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Cone beam kompjutorska tomografija: metoda procjene uspješnosti instrumentacije korijenskih kanala

Cone Beam Computed Tomography: a Tool to Evaluate Root Canal Preparations

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Sažetak

Svrha: Ovim se istraživanjem željela, kod procjene instrumentacije korijenskih kanala, usporediti uporaba *cone beam* kompjutorizirane tomografije (CBCT) s metodom dvostruke superpozicije rendgenskih snimaka. **Materijale i metode:** Četrdeset meziobukalnih kanala ekstrahiranih prvih kutnjaka podijeljeno je u dvije skupine. U prvoj je 20 kanala procijenjeno metodom dvostruke superpozicije rendgenskih slika prije instrumentacije i nakon toga postupka, a u drugoj je na isti način procijenjeno također 20 kanala, ali CBCT-om. **Rezultati:** U prvoj je skupini kod 100 posto korijenskih kanala zabilježeno centriranje u koronalnoj i srednjoj trećini. Kod 75 posto korijenskih kanala centriranje je bilo u apikalnoj trećini. U drugoj skupini su bukolingvalna i meziolingvalna mjerenja pokazala centriranje u svim (100%) korijenskim kanalima u koronalnoj, srednjoj i apikalnoj trećini. **Zaključak:** Metoda dvostruke rendgenske superpozicije pokazala se kao ograničena jer je moguća samo dvodimenzionalna procjena korijenskog kanala. Metoda CBCT-om može se ponoviti i pokazala se kao točan i neinvazivan način procjene određenih aspekata instrumentacije korijenskih kanala, kao što je, primjerice, mogućnost centriranja.

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Ključne riječi
korijenski kanal, preparacija; *cone-beam* kompjutorizirana tomografija; obrada slike, računalno podržana; procjena uspješnosti postupka

Uvod

Mnoge metode, primjerice, plastični modeli, histološki preparati, skeniranje elektronskim mikroskopom i radiološke analize, rabile su se kako bi se procijenili oblici kanala prije instrumentacije i nakon toga postupka (1). Kod metode dvostruke superpozicije rendgenska slika, slike prije instrumentacije kanala i nakon toga postupka daju informaciju o dvodimenzionalnom longitudinalnom obliku korijenskog kanala. Kompjutorizirana tomografija (CT) ocijenjena je kao neinvazivna metoda za analizu geometrije korijenskih kanala i uspješnost njihove preparacije. Koristeći se tom tehnikom snimanja mogu se usporediti anatomske strukture korijenskih kanala prije instrumentacije i nakon nje (2, 3).

Cone beam kompjutorizirana tomografija (CBCT) razvijena je kako bi se omogućio trodimenzionalni prikaz anatomskih struktura. Primjenjujemo je u oralnoj i maksilofacijalnoj regiji uz pomoć sofisticiranih i jednostavnih računalnih programa jer ima mnogo nižu dozu zračenja od konvencionalnih kompjutorskih tomografa (CT) (4). Uporaba CBCT-

Introduction

A number of methods have been used to compare canal shape before and after preparation, such as plastic models, histological sections, scanning electron microscopic studies, and radiographic comparisons (1). In the double superimposition method, radiographs taken before and after root canal preparation provide the means for a two-dimensional study of the longitudinal shape of the root canal. Computed tomography (CT) imaging techniques have been evaluated as noninvasive methods for the analysis of canal geometry and efficiency of shaping techniques. With this technique, it is possible to compare the anatomic structure of root canal before and after instrumentation (2, 3).

Cone beam computed tomography (CBCT) has been developed to provide 3-dimensional anatomic features and is used in oral and maxillofacial region with more sophisticated and simpler software processes, with a significantly lower effective radiation dose compared with conventional CT (4). Application of CBCT in endodontics has been careful-

uređaja u endodonciji potanko je opisana i ocijenjena u nedavnim istraživanjima (4 – 7). To je metoda izbora kada se žele prevladati ograničenja konvencionalne radiografije, kao što su preklapanje slika i geometrijske distorzije (8).

Instrumentacija korijenskog kanala važan je dio endodontskog tretmana (9). Jedan od njezinih glavnih ciljeva jest konusno oblikovanje kanala kako bi se mogao što bolje zabrtviti od koronalnog do apikalnog dijela, uz uvjet da zadrži prvotni oblik (2). Tijekom tog postupka instrumenti moraju ostati u centru korijenskog kanala (5, 10).

