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C-oblik kanala gornjeg drugoga kutnjaka: 3D Cone-Beam kompjutorizirana tomografska analiza uređajem Prexion

A C-Shaped Canal in a Maxillary Second Molar: Prexion 3D Cone-Beam Computed Tomography Analysis

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Sažetak

Svrha: Željelo se predstaviti netipičan slučaj C-oblika kanala u vestibularnom korijenu trajnoga maksilarnog kutnjaka, a pritom su korišteni kompjutorizirana 3D tomografija koničnom zrakom (CBCT) i dijagnostički uređaj PreXion. **Materijali i metode:** Nakon rutinskoga pregleda 50-godišnja pacijentica upućena je u privatnu dijagnostičko-radiološku kliniku u Recife-Pernambucu u Brazilu. Tijekom pregleda uočena je neuobičajena anatomija vestibularnog kanala u obliku velikoga slova C s meziodistalnom anastomozom koja se protezala od apikalne do cervikalne trećine, a otkrivena je aksijalnim rezovima na uređaju PreXion 3D. **Rezultati:** Premda se C-oblici korijenskih kanala najčešće nalaze u drugim mandibularnim kutnjacima, u ovom radu opisana je rijetka pojava u drugom maksilarnom trajnom molaru. **Zaključak:** PreXion 3-D CBCT najnoviji je uređaj visoke rezolucije koji pomaže pri postavljanju dijagnoza anatomskih varijacija poput C-oblika korijenskih kanala. Ipak, uporaba takvih sustava prikazivanja ne preporučuje se u rutinskoj uporabi.

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Uvod

Poznavanje unutarnje anatomije zuba i njihovih varijacija prijeko je potrebno za uspješnu endodontsku terapiju jer, ako se te anomalije ne otkriju, poneke mogu biti i uzrok terapijskog neuspjeha. C-oblik kanala su, među varijacijama anatomskih konfiguracija u sustavu korijenskih kanala, prvi opisali Cooke i Cox godine 1979. (1). Pritom su istaknuli da je tom obliku korijenskih kanala svojstven trakasti oblik otvora od 180° (ili više) te da postoje različite anatomske varijacije (2 – 4).

Takvi kanali značajna su etnička varijacija i najčešće ih imaju Azijci (od 31,5 % do 44,5 %) (5), ali uočeni su i u populaciji bijelaca (2,7 %) (1).

C-oblik korijenskoga kanala najčešći je u drugom donjem trajnom kutnjaku (6) – učestalost je 39 posto, premda se može pojaviti i u prvim trajnim molarima maksilarnog područja (7) – incidencija je 0,091 posto. U nekim izvještajima ističe

Introduction

A good knowledge of the internal dental anatomy and its variations is an absolute necessity for successful endodontic therapy. In cases where variations are not detected therapeutic failure can be expected to occur. The “C-shaped” configuration is among the various anatomical configurations of the root canal system, and this configuration was originally described by Cooke & Cox in 1979(1). C-shaped root canals are characterized by a single ribbon-shaped orifice of 180° (or more). The C-shaped canal system can assume different anatomical variations (2-4).

Such canal systems are a significant ethnic variation and are predominantly observed in Asian people (31.5% to 44.5%), (5) but are also present in Caucasian populations (2.7%) (1).

C-shaped root canals are commonly observed in mandibular permanent second molars(6) at a frequency of 39%, al-

se da je ta pojava uočena u drugim (8) i trećim trajnim kutnjacima maksilarnog područja (9).

Opis C-oblika trajnih maksilarnih kutnjaka dobiven je iz stopljenih distovestibularnih i palatalnih korijena koji se protežu do apikalne trećine, dovode do uzajamne veze među korijenskim kanalima te su odgovorni za nastali oblik (10).

