was used on a Dell Precision T5400 (Dell, Round Rock, TX) workstation with a 17-inch Dell LCD screen with a resolution of 1280 × 1024 pixels in a room with dim lighting. The images were analyzed in the sagittal, axial, and coronal planes. Contrast and brightness were also adjusted to ensure better visualization using software image processing tools.

The number of roots and their morphology, the number of root canals, and the anatomical configuration of the root canal system were evaluated according to Vertucci's classification.[4] The data were analyzed statistically by Pearson's chi-square test (Statistical Package for the Social Sciences 20.0 for Windows), being considered significant when $p < 0.05$.

## Results

A total of 1,501 teeth were evaluated, consisting of 700 maxillary first molars and 801 maxillary second molars. The mean age of participants was 44.5 years old, of which 184 were men and 328 were women.

It was observed that first and second molars showed a significantly higher frequency of three roots. However, the second molars had relatively more teeth with two roots in relation to the first molars ($p < 0.01$). Molars with a single root were identified only in second molars (1.87%) and molars with five roots were not observed (Table 1). No teeth had two palatine roots.

With regards to the number of canals, the first and second molars had a significantly higher frequency of three (50.43% and 65.54%, respectively) and four canals (48.71% and 22.72%, respectively). However, the maxillary second molars presented a significantly higher number of teeth with two canals when compared to the first molars, which showed a higher relative frequency of teeth with four canals ($p < 0.01$). It was observed that the first and second upper molars had a low frequency of teeth with five root canals (0.29% and 0.25%, respectively). Only 1.87% of the second molars had a single canal (Table 2).

Regarding the configuration of the root canal system in the mesiobuccal (MB) root according to Vertucci's classification, the first and second molars possessed a high prevalence of type I and II configurations. Nonetheless, the second molars presented relatively more cases of type I configurations than the first molars, which had more cases of types II, III and IV ($p < 0.01$). Only one of the second molars, in a female patient, presented a type VIII configuration for the MB root (Table 3).

The two first molars with four roots presented five canals (0.29%), two of which were in the mesiobuccal root type IV, and one in the mesiopalatine root (MP). One of the nine molars with four roots had five canals, with a type IV configuration in the MB root, and the other seven presented a type I root canal (MB, MP, DB and DP).

Concerning the age groups, a reduction in the prevalence of a second mesiobuccal canal (MB2) was observed in both dental groups evaluated as the

**Table 1.** Number of roots in first and second maxillary molars.

| Roots | First molars (n = 700) | | Second molars (n = 801) | | p-value |
|---|---|---|---|---|---|
| | n | % | n | % | |
| One | 0 | 0.00 (0.00–0.55) | 15 | 1.87 (1.14–3.07) | < 0.001 |
| Two | 4 | 0.57 (0.22–1.46) | 78* | 9.74 (7.87–11.99) | |
| Three | 694* | 99.14 (98.14–99.61) | 699 | 87.27 (84.78–84.90) | |
| Four | 2 | 0.29 (0.08–1.04) | 9 | 1.12 (0.59–2.12) | |
| Five | 0 | 0.00 (0.00–0.55) | 0 | 0.00 (0.00–0.48) | |

*p<0.05, Pearson's chi-square test. Values expressed as absolute frequency and percentage frequency (95% confidence interval).

**Table 2.** Number of root canals according to dental group.

| Root canals | First molars (n = 700) | | Second molars (n = 801) | | p-value |
|---|---|---|---|---|---|
| | n | % | n | % | |
| One | 0 | 0.00 (0.00–0.55) | 15 | 1.87 (1.30–3.51) | < 0.001 |
| Two | 4 | 0.57 (0.22–1.46) | 77* | 9.61 (8.89–13.53) | |
| Three | 353 | 50.43 (46.73–54.12) | 525* | 65.54 (71.66–78.07) | |
| Four | 341* | 48.71 (45.03–52.41) | 182 | 22.72 (22.89–29.37) | |
| Five | 2 | 0.29 (0.08–1.04) | 2 | 0.25 (0.08–1.04) | |

*p<0.05, Pearson's chi-square test. Values expressed as absolute frequency and percentage frequency (95% confidence interval).