Svrha ovog istraživanja bila je usporediti CBCT i rendgensku metodu superpozicije slika kako bismo mogli odrediti kvalitetu instrumentacije korijenskih kanala.

Materijali i metode

Odabir i priprema uzoraka

Odabrano je 40 meziobukalnih kanala ekstrahiranih prvih mandibularnih molara (duljine 20 do 21 mm). Dobiveni su iz banke zuba Zavoda za protetiku, oralnu i maksilofacijalnu kirurgiju Federalnog sveučilišta Perambuco. Odabir je odobrio Sveučilišni etički znanstveni odbor Centra za medicinske znanosti. Meziobukalni korijeni imali su formirane apekse te zakrivljene korijenske kanale u rasponu od 25° do 30° – određeno prema tehnici kuta pristupa kanalu (CAA) (11). Nakon pripreme pristupnog kaviteta određena je radna duljina (WL) kanala s pomoću iglice broj 10 Senseus – Flexofile (Dentsply/Maillefer, Ballaigues, Švicarska) koja je umetnuta u meziobukalni kanal sve do pojave na apikalnom foramenu. Radna duljina izračunata je tako da se oduzeo jedan milimetar od duljine zabilježene nakon što se iglica pojavila na apikalnom foramenu.

Uzorci su nasumce podijeljeni u dvije skupine od po 20 korijenskih kanala. Svaka je determinirana načinom procjene uspješnosti instrumentacije i to na sljedeći način: u prvoj je skupini 20 korijenskih kanala bilo procijenjeno metodom dvostruke radiografske superpozicije, a u drugoj, s također 20 korijenskih kanala, procjena je obavljena CBCT-om.

Prva skupina – metoda dvostruke radiografske superpozicije

Uzorci su uronjeni u autopolimerizacijsku polietilensku smolu *Cristal* (Assunção Representações e Comércio Ltda, Recife, Brazil) ulivenu u plastični kalup za pravljenje leda (Plasútil, Bauru, Brazil). Stabilizirani su komadom voska broj 7 (Wilson, Sao Paulo, Brazil) i izvađeni iz kalupa nakon 48 sati. Kako bi se spriječio prodor smole kroz apiklani foramen te polimerizaciju u foramenu, apiklani forameni zatvoreni su voskom. Da bi se osigurali standardizirani uvjeti za inicijalnu i finalnu rendgensku sliku, napravljena je platforma za snimanje (12) (slika 1.).

Instrumentacija korijenskog kanala

Prvi potez bilo je rendgensko slikanje korijenskog kanala s iglicom K broj 10 u njemu. Već je prije snimanja bila postavljena na određenu radnu dužinu. Svi uzorci snimani su periapikalnim Kodakovim filmovima Insight (Eastman Kodak Company, New York, SAD) s vremenom ekspozicije od 0,8 sekundi u vestibulolingvalnom smjeru. Nakon što je sni-

ly evaluated in recent studies (4-7). CBCT is recommended to overcome limitations of conventional radiography such as anatomic image overlap and geometric distortion (8).

Root canal preparation is an important part of endodontic treatment (9). One of the main objectives in root canal preparation is to develop a shape that tapers from apical to coronal, maintaining the original canal shape (2). Instruments should remain centered in the root canal throughout the preparation (5, 10).

The objective of this study was to compare the use of the CBCT and the double radiographic superimposition method to evaluate root canal preparations.

Materials and Methods

Selection and preparation of samples

Forty mesiobuccal canals of extracted human mandibular first molars (length, 20-21 mm) obtained from the tooth bank of the Department of Prosthetics and Oral and Facial Surgery of the Federal University of Pernambuco, were selected with the approval of the Ethics in Research Committee of the Center of Health Sciences of the University. The mesiobuccal roots had completely formed apices and curved root canals whose curvature ranged from 25° to 30° according to the canal access angle (CAA) technique (11). The access cavities were prepared, and to determine the working length (WL), a #10 Senseus-Flexofile (Dentsply/Maillefer, Ballaigues, Switzerland) was inserted into the mesiobuccal canal until it was visible at the apical foramen. The WL was calculated to be 1 mm less than the length obtained with this initial file.