Iako su rutinske tehnike, poput periapikalne analize radiograma, korisne za prijeoperacijsku procjenu anatomije korijenskih kanala, imaju ograničenu vrijednost u određivanju složenosti pojedinih anatomija. Primjerice, te su tehnike ograničene u dijagnozi C-oblika korijenskih kanala zbog preklapanja struktura na dvodimenzionalnom prikazu. Kompjutorizirana tomografija koničnom zrakom (CBCT) smatra se dovoljno preciznom za istraživanja morfologije i dijagnostike jer je BCT sredstvo za proučavanje korijena i kanala te njihovih složenih oblika, a rezultira trodimenzionalnim prikazima koji omogućuju višestruke presjeke korijena i njihovih kanala (11). PreXion jedan je od najsuvremenijih novih skenera s visokom prostornom rezolucijom – ima voksel veličine 0,05 do 0,15 milimetara, varijabilno vrijeme akvizicije (19 – 37 sekunda) te niže kilovolte i miliampere negoli starija oprema poput i-CAT-a. CBCT ima također malo područje pregleda, što omogućuje smanjenje apsorbirane radijacijske doze i veći broj projekcijski slika dobivenih rotacijom (12). Ipak, kao kod bilo kojeg uređaja koji emitira ionizirajuće zrake, pri korištenju toga aparata koristi bi trebale prevladati u odnosu na opasnosti od zračenja (13).

Svrha ovog istraživanja bila je opisati netipičan kanal u vestibularnom korijenu trajnoga maksilarnog kutnjaka korištenjem dijagnostičkog uređaja PreXion 3-D CBCT-a.

Materijali i metode

Tijekom rutinskoga pregleda 50-godišnje pacijentice miješanog podrijetla – imala je primjese crne rase – u privatnoj klinici za dijagnostiku uočena je neuobičajena anatomska pojava u maksilarnom području. Nalazila se u vestibularnom korijenu drugoga trajnog kutnjaka, a otkrivena je koničnom zrakom 3D kompjutorizirane tomografije (CBCT) na skeneru PreXion (Yoshida Dental Mfg. Co. LTD., Tokio, Japan). U radu su se stručnjaci koristili sljedećim parametrima: poljem pregleda (FOV) 80 x 80 mm, prostornom rezolucijom od 0,10-mm voksel, te s 90 kVp i 4 mA. Prema studiji Fana i suradnika iz 2004. (2, 3) temeljenoj na aksijalnim presjecima i poslije potvrđenoj na sagitalnim i koronalnim presjecima, izabrana su tri presjeka okomita na uzdužnu os zuba – jedan presjek bio je iz cervikalne trećine, jedan iz srednje trećine i jedan iz apikalne trećine (slike 1. – 3.).

Presjeci su otkrili dva korijenska kanala – jedan ovalnog oblika u palatinalnom korijenu i jedan veći nalik na veliko slovo C koji se protezao od distovestibularnog do meziovestibularnog kanala, te od cervikalne do apikalne trećine, a potvrđen je sagitalnim i koronalnim presjecima.

though they also occur in permanent first molars in the maxillary region (7) with an incidence of 0.091%. There are also reports of such occurrences in the permanent second (8) and third molars in the maxillary region (9).

A “C-shaped” root canal configuration of permanent maxillary molars results from the fused distovestibular and palatal roots that reach the apical third and lead to an intercommunication between the root canal that is responsible for the shape (10).