**Table 3.** Root canal configuration of MB root, according to Vertucci's classification (1984).

| Type | Image | First molars (n = 700) | | Second molars (n = 801) | | p-value |
|---|---|---|---|---|---|---|
| | | n | % | n | % | |
| I |  | 358 | 51.14 (47.44–54.83) | 626* | 78.15 (75.16–80.88) | <0.001 |
| II |  | 185* | 26.42 (23.30–29.82) | 95 | 11.86 (9.80–14.28) | |
| III |  | 29* | 4.14 (2.90–5.89) | 19 | 2.37 (1.52–3.67) | |
| IV |  | 103* | 14.71 (12.28–17.53) | 48 | 5.99 (4.55–7.86) | |
| V |  | 19 | 2.71 (1.74–4.20) | 11 | 1.37 (0.77–2.44) | |
| VI |  | 6 | 0.85 (0.39–1.86) | 1 | 0.12 (0.02–0.70) | |
| VII |  | 0 | 0.00 (0.00–0.55) | 0 | 0.00 (0.00–0.48) | |
| VIII |  | 0 | 0.00 (0.00–0.55) | 1 | 0.12 (0.02–0.70) | |

*p<0.05, Pearson's chi-square test. Values expressed as absolute frequency and percentage frequency (95% confidence interval).

age increased (Figures 1 and 2). In the first molars, patients up to 50 years of age had a significantly higher prevalence of MB2 (53.68 - 69.57%) when compared to patients older than 50 years old (29.22 - 43.79%) ($p < 0.001$). In the second molars, patients up to 20 years of age had a significantly higher prevalence of MB2 (50%) than patients older than 20 years old (13.14 - 35.29%) ($p < 0.001$).

In terms of gender, the presence of MB2 was significantly higher in male patients than in female patients ($p < 0.001$), in both the first and second molars. In the first molars, more than 60% of patients who presented MB2 were male (Table 4).

## Discussion

The study of internal dental anatomy is very important for the success of endodontic treatment, since the configuration of the root canal morphology presents variation among populations.[6,7,9,17,18,19] The results of this study showed that approximately 48% of the maxillary molar MB roots presented two canals, in agreement with previous studies.[13,17,18,19] However, some authors showed that more than half of first maxillary molars had an MB2 root canal.[1,5,6,7,11,15,20,21,22,23,24,25] It was also observed that 23% of second molars had more than one root canal in the mesiobuccal root, a result similar to that found in other populations.[20,22,24] In several previous studies, MB2 canal frequency was from 29.4% to 57.93% in the maxillary second molars.[1,6,7,13] In contrast, in the studies of Ghoncheh et al.[15] and Lin et al.,[24] only 13.84% and 7.7% of maxillary second molars presented a second canal in the mesiobuccal root, respectively. These differences may be due to sample diversity in number and in ethnicity.

CBCT studies of the internal dental anatomy of maxillary molars in the Brazilian population are

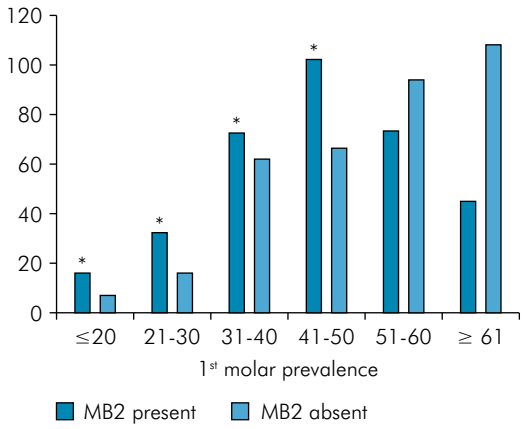


**Figure 1.** Distribution by age group of a second mesiobuccal canal (MB2) in the first maxillary molars. (*$p < 0.05$ versus other age groups, Pearson's chi-square test).