The specimens were randomly divided into 2 groups with 20 root canals each according to the methodology used to evaluate root canal preparation as follows: group 1: 20 canals were evaluated by the double radiographic superimposition method; group 2: 20 canals were evaluated by CBCT method.

Group 1: double radiographic superimposition method

The specimens were imbedded in autopolymerisable polyethylene resin Cristal (Assunção Representações e Comércio Ltda, Recife, Brazil), using a mould consisting of a plastic tray used for making ice blocks (Plasútil, Bauru, Brazil), stabilized through the anatomical neck by a bar of #7 wax (Wilson, Sao Paulo, Brazil) and removed from the mould after 48 h. In order to prevent the resin from entering the apical foramen and polymerizing inside it, the apices of the specimens were sealed with wax. For the purpose of obtaining standardized initial and final radiographs, a radiographic platform was made (12) (Figure 1).

Root canal preparation

First, the preoperative radiograph was taken using a K #10 file in the previously established actual working length (WL). All the samples were radiographed using periapical Kodak Insight films (Eastman Kodak Company, New York, USA) and the radiographic exposure time was 0.8 s in the vestibulolingual view. After the preoperative radiograph, the

mljena inicijalna rendgenska slika, kanali su obrađeni uporabom sustava ProTaper Universal™ Rotary na sljedeći način: (a) iglica SX koristila se do pola WL-a, (b) iglica S1 rabila se do 4 milimetra od apeksa, (c) iglice S1 i S2 korištene su do punog WL-a, (d) iglice F1 i F2 rabile su se također do punog WL-a.

Nakon uporabe svake iglice korijenski kanali isprani su s tri mililitra tek pripremljenog natrijeva hipoklorita (Roval, Recife, Brazil). Glyde™ (Dentsply, Maillefer, Ballaigues, Švicarska) je tijekom instrumentacije služio kao lubrikant. Sve preparacije korijenskih kanala obavio je iskusni endodont. Svaki instrument promijenjen je nakon obrade pet kanala. Osim toga pregledani su nakon svake uporabe kako bi se uočile moguće deformacije i nepravilnosti. Električni motor (Driller Endo – Pro Torque, Sao Paulo, Brazil) imao je brzinu od 300 rpm.

Postoperativna slika dobivena je ekspozicijom predoperativne slika. Postoperativna slika za sve primjerke načinjena je s iglicom F2 u korijenskom kanalu koja je umetnuta na WL. Ekspozicija je trajala 0,8 sekundi u vestibulolingvalnom smjeru.

Procjena mogućnosti centriranja

Nakon razvijanja rendgenske su snimke postavljene u okvire kako bi ih analizirala dva iskusna endodonta. Svaki je pregledao svih 20 snimaka povećalom s peterostrukim povećanjem (CRS, Sao Paulo, Brazil). Upozoreni su također da posebnu pozornost posvete koronalnoj, srednjoj i apikalnoj trećini korijena. Ako su uočili dvije sjene iglica u istom kanalu, klasificirali su ga kao *necentralizirani*. Ako su opazili samo jednu sjenu iglice, ocijenili su korijenski kanal kao *centralizirani* (slika 2. a i b). Dogovor između endodonata o uporabi instrumenata ocijenjen je Kappa testom (κ=1,000). I jedan i drugi su prije toga sudjelovali u pokusnoj studiji.

Druga skupina: metoda CBCT-om

Snimanje predoperativnih slika

Uzorci su stavljeni u alginat (Jeltrade; Dentsply, Petropolis, Brazil) izliven u plastične kalupe kako bismo osigurali da predoperativne i postoperativne snimke budu približno u istoj ravnini (13).

Nakon što se alginat stvrdnuo zubi su snimljeni CBCT-om (i-Cat®, Imaging Sciences International, Hatfield, PA, SAD) kako bi se odredio oblik korijenskog kanala prije instrumentacije. Vrijeme ekspozicije iznosilo je 26, 9 sekundi, napon 120 kV i jakost 7 mA. Snimke su podijeljene u tri dijela – 9 milimetara od apeksa označeno je kao koronalni dio, 6 milimetara od apeksa označeno je kao srednji dio i 3 milimetra od apeksa označeno je kao apikalni dio (slika 3.). Sve slike pohranjene su u računalu radi kasnije usporedbe (slika 4.).