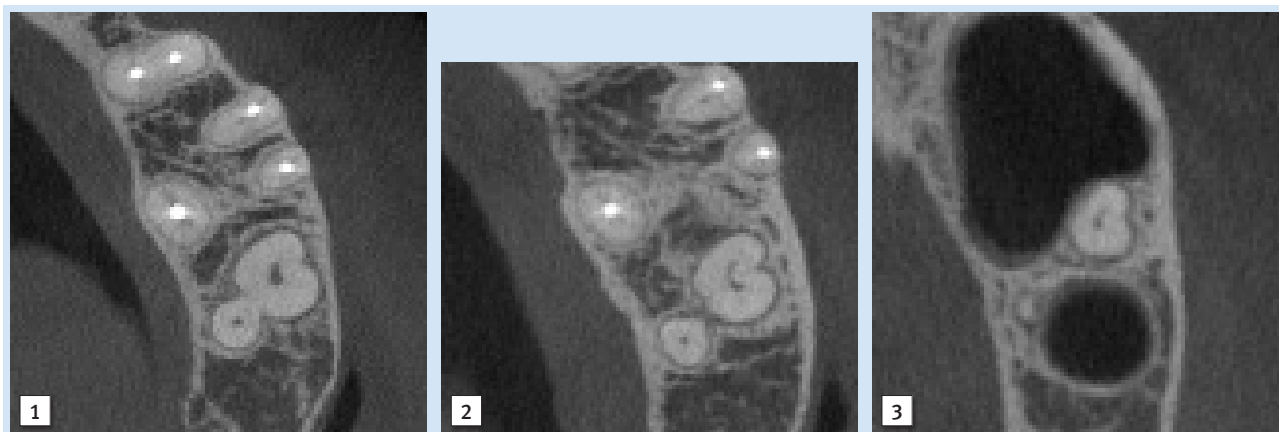
Although routine techniques, such as periapical analysis, are useful for preoperative evaluations of the anatomy of the root canal, these techniques have limited value in determining the complexities of such anatomies; for example, these techniques are limited in the diagnosis of C-shaped root canals based on superposition of two-dimensional images. Cone beam computed tomography (CBCT) has been suggested to be sufficiently precise for morphological studies with diagnostic purposes because CBCT is a tool for investigating roots and canals and their complexities. Cone beam computed tomography results in three-dimensional scans that produce images of multiple sections of roots and canals (11). The PreXion 3D is one of the most advanced new scanners available. It has a higher spatial resolution with voxel sizes of 0.05 to 0.15 mm, the most variable image acquisition time (19-37 sec) and employs lower kilo voltages and mill amperages than other pioneering equipment such as the i-CAT. In addition, CBCT has a small field of view, which allows for adjustments to the radiation dose absorbed by the patient and provides a greater number of image projections by rotation (12). However, as with any ionizing radiation-emitting device, the benefits of CBCT should outweigh the risks (13).

Therefore, the aim of this study was to present an atypical case of a C-shaped root canal that was present in the vestibular root of a permanent maxillary second molar using the PreXion 3-D CBCT as a diagnostic device.

Materials and Methods

During a routine examination of a 50-year-old female patient of mixed ethnicity with Negroid features in a private diagnostic imaging clinic, an unusual anatomic occurrence was observed in the maxillary region. This occurrence was present in the vestibular root of a permanent second molar. It was detected by 3-D cone-beam computerized tomography (CBCT) using a PreXion scanner (Yoshida Dental Mfg. Co. LTD., Tokyo, Japan). The following parameters were considered: field of view (FOV), 80x80 mm, spatial resolution, 0.10-mm voxels, 90 kVp and 4 mA. According to the studies of Fan et al. 2004b, based on axial slices and later confirmed on sagittal and coronal slices, three axial slices perpendicular to the long axis of the tooth were selected: one slice from the cervical third, one slice from the middle third and one slice from the apical third (Figures 1-3), (3).

The sections revealed the presence of two root canals: one oval-shaped canal that was present in the palatal root and an additional, larger canal with a shape that resembled the capital letter C. It extended from the entrance of the distovestibular canal to the mesiovestibular canal and from the cervical



Slika 1. Drugi maksilarni kutnjak s C-oblikom kanala – slika dobivena koničnom zrakom kompjutorske tomografije; aksijalni presjek cervikalne trećine dobiven softverom PrexViewer

Figure 1 Cone-beam computed tomography image of a maxillary second molar with a C-shaped canal. An axial section of the cervical third acquired with the PrexViewer software is shown.

Slika 2. Drugi maksilarni kutnjak s C-oblikom kanala – slika dobivena koničnom zrakom kompjutorske tomografije; aksijalni presjek srednje trećine dobiven softverom PrexViewer

Figure 2 Cone-beam computed tomography image of a maxillary second molar with a C-shaped canal. An axial section of the middle third acquired with the PrexViewer software is shown.