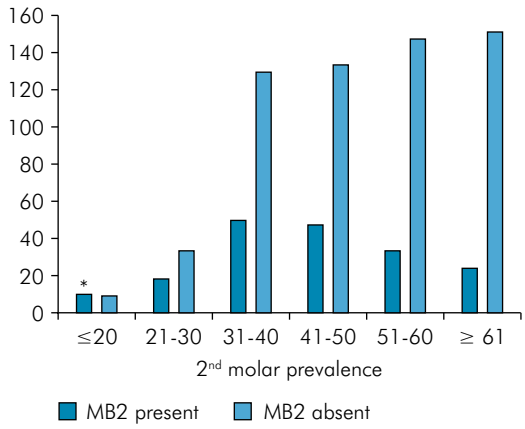


**Figure 2.** Distribution by age group of a second mesiobuccal canal (MB2) in the second maxillary molars. (*$p < 0.05$ versus other age groups, Pearson's chi-square test).

**Table 4.** Distribution of MB2 root canals by gender.

| Molars | Male | | Female | | p-value |
|---|---|---|---|---|---|
| | n | % | n | % | |
| First molars evaluated | 237 | 100.00% | 464 | 100.00% | < 0.001 |
| MB2 present | 139* | 60.17% | 203 | 43.75% | |
| Second molars evaluated | 296 | 100.00% | 505 | 100.00% | < 0.001 |
| MB2 present | 90* | 30.41% | 85 | 16.83% | |

*p<0.05, Pearson's chi-square test.

still limited to the Southeast and Central regions of the country. Considering that Brazil has continental dimensions, the dental anatomy within the country may be variable. The Northeast region shows a low MB2 canal index of maxillary second molars compared to that found in other studies, especially in relation to the Central-West and South regions.[12,13,14,16] Estrela et al.,[14] when evaluating the internal dental anatomy of a subpopulation of the Central region of Brazil, observed that the first maxillary molars had a higher frequency of four root canals and four apical foramina (76% and 33%, respectively), followed by the second molars (41% and 25%, respectively). All the studies observed that only the mesiobuccal roots had two root canals.[12,13,14,16]

For both dental groups, the most common MB root configuration was Vertucci's type I, an outcome similar to the findings of another Brazilian population and to those in a Thai population.[7,13] Other studies on Chinese, Chilean and Egyptian populations had the type II configuration as the more prevalent, presenting only one foramen.[1,6,21] However, in other studies, with Indian, Korean, North American and Iranian populations, the most common canal configurations for the MB root had two foramens.[5,15,19,20,24] In the work of Hiebert et al.[25], performed on extracted teeth, it was also observed that the majority of molars with MB2 canal presented configuration with more than one foramen according to Vertucci's classification.[4]

This study has verified the presence of five canals in two of the first and second molars, of which three had four roots, containing two canals in the MB root, one in the MP root, one in the DB root and one in the DP root. A final second molar presented five canals and three roots, with three canals in the MB root. Kim et al.[23] found only one first maxillary molar in a total of 802 with five canals and three roots, being Vertucci's type VIII configuration of the MB root.

In the present research, the experimental hypothesis was accepted, once that it was observed a reduction in the presence of MB2 as age increases, especially above age 50. There is also a male preference, in agreement with the previous researches that obtained also observed an inverse correlation between the presence of the MB2 canal and age, regardless of gender influence.[1,5,11,12] These results suggest that, as age advances, the chances of identification of an MB2 canal decrease, probably as a result of dentin apposition on the root canal walls. In the studies of Ratanajirasut et al.[7] and Kim et al.,[23] no correlation with age was observed and a higher frequency of MB2 in male patients was found; in Ghobashy et al.[6] no correlation regarding age or sex was found.

In vivo CBCT has been shown to be a noninvasive and clinically effective tool in the analysis of the roots and morphology of the root canals, assisting in the identification of the MB2 canal and making it possible to improve the quality of endodontic treatment. This result is consistent with other previous studies that used the same method of identification.[1,5,6,7,12,13,15,24] Conversely, in the study by Hiebert et al.[25], in which the identification of the MB2 was compared based on CBCT scans or on endodontic access, it was observed that CBCT identified a lower percentage of MB2 canals when compared to canal access and exploitation. In contrast, the association of the two methods led to a higher identification rate of this canal.