Instrumentacija korijenskog kanala

Svi primjerci stavljeni su u škrip (Neboluz, São Paulo, Brazil) kako bi se osigurala nepomičnost tijekom instrumentacije. Na isti način kao i kod prve skupine obrađeno je svih 20 kanala.

canals were instrumented with the ProTaper Universal™ Rotary System as follows: (a) the SX file was used to one half the of the WL, (b) the S1 file was used up to 4 mm short of the apex, (c) the S1 and S2 files were used to the full WL, and (d) the F1 and F2 files were used to the full WL.

After the use of each file, the root canals were irrigated with 3 mL of a freshly prepared 1% sodium hypochlorite solution (Roval, Recife, Brazil). Glyde™ (Dentsply, Maillefer, Ballaigues, Switzerland) was used as a lubricant during instrumentation. A single operator experienced in rotary systems prepared all root canals. Each instrument was changed after five canals. Instruments were examined after every use to record and reject deformed or fractured instruments. The electric motor (Driller Endo-Pro Torque, Sao Paulo, Brazil) was used at a speed of 300 rpm.

To obtain the postoperative image, the initial periapical film was radiographed again. In all samples, the final radiograph was taken with the final file (F2) at the working length. The radiographic exposure time was 0.8 s in the vestibulolingual view.

Evaluation of centering ability

After processing, the radiographs were mounted in slide frames to allow them to be evaluated by the two examiners, who were specialists in endodontics. Each examiner evaluated the 20 radiographs, viewing them on a magnifier-viewer with the aid of a fivefold magnifier (CRS, Sao Paulo, Brazil). The examiners were asked to pay special attention to the coronal middle, and apical thirds; if they detected two distinct images of files, they would classify the root canal as 'without centralization', and if they observed a single image, the canal would be classified as 'with centralization' (Figure 2, A and B). The agreement between the two examiners in the use of each of the instruments was evaluated by the Kappa test (κ=1.000). The examiners were previously calibrated in a pilot study.

Group 2: CBCT method

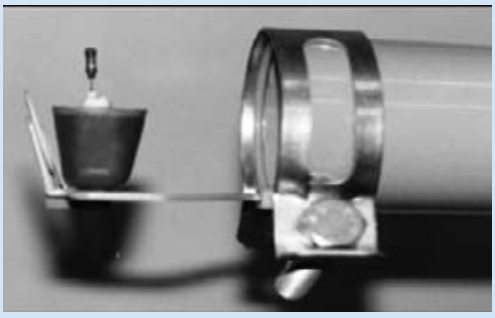
Obtaining the preoperative images

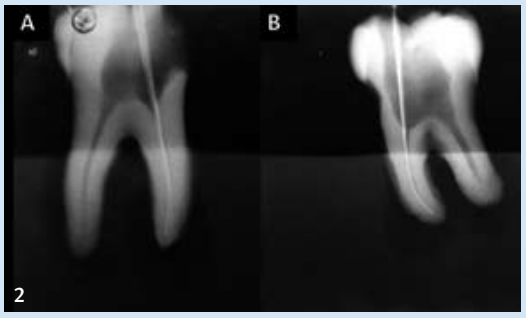
The specimens were stored in alginate hydrogel (Jeltrade; Dentsply, Petropolis, Brazil) poured in plastic containers to ensure a very close approximation of the preoperative and postoperative images according to a previously described method (13).

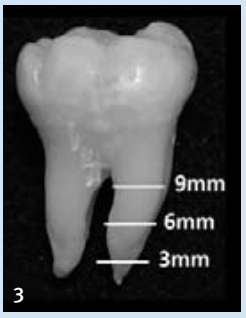
After the alginate solidified, all teeth were scanned by CBCT (i-Cat®, Imaging Sciences International, Hatfield, PA, USA) to determine the root canal shape before instrumentation. The exposure time was 26.9 seconds, operating at 120kV and 7mA. The images were sectioned into three points, located respectively at 9 mm (coronal level), 6 mm (middle level), and 3mm (apical level) from the apex (Figure 3). The images were saved in a computer for later comparison (Figure 4).