Slika 3. Prikaz drugoga maksilarnog kutnjaka s C-oblikom kanala dobiven koničnom zrakom kompjutorske tomografije; aksijalni presjek apikalne trećine dobiven softverom PrexViewer

Figure 3 Cone-beam computed tomography image of a maxillary second molar with a C-shaped canal. An axial section of the apical third acquired with the PrexViewer software is shown.

C-oblik korijenskog kanala uočen je u drugom trajnom kutnjaku maksilarnog područja. Taj je kanal klasificiran radiografski kao tip 1 i anatomski kao klasa 1 (2, 3). Karakterizira ga kontinuirani izgled velikoga, zavijenog kanala koji se tako proteže do apikalnog foramena. Uočena je i longitudinalna radiolucetna crta od koronarnog dijela do kraja pretezanja.

Rasprava

U ovom istraživanju opisana je rijetka anatomska varijacija korijenskoga vestibularnog kanala drugoga trajnog maksilarnog kutnjaka koja uključuje C-oblik korijenskog kanala utvrđen koničnom zrakom kompjutorizirane tomografije na uređaju 3D PreXion.

Ograničen broj istraživanja pokazao je da postoje takvi korijenski kanali i u drugom maksilarnom kutnjaku (9) jer prvi i drugi maksilarni kutnjak uobičajeno imaju tri kanala s tri i četiri korijenska kanala (1). Dodatno, drugi mandibularni molari među zubima su koji najčešće imaju takvu morfološku varijaciju (1 – 4, 10), čime se ističe važnost ovog istraživanja kao i svakoga daljnjega o toj temi.

Tipično, takva konfiguracija kanala pronalazi se u zubima čiji su korijeni spojeni, a to se događa zbog neformiranja Hertwigova epitelnog ovoja i rezultira longitudinalnom vezom među kanalima (10). U ovom slučaju spajanje se dogodilo između meziovestibularnog i distovestibularnog korijena i proširilo se na apikalnu trećinu. Ovi zaključci slični su onima iz istraživanja u kojima se opisivalo spajanje u maksilarnim kutnjacima (1, 10).

Kompjutorska tomografija koničnom zrakom važna je za

to the apical thirds and was confirmed on sagittal and coronal slices.

Thus, the presence of a C-shaped root canal was observed in a permanent second molar in the maxillary region. This canal and was radiographically and anatomically classified (2,3) as Type I and Class I, respectively, and was characterized by a continuous image of a large canal with a curved shape extending to the apical foramen. A longitudinal radiolucent line in its coronal portion or across its entire extension was also present.

Discussion

This paper describes the occurrence of a rare anatomical variation in the root canal of the vestibular root of a permanent second molar in the maxillary region that involved a C-shaped root canal as assessed with cone-beam computerized tomography image analysis with a 3D Prexion scanner.

A limited number of studies have demonstrated the existence of root canals with this configuration in maxillary second molars (9) because maxillary first and second molars commonly have three roots with three or four root canals (1). Additionally, the mandibular second molar is also the most likely of the permanent teeth to exhibit this morphological variation (1-4, 10), which highlights the importance of this paper for further studies.

Typically, this canal configuration is found in teeth in which the roots are fused, which occurs due to a failure in the formation of Hertwig's epithelial sheath that leads to longitudinal communication between canals (10). In the present case, the fusion occurred between the mesiovestibular and distovestibular roots and extended to the apical third. Similar results were reported in previous studies that have reported fusion in maxillary molars (1, 10).

dobivanje visoko detaljiziranih informacija o morfologiji i za točnu topografiju sustava korijenskog kanala, iako treba imati na umu da se ta tehnologija upotrebljava samo ako dodatni nalazi opravdavaju izlaganje zračenju (13, 14).