The results of this study may provide some useful information for endodontic treatment, given that prior knowledge of anatomical variations is of great value in assisting dentists with regard to locating the root canal system and subsequent cleaning and filling, which might improve treatment perspectives and patient prognosis.

## Conclusions

In conclusion, first and second maxillary molars presenting three roots are highly prevalent, with the first molars having the highest prevalence of four canals in comparison to the second molars. The type I configuration according to Vertucci's classification is the most prevalent in the MB root. It was also possible to observe that the configuration of the MB root is influenced by gender and age, in that a higher prevalence of the MB2 canal could be found in male patients as well as in patients younger than 50 years of age.

## References


1. Abarca J, Gómez B, Zaror C, Monardes H, Bustos L, Cantin M. Assessment of mesial root morphology and frequency of MB2 canals in maxillary molars using cone beam computed tomography. Int J Morphol. 2015 Jun;33(4):1333-7. https://doi.org/10.4067/S0717-95022015000400023.
2. Estrela C, Leles CR, Hollanda AC, Moura MS, Pécora JD. Prevalence and risk factors of apical periodontitis in endodontically treated teeth in a selected population of Brazilian adults. Braz Dent J. 2008;19(1):34-9. https://doi.org/10.1590/S0103-64402008000100006
3. Estrela C, Holland R, Estrela CR, Alencar AH, Sousa-Neto MD, Pécora JD. Characterization of successful root canal treatment. Braz Dent J. 2014 Jan-Feb;25(1):3-11. https://doi.org/10.1590/0103-6440201302356
4. Vertucci FJ. Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol. 1984 Nov;58(5):589-99. https://doi.org/10.1016/0030-4220(84)90085-9
5. Guo J, Vahidnia A, Sedghizadeh P, Enciso R. Evaluation of root and canal morphology of maxillary permanent first molars in a North American population by cone-beam computed tomography. J Endod. 2014 May;40(5):635-9. https://doi.org/10.1016/j.joen.2014.02.002
6. Ghobashy AM, Nagy MM, Bayoumi AA. Evaluation of root and canal morphology of maxillary permanent molars in an Egyptian Population by cone-beam computed tomography. J Endod. 2017 Jul;43(7):1089-92. https://doi.org/10.1016/j.joen.2017.02.014
7. Ratanajirasut R, Panichuttra A, Panmekiate S. A cone-beam computed tomographic study of root and canal morphology of maxillary first and second permanent molars in a Thai population. J Endod. 2018 Jan;44(1):56-61. https://doi.org/10.1016/j.joen.2017.08.020
8. Weng XL, Yu SB, Zhao SL, Wang HG, Mu T, Tang RY, et al. Root canal morphology of permanent maxillary teeth in the Han nationality in Chinese Guanzhong area: a new modified root canal staining technique. J Endod. 2009 May;35(5):651-6. https://doi.org/10.1016/j.joen.2009.02.010
9. Kulild JC, Peters DD. Incidence and configuration of canal systems in the mesiobuccal root of maxillary first and second molars. J Endod. 1990 Jul;16(7):311-7. https://doi.org/10.1016/S0099-2399(06)81940-0
10. Somma F, Leoni D, Plotino G, Grande NM, Plasschaert A. Root canal morphology of the mesiobuccal root of maxillary first molars: a micro-computed tomographic analysis. Int Endod J. 2009 Feb;42(2):165-74. https://doi.org/10.1111/j.1365-2591.2008.01472.x
11. Zhang Y, Xu H, Wang D, Gu Y, Wang J, Tu S, et al. Assessment of the second mesiobuccal root canal in maxillary first molars: a cone-beam computed tomographic study. J Endod. 2017 Dec;43(12):1990-6. https://doi.org/10.1016/j.joen.2017.06.021