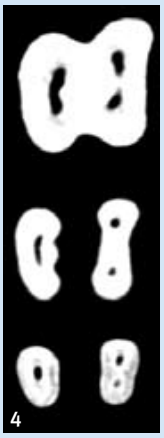
Root canal preparation

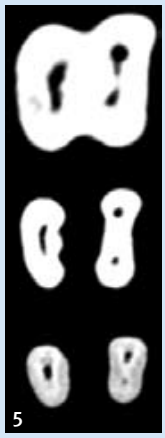
The specimens were fastened to a morse (Neboluz, São Paulo, Brazil) to keep them immovable during preparation. The 20 canals were instrumented in the same manner described for Group 1.

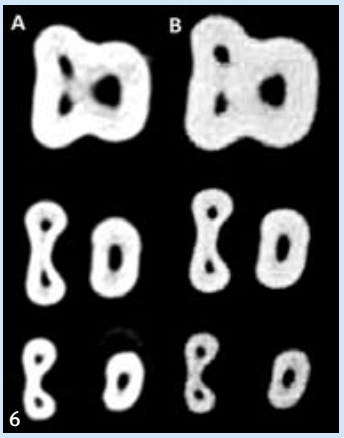


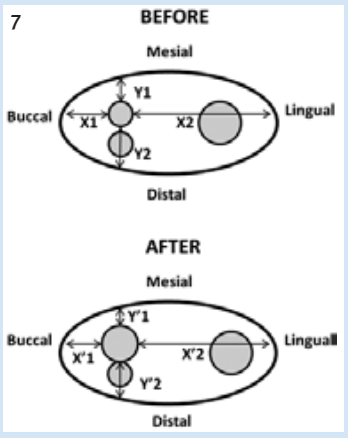












Slika 1. Radiološka platforma
Figure 1 Radiographic platform
Slika 2. (A) Odsutnost centraliziranja u apikalnoj trećini
(B) Prisutnost centraliziranja u apiklanoj trećini
Figure 2 (A) Absence of centralization in the apical third
(B) Presence of centralization in the apical third
Slika 3. Pregled poprečnih presjeka na intervalima od 3, 6 i 9 milimetara
Figure 3 Cross-sectional views of each canal were obtained at 3-,6- and 9mm intervals
Slika 4. CBCT-snimke prije instrumentacije u koronalnoj, srednjoj i apikalnoj trećini
Figure 4 CBCT images before instrumentation at coronal, middle and apical levels, respectively
Slika 5. CBCT snimke nakon instrumentacije u koronalnoj, srednjoj i apikalnoj trećini
Figure 5 CBCT images after instrumentation at coronal, middle, and apical levels, respectively
Slika 6. CBCT snimke prije (a)) i nakon (b) instrumentacije kanala u koronalnoj, srednjoj i apikalnoj trećini
Figure 6 CBCT scan images before (A) and after (B) preparation at coronal, middle, and apical levels, respectively
Slika 7. Shematski prikaz slika – pokazuje na koji se način dobivaju omjeri centriranja
Figure 7 Schematic representation of the image showing how centering ratios of the tooth were derived

Snimanje postoperativnih snimaka

Nakon instrumentacije svi uzorci skenirani su u istim uvjetima i na isti način kao i inicijalne slike. Sve postoperativne slike pohranjene su u računalu (slika 5.).

Procjena mogućnosti centriranja

S pomoću softvera Image Tool Teksaškoga medicinskog fakulteta i njegova Znanstvenog centra (University of Texas Health Science Center, Texas, SAD) uspoređene su predoperativne i postoperativne slike (slika 6., a i b). Gambill je sa suradnicima (14) definirao odnos centriranja kao mjeru kojim se određuje mogućost instrumenta da ostane u centru korijenskog kanala. Taj odnos izračunat je za svaki dio korijenskog kanala zahvaljujući sljedećoj jednadžbi (slika 7.):

D1: (X1 – X′1)/(X2 – X′2)

D2: (Y1 – Y′1)/(Y2 – Y′2)

D1 predstavlja bukolingvalnu mjeru, a D2 meziodistalnu. Prema ovoj jednadžbi ako je rezultat 1, to znači savršenu mogućnost centriranja. Što je rezultat bliži nuli, to je lošija mogućnost instrumenta da ostane centriran u kanalu.