Moramo istaknuti važnost aksijalnih presjeka za definiranje kanalske konfiguracije kao C-oblika jer, iako se klasična radiografija uobičajeno upotrebljava, ona ne daje dovoljno informacija kad je riječ o složenim slučajevima te postavlja izazove tom dvodimenzionalnom sustavu (8, 11). Tomografski podaci dobiveni u ovom istraživanju bili su iznimno važni za detaljnu procjenu korijena i morfologije navedenih kanala, a opisali smo neuobičajen slučaj iz Brazila dijagnosticiran uređajem PreXion 3D, jednim od najnovijih dostupnih skenera. Za opisani slučaj koristili smo se presjecima s veličinom od 0,1 mm vokseli i malim poljem pregleda – FOV 8 x 8 mm, što je omogućilo veći broj prikaza rotiranjem.

Treba istaknuti važnost ovog istraživanja jer opisuje neuobičajenu morfološku varijaciju pronađenu kod pacijenta iz Brazila. Uočen je C-oblik konfiguracije u drugom gornjem kutnjaku s netipično spojenim vestibularnim korijenima, a analiziran je najmodernijim uređajem za kompjutorsku tomografiju koničnom zrakom – Prexion 3D-om.

Kad je riječ o kliničkoj primjeni, zaključci iz ove studije značajan su pomak prema proširenju ograničenih i standardiziranih koncepata vezanih za broj i oblik korijenskih kanala, jer u određenim situacijama dodatni kanal ili kanali s različitom morfologijom mogu ostati neobrađeni tijekom endodontske terapije jer ih liječnik ne uoči, a takve pogreške najvažniji su uzrok neuspjeha. Ipak, potrebne su dodatne studije kako bi se proširila uporaba ovakvog prikazivanja i postigle još točnije dijagnoze.

Zaključak

I na kraju – u ovoj studiji opisana je rijetka varijacija morfologije vestibularnoga C-oblika korijena u maksilarnom kutnjaku koja ima važnu obrazovnu ulogu jer su ovakvi slučajevi u literaturi rijetko opisani.

Sukob interesa

Autori nisu bili u sukobu interesa.

Cone-beam computed tomography has emerged as a valuable tool for acquiring highly detailed information on morphology and exact topography of the root canal system, although it should be kept in mind that this technique should only be utilized when it is associated with additional benefits that justify the exposure dose (13,14). We must highlight the importance of the axial slices for defining the canal configuration as C-shaped because, although conventional radiograph is commonly used, it does not provide sufficient information on more complex cases that challenge the inherent two-dimensionality of these systems (8, 11).

The tomographic data obtained for this paper were of particular relevance to a thorough evaluation of the root and, also, to morphologies of the respective canals. In this study, we reported an unusual case of a C-shaped root canal in a Brazilian patient which was diagnosed using a PreXion 3D scanner, which is one of the newest scanners available. For the case described here, we used slices so that each slice had 0.1mm x 0.1mm voxel size and a small FOV of 8 x 8 mm that allowed for a greater number of rotation image projections.

The importance of this study should be emphasized because it is a report of an unusual morphological variation in a Brazilian patient. A C-shaped configuration in an upper second molar with an atypical fusion of the vestibular roots was observed and analyzed with the most modern cone-beam computed tomography device available in this area: the Prexion 3D.

With regard to clinical implications, the findings of this study represent a major step towards harmonization of limited and standardized concepts related to numbers and shapes of root canals because, in certain situations, undetected extra roots or root canals with different morphologies are a major reason for failure of endodontic therapy due to the inability to detect their presence. Further studies are needed to expand the use of this imaging tool, which may facilitate even more accurate diagnoses.

Conclusion

In conclusion, the present study described a rare variation in morphology of vestibular C-shaped roots in a maxillary molar, which has an important didactic value since such cases are rarely described in textbooks.