12. Reis AG, Grazziotin-Soares R, Barletta FB, Fontanella VR, Mahl CR. Second canal in mesiobuccal root of maxillary molars is correlated with root third and patient age: a cone-beam computed tomographic study. J Endod. 2013 May;39(5):588-92. https://doi.org/10.1016/j.joen.2013.01.003
13. Silva EJ, Nejaim Y, Silva AI, Haiter-Neto F, Zaia AA, Cohenca N. Evaluation of root canal configuration of maxillary molars in a Brazilian population using cone-beam computed tomographic imaging: an in vivo study. J Endod. 2014 Feb;40(2):173-6. https://doi.org/10.1016/j.joen.2013.10.002
14. Estrela C, Bueno MR, Couto GS, Rabelo LE, Alencar AH, Silva RG, et al. Study of root canal anatomy in human permanent teeth in a subpopulation of Brazil's center region using cone-beam computed tomography - Part 1. Braz Dent J. 2015 Oct;26(5):530-6. https://doi.org/10.1590/0103-6440201302448
15. Ghoncheh Z, Zade BM, Kharazifard MJ. Root morphology of the maxillary first and second molars in an Iranian population using cone beam computed tomography. J Dent (Tehran). 2017 May;14(3):115-22.
16. Alves CRG, Marques MM, Moreira MS, Cara SPHM, Bueno CES, Lascala CA. Second mesiobuccal root canal of maxillary first molars in a Brazilian population in high-resolution cone-beam computed tomography. Iran Endod J. 2018;13(1):71-7. https://doi.org/10.22037/iej.v13i1.18007
17. Pattanshetti N, Gaidhane M, Al Kandari AM. Root and canal morphology of the mesiobuccal and distal roots of permanent first molars in a Kuwait population: a clinical study. Int Endod J. 2008 Sep;41(9):755-62. https://doi.org/10.1111/j.1365-2591.2008.01427.x
18. Neelakantan P, Subbarao C, Ahuja R, Subbarao CV, Gutmann JL. Cone-beam computed tomography study of root and canal morphology of maxillary first and second molars in an Indian population. J Endod. 2010 Oct;36(10):1622-7. https://doi.org/10.1016/j.joen.2010.07.006
19. Plotino G, Tocci L, Grande NM, Testarelli L, Messineo D, Ciotti M, et al. 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 Dec;39(12):1545-8. https://doi.org/10.1016/j.joen.2013.09.012
20. al Shalabi RM, Omer OE, Glennon J, Jennings M, Claffey NM. Root canal anatomy of maxillary first and second permanent molars. Int Endod J. 2000 Sep;33(5):405-14. https://doi.org/10.1046/j.1365-2591.2000.00221.x
21. Zhang R, Yang H, Yu X, Wang H, Hu T, Dummer PM. Use of CBCT to identify the morphology of maxillary permanent molar teeth in a Chinese subpopulation. Int Endod J. 2011 Feb;44(2):162-9. https://doi.org/10.1111/j.1365-2591.2010.01826.x
22. Lee JH, Kim KD, Lee JK, Park W, Jeong JS, Lee Y, et al. Mesiobuccal root canal anatomy of Korean maxillary first and second molars by cone-beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2011 Jun;111(6):785-91. https://doi.org/10.1016/j.tripleo.2010.11.026

23. Kim Y, Lee SJ, Woo J. Morphology of maxillary first and second molars analyzed by cone-beam computed tomography in a korean population: variations in the number of roots and canals and the incidence of fusion. J Endod. 2012 Aug;38(8):1063-8. https://doi.org/10.1016/j.joen.2012.04.025
24. Lin YH, Lin HN, Chen CC, Chen MS. Evaluation of the root and canal systems of maxillary molars in Taiwanese patients: a cone beam computed tomography study. Biomed J. 2017 Aug;40(4):232-8. https://doi.org/10.1016/j.bj.2017.05.003
25. Hiebert BM, Abramovitch K, Rice D, Torabinejad M. Prevalence of second mesiobuccal canals in maxillary first molars detected using cone-beam computed tomography, direct occlusal access, and coronal plane grinding. J Endod. 2017 Oct;43(10):1711-5. https://doi.org/10.1016/j.joen.2017.05.011