Obtaining the postoperative images

After instrumentation, the specimens were scanned under the same conditions as the initial scans. The postoperative images were captured by a computer (Figure 5).

Evaluation of centering ability

Using the Image Tool software (University of Texas Health Science Center, Texas, USA) the preoperative and postoperative images were compared (Fig. 6, A and B). Gambill *et al.* (14) defined centering ratio as the measurement of the ability of the instrument to stay centered in the canal. This ratio was calculated for each section using the following ratio (Figure 7):

D1: (X1 – X′1)/(X2 – X′2)

D2: (Y1 – Y′1)/(Y2 – Y′2)

Where D1= the buccolingual measurement and D2 = the mesiodistal measurement. According to this formula, a result of 1 indicates perfect centering ability; the closer the result is to zero, the worse the ability is of the instrument to remain centered.

Rezultati

Tablica 1. pokazuje prisutnost i odsutnost centriranja u korijenskim kanalima instrumentiranih sustavom strojne endodoncije ProTaper Universal™ i snimljenih tehnikom dvostruke radiografske superpozicije slika. Kod dvadeset (100%) kanala centriranje je obavljeno u koronalnoj i srednjoj trećini kanala. Kod njih pet (25%) nije se uspjelo postići centriranje, a kod 15 (75%) centriranje se dogodilo u apikalnoj trećini.

Tablica 2. predstavlja glavnu opisnu statistiku bukolingvalnih mjera (D1) i meziodistalnih mjera (D2) dijelova korijenskih kanala udaljenih 9 milimetara (koronalno), 6 milimetara (srednje) i 3 milimetra (apikalno) od apeksa snimljenih metodom CBCT-a.

Kod bukolingvalne mjere (D1) srednje odstupanje iznosilo je 0,88±0,257, 1,00±0,000 i 1,00±0,000 za udaljenosti od 9 milimetara (koronalno), 6 milimetara (srednje) i 3 milimetra (apiklano) od apeksa.

Kod meziodistalnih mjera (D2) srednje odstupanje iznosilo je 1,00±0,00, 1,00±0,00 i 1,00±0,00 za udaljenosti od 9 milimetara (koronalno), 6 milimetara (srednje) i 3 milimetra (apikalno) od apeksa.

Results

Table 1 shows the presence and absence of centralization of root canals instrumented with the ProTaper Universal™ rotary system by using the double radiographic superimposition method. Twenty (100%) root canals showed presence of centralization in the coronal and middle thirds. Five (25%) root canals showed absence of centralization, while 15 (75%) root canals showed presence of centralization in the apical third.

Table 2 presents the main descriptive statistics of the buccolingual measurement (D1) and mesiodistal measurement (D2) according to the root segment instrumented at distances of 9 mm (coronal), 6mm (middle), and 3mm (apical) from the apex by using the CBTC method.

In the buccolingual measurement (D1), the mean deviation was 0.88±0.257, 1.00±0.000, and 1.00±0.000 at distances of 9 mm (coronal), 6mm (middle), and 3mm (apical) from the apex, respectively.

In the mesiodistal measurement (D2), the mean deviation was 1.00±0.00, 1.00±0.00, and 1.00±0.00 at distances of 9 mm (coronal), 6mm (middle), and 3mm (apical) from the apex, respectively.

Tablica 1. Prisutnost i odsutnost centraliziranja nakon korištenja metode dvostruke radiološke ekspozicije
Table 1 Presence and absence of centralization by using the double radiographic superimposition

Trećina • Third	Centraliziranje • Centralization		Ukupno • Total
	Prisutnost • Presence	Odsutnost • Absence	
Koronalna • Coronal	20 (100.0%)	-	20 (100.0%)
Srednja • Middle	20 (100.0%)	-	20 (100.0%)
Apikalna • Apical	15 (75.0%)	5 (25.0%)	20 (100.0%)

Tablica 2. Srednja vrijednost i standardna devijacija bukolingvalnih i meziodistalnih mjerenja dijelova korijenskih kanala CBCT-om
Table 2 Mean and standard deviation of the buccolingual and mesiodistal measurements according to the root segment instrumented by using the CBCT