Acknowledgments

The authors deny any conflicts of interest related to this study

Abstract

Objective: The aim of this study was to present an atypical case of a C-shaped root canal that was present in the vestibular root of a permanent maxillary second molar using PreXion 3-D cone-beam computed tomography (CBCT) as a diagnostic device. **Materials and Methods:** A 50-year-old female patient was referred for routine examination to a private diagnostic imaging clinic in Recife-Perambuco. During the physical examination, the presence of an unusual C-shaped anatomy in the vestibular canal with a mesiodistal interconnection that extended from the apical to the cervical third was detected in axial slices acquired with a PreXion 3-D scanner. **Results:** Although C-shaped root canals are most frequently observed in the mandibular second molar, this case presented a rare finding in the permanent maxillary second molar. **Conclusions:** PreXion 3-D CBCT has emerged as a new high-resolution imaging test technology, thus assisting with the diagnosis of anatomical variations such as C-shaped root canals. However, such imaging technology is not recommended for routine use.

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Key words

Tooth Root; Dental Pulp Cavity; Cone-Beam Computed Tomography; Tooth Abnormalities

References

1. Cooke HG 3rd, Cox FL. C-shaped canal configurations in mandibular molars. *J Am Dent Assoc.* 1979 Nov;99(5):836-9.
2. Fan B, Cheung GS, Fan M, Gutmann JL, Bian Z. C-shaped canal system in mandibular second molars: part I—anatomical features. *J Endod.* 2004 Dec;30(12):899-903.
3. Fan B, Cheung GS, Fan M, Gutmann JL, Fan W. C-shaped canal system in mandibular second molars: part II—Radiographic features. *J Endod.* 2004 Dec;30(12):904-8.
4. Fan W, Fan B, Gutmann JL, Cheung GSP. Identification of C-shaped canal systems in mandibular second molars. Part I: Radiographic and anatomic features revealed by intraradicular contrast medium. *J Endod.* 2007 Jul;33(7):806-10.
5. Yang ZP, Yang SF, Lin YC, Shay JC, Chi CY. C-shaped root canals in mandibular second molars in a Chinese population. *Endod Dent Traumatol.* 1988 Aug;4(4):160-3.
6. Zheng Q1, Zhang L, Zhou X, Wang Q, Wang Y, Tang L, et al. C-shaped root canal system in mandibular second molars in a Chinese population evaluated by cone-beam computerized tomography. *Int Endod J.* 2011 Sep;44(9):857-62.
7. De Moor RJ. C-shaped root canal configuration in maxillary first molars. *Int Endod J.* 2002 Feb;35(2):200-8.
8. Singla M, Aggarwal V. C-shaped palatal canal in maxillary second molar mimicking two palatal canals diagnosed with the aid of spiral computerized tomography. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2010 Jun;109(6):e92-5.
9. Keinan D, Nuni E, Slutzky-Goldberg I. Is a C-shaped configuration possible in teeth other than mandibular molars? *Quintessence Int.* 2009 Jul-Aug;40(7):541-3.
10. Jafarzadeh H, Wu YN. The C-shaped root canal configuration: a review. *J Endod.* (2007); 33: 517-523.
11. Kottoor J, Velmurugan N, Sudha R, Hemamalathi S. Maxillary first molar with seven root canals diagnosed with cone-beam computed tomography scanning: a case report. *J Endod.* 2007 May;33(5):517-23.
12. Andrade ME, Khoury HJ, Nascimento Neto JB, Kramer R. Dosimetric evaluation of dental implant planning examinations with cone-beam computed tomography. *Radiat Prot Dosimetry.* 2014 Jan;158(2):175-80.
13. European Society of Endodontology, Patel S, Durack C, Abella F, Roig M, Shemesh H, Lambrechts P, Lemberg K. European Society of Endodontology position statement: the use of CBCT in endodontics. *Int Endod J.* 2014 Jun;47(6):502-4.
14. Karanxha L, Kim HJ, Hong SO, Lee W, Kim PS, Min KS. Endodontic management of a C-shaped maxillary first molar with three independent buccal root canals by using cone-beam computed tomography. *Restor Dent Endod.* 2012 Aug;37(3):175-9.