Trećina • Third	Srednja vrijednost ± SD • Mean ± SD
Koronalna D1 • Coronal D1	1.00 ± 0.000
Koronalna D2 • Coronal D2	1.00 ± 0.000
Srednja D1 • Middle D1	1.00 ± 0.000
Srednja D2 • Middle D2	1.00 ± 0.000
Apikalna D1 • Apical D1	1.00 ± 0.000
Apikalna D2 • Apical D2	1.00 ± 0.000

SD: standardna devijacija • standard deviation;
D1: bukolingvalno mjerenje • buccolingual measurement;
D2: meziodistalno mjerenje • mesiodistal measurement

Rasprava

Nekoliko načina koristilo se u nastojanju da se ocijeni konačan izgled korijenskih kanala, primjerice, metoda Serial Sectioning Technique (15) i optička mikroskopija (16). No, kod tih metoda dijelovi struktura uzoraka gube se zato što se uzorak mora razrezati za postoperativni pregled.

Simuliranje korijenskih kanala u smoli (17) ne potiče kliničke uvjete u kojima instrumenti rade zbog razlike u tvrdoći dentina i smole, takav se način može lako ponoviti i standardiziran je za istraživanja. Metoda dvostruke radiografske superpozicije (12) unatoč svemu nije destruktivna, ali ako se

Discussion

Several methodologies have been used to evaluate the final shape of root canal preparations such as the Serial Sectioning Technique (15) and optical microscopy (16). However, when using these methods, part of the specimen structure is lost, because there is a need to cut the tooth before the postoperative evaluation. The use of simulated root canals in resin blocks (17), in spite of allowing for a high degree of reproducibility and standardization, does not reflect the clinical behavior of the instruments, because of the difference in hardness between the resin and dentine. The double ra-

izabere moguća je samo dvodimenzionalna procjena korijenskih kanala te je presjek kanala nemoguće vizualizirati.

CBCT je posljednjih godina prilagođen stomatologiji i sada je precizniji, ima bolju rezoluciju i smanjeno vrijeme nastanka slike, što znači i manju izloženost pacijenta zračenju. Još jedna prednost ove metode jest to što se uzorci tijekom analize ne oštećuju (7). CBCT u usporedbi s periapikalnom radiologijom ima i nedostatke – uređaj je skup, pacijenti su izloženi većoj dozi zračenja, tehnologija nije široko dostupna i njezina bi uporaba trebala imati opravdan klinički razlog (18).

Metoda CBCT-om uglavnom se koristi kako bi se procijenila uspješnost instrumenata strojne endodoncije u oblikovanju korijenskih kanala različite anatomije (19). Podaci dobiveni tim uređajem omogućuju uočavanje morfoloških promjena u kanalima kao što su devijacije, uklanjanje dentina i konačnu instrumentaciju. Sve je to rezultat različitih metoda biomehaničkih instrumentacija. Najveća prednost CBCT-tehnologije jest mogućnost vrlo detaljnih prikaza oblika korijenskih kanala mjerenjem 3D snimaka (1). CBCT i specijalizirani program (i-CAT Cone Beam) uspješno su primijenjeni u ovom istraživanju za procjenu oblika korijenskih kanala prije instrumentacije i nakon toga postupka te za procjenu centriranja endodontskog sustava ProTaper Universal™. Metodologija u ovom istraživanju temelji se na ranijem istraživanju Sanfelicea i njegovih suradnika (13). Oni su dokazali da je metoda pouzdana i da nije potrebno destruktivno rezanje uzoraka koje rezultira gubitkom materijala. Dosadašnja istraživanja pokazala su da korištenje CBCT-a za procjenu uspješnosti instrumentacije kanala NiTi-instrumentima predstavlja nedestruktivnu metodu koja se lako ponavlja (3,6,13,18,19,20,21). Ovo istraživanje dokazalo je da je sustav ProTaper Universal™ uspješan u instrumentaciji korijenskih kanala bez devijacija i s mogućnošću centriranja.

Svrha ovog istraživanja bila je usporediti CBCT i metode dvostruke radiografske superpozicije kod procjene instrumentacije korijenskih kanala. Razlika između podataka dobivenih tim dvjema različitim metodama može se pripisati činjenici da se zadnja iglica kod instrumentacije nije mogla potpuno prilagoditi obliku korijenskih kanala. Sljedeće što treba istaknuti jest da se radiografskom metodom dobiva samo dvodimenzionalna analiza oblika korijenskih kanala, a CBCT-om se mogu izmjeriti meziodistalne i bukolingvalne dimenzije te je omogućen trodimenzionalni uvid u oblik kanala.

Zaključak

Metoda dvostruke radiografske superpozicije ograničena je zato što je u slučaju njezine primjene analiza korijenskih kanala samo dvodimenzionalna.

diographic superimposition method (12), however, is not destructive, but only allows for two-dimensional evaluation of the root canal, and a cross section of the root canal is impossible to observe.

Recently, CBCT has been adapted for dentistry and compared with medical tomography that leads to increased precision and resolution, as well as reducing the image acquisition time and, as a consequence, the time of exposure to radiation. Another advantage of this method is that there is no destruction of the sample (7). There are obvious disadvantages of CBCT compared with periapical radiography: the technique is expensive, higher radiation dose is involved and it has limited availability, and therefore the diagnostic gain from applying this method compared with intraoral radiography should have clinical relevance for treatment or other advantages for the patient (18).

CBCT has been successfully used to evaluate the performance of endodontic rotary instruments on shaping root canals despite varied anatomies (19). Data obtained with CBCT enable the identification of morphologic changes associated with different biomechanical preparations including canal deviation, dentin removal, and final canal preparation. A major advantage of CBCT is the possibility to obtain highly accurate evaluation of root canal shape by the superimposition and measurement of 3D renderings (1). CBCT and specialized software (i-CAT Cone Beam) were successfully used in the present research for measurements before and after instrumentation of root canals and for the calculations of the centering ability of the ProTaper Universal™ rotary systems during cleaning and shaping of the root canals. The use of this methodology was based on the study of Sanfelice *et al.* (13), which showed it to be reliable, without destructive sectioning of the specimens or loss of the root material during sectioning. Previous studies showed that CBCT used to evaluate root canals prepared with NiTi rotary instruments provided a nondestructive and easy-to-repeat method (3, 6, 13, 18, 19, 20, 21). In this study, the CBCT analysis showed that the ProTaper Universal™ had the ability to create centered preparations, without deviations.

The objective of this study was to compare the use of the CBCT and the double radiographic superimposition method to evaluate root canal preparations. The discrepancy of the data obtained with the double radiographic superimposition method and the CBCT method can be explained by the fact that the final file could not be perfectly adapted to the root canal walls. Another fact that is worth mentioning is that in the double radiographic superimposition method, the image of the root canal can only be evaluated in a two-dimensional way, while CBCT allows a buccolingual measurement and a mesiodistal measurement, thereby allowing a more accurate assessment, precluding observation of the three-dimensional conformation of root canals.

Conclusions

The double radiographic superimposition technique showed limitations, only allowing a two-dimensional evaluation of the root canal.

CBCT-tehnologija korištena u ovom istraživanju dokazala se kao točna i neinvazivna te se može ponavljati u procjeni određenih aspekata endodontske instrumentacije, kao što je sposobnost centriranja instrumenata u korijenskom kanalu.

Priznanja

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The CBCT imaging system used in this study provided a repeatable, accurate, and noninvasive method of evaluating certain aspects of endodontic instrumentation, such as the centering ability.

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Abstract

Purpose: The objective of this study was to compare the use of the cone beam computed tomography (CBCT) and the double radiographic superimposition method to evaluate root canal preparations. **Material and methods:** Forty mesiobuccal canals of extracted human mandibular first molars were divided into 2 groups. Group 1: 20 canals were evaluated with the double radiographic superimposition before and after instrumentation; Group 2: 20 canals were evaluated by CBCT before and after instrumentation. **Results:** In group 1, 100% of the root canals showed presence of centralization in the coronal and middle thirds. 75% of the root canals showed presence of centralization in the apical third. In group 2, in the buccolingual and mesiodistal measurements, the presence of centralization could be observed in 100% of the root canals in the coronal, middle, and apical thirds. **Conclusion:** The double radiographic superimposition technique showed limitations, only allowing a two-dimensional evaluation of the root canal. The CBCT imaging system used in this study provided a repeatable, accurate, and noninvasive method of evaluating certain aspects of endodontic instrumentation, such as the centering ability.

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Key words
Root Canal Preparation; Cone-Beam Computed Tomography; Image Processing, Computer-Assisted, Evaluation Studies as Topic

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