ACTA
STOMATOLOGICA
CROATICA
www.ascro.hr

Acta Stomatol Croat. 2012;46(3):222-229.

IZVORNI ZNANSTVENI RAD
ORIGINAL SCIENTIFIC PAPER

Carlos Menezes Aguiar[1], Camille Gomes Faria[2], Andréa Cruz Câmara[3], Marco Frazão[4]

Usporedna procjena strojnih sustava Twisted File™ i Revo-S® korištenjem CBCT-a

Comparative Evaluation of the Twisted File™ and Revo-S® Rotary Systems Using Cone Beam Computed Tomography

[1] Izvanredni professor, Zavod za protetiku I oralnu I facijalnu kirurgiju, Stomatološki fakultet Državno sveučilište Pernambuco, Recife, Brazil
Associate Professor, Department of Prosthetics and Oral and Facial Surgery, Faculty of Dentistry, Federal University of Pernambuco, Recife, Brazil
[2] Student, Stomatološki fakultet fakultet Državno sveučilište Pernambuco, Recife, Brazil
Undergraduate Student, Faculty of Dentistry, Federal University of Pernambuco, Recife, Brazil
[3] Zavod za protetiku I oralnu I facijalnu kirurgiju, Stomatološki fakultet Državno sveučilište Pernambuco, Recife, Brazil
Department of Prosthetics and Oral and Facial Surgery, Faculty of Dentistry, Federal University of Pernambuco, Recife, Brazil
[4] Privatna ordinacija, Recife, Brazil
Private Practice, Recife, Brazil

Sažetak

Svrha: Korištenjem konične kompjutorizirane tomografije (CBCT-a) željela se odrediti mogućnost centriranja Twisted Fileom™ u usporedbi sa strojnim sustavom Revo-S®. **Materijali i metode:** Četrdeset bukomezijalnih kanala maksilarnog prvog kutnjaka sa zakrivljenošću od 25° do 30° podijeljeni su u dvije skupine po 20, ovisno o korištenom sustavu (skupina 1: Twisted File™; skupina 2: strojni sustav Revo-S®). Svi zubi slikani su CBCT-om te im je određen oblik korijenskih kanala prije instrumentacije i nakon toga postupka. Zatim su slike digitalno obrađene Image Tools Softwareom i izračunat je omjer centriranja kanala. Rezultati su statistički analizirani *t*- i Mann-Whitneyjevim testom. Stupanj statističke značajnosti postavljen je na ,05. **Rezultati:** Ni kod jednog sustava centriranje nije bilo besprijekorno te između dviju eksperimentalnih skupina nije bilo statistički značajnih razlika ($p<0,05$). **Zaključak:** Ni jedan od procijenjenih strojnih sustava nije bio savršeno učinkovit tijekom biomehaničke obrade korijenskih kanala jer su oba prouzročila pomak sredine kanala.

Zaprimljen: 14. svibnja 2012.
Prihvaćen: 23. srpnja 2012.

Adresa za dopisivanje
Prof. Dr. Carlos Menezes Aguiar,
Rua Aristides Muniz, 70/501,
Boa Viagem, Recife PE 51020-150 Brazil.
Tel: (+55) 81 3467 6821.
cmaguiar.ufpe@yahoo.com.br

Ključne riječi
konična kompjutorizirana tomografija; stomatološki instrumenti; endodoncija; korijenski kanal, obrada

Uvod

Instrumentacija korijenskih kanala jedan je od temelja endodontske terapije i neposredno je povezana s dezinfekcijom i punjenjem (1).

Svrha joj je dobiti konični oblik kanala s najmanjim promjerom na apikalnom otvoru i najvećim na ulaznom, kako bi se omogućili učinkovita irigacija i punjenje (2), bez devijacije od ishodišne trajektorije (3,4). Ako je kanal zakrivljen, endodontska terapija je teža i postoji tendencija odstupanja od izvorne osovine kanala, bez obzira na tehnike instrumentacije (5).

Strojni instrumenti izrađeni od nikal-titanija, zahvaljujući superelastičnim svojstvima, mogu zadržati izvorni oblik kanala bez veće transportacije ili pogrešaka poput *zipa*, luka, perforacija ili oslabljivanja stijenke *opasne zone* u zakrivljenim kanalima (6). Konstruirano je mnogo instrumenata za strojnu obradu, različitih poprečnih presjeka, oštrica, navojnog uspona i koniciteta (7, 8).

Nedavno je SybronEndo predstavio potpuno nov proizvodni postupak za instrumente potrebne za strojnu obradu

Introduction

Root canal preparation is one of the major components of endodontic treatment, and it is directly related to subsequent disinfection and filling (1). The aim of root canal preparation is to form a continuously tapered shape with the smallest diameter at the apical foramen and the largest at the orifice to allow effective irrigation and filling (2) without deviating from the original trajectory (3,4). When curvature is present, endodontic preparation becomes more difficult, and there is a tendency for all preparation techniques to divert the prepared canal away from the original axis (5).

Nickel-titanium (NiTi) rotary instruments, owing to their superelastic properties, are able to maintain the original canal shape without any significant transportation or creation of irregularities such as zipping, ledges, perforations, or danger zones, in curved canals (6). Many types of rotary root canal instruments have been introduced, varying in cross-section, blade and pitch design, and taper (7,8).

Recently, a completely different manufacturing process has been developed by SybronEndo to create a new rotary

korijenskih kanala nazvan Twisted File™ (SybronEndo, Kalifornija, SAD). Ti instrumenti imaju trokutasti presjek s kontinuiranim konicitetima od .04, .06, .08, .10 i .12 i veličinu vrhova od 25 do 50. Proizvođač tvrdi da tri nova postupka u proizvodnji tih instrumenata – R-faza obrade toplinom, svijanje metala i posebno obrađivanje površine – znatno pridonose otpornosti na cikličko zamaranje materijala i fleksibilnost čak i kod instrumenata koniciteta .06, .08, .10, i .12, te se može sačuvati izvorni centar korijenskog kanala i minimizirati njegova transportacija, čak ako je i jako zakrivljen (5, 9– 12).

Micro-Mego® također je proizveo novi sustav instrumenata kako bi se pojednostavnila inicijalna endodontska terapija i optimiziralo čišćenje. Asimetrični rezni profil instrumenata Revo-S® (Micro-Mega, Besançon, Francuska) olakšava njihov ulazak pomacima poput zmijskih i omogućuje prilagođeno oblikovanje korijenskih kanala prema biološkim i ergonomskim zahtjevima. Taj sustav omogućuje temeljito čišćenje i apikalno ispiranje, što zadovoljava anatomske i ekološke kriterije kanala. Sustav se sastoji od samo dvaju instrumenata za obradu početnog dijela kanala (SC1 i SC2) te jednoga za rekapitulaciju, čišćenje (SU) i apikalnu obradu (AS 30, AS 35, AS 40) (13).

Nakon endodontske instrumentacije, neinvazivna metoda za procjenu promjene geometrije korijenskih kanala jest kompjutorizirana tomografija visoke rezolucije (CT) koja omogućuje trodimenzionalnu procjenu prije instrumentacije i nakon nje, te točne izračune metričkih vrijednosti (14). Konična kompjutorizirana tomografija (CBCT) rabi se ako je potrebno znati kakva su tvrda tkiva maksilofacijalnog područja. CBCT omogućuje visoku rezoluciju – manju od milimetra – na slikama velike dijagnostičke kvalitete, kratko vrijeme snimanja (10 do 70 sekundi) te niske apsorpcijske doze zračenja – čak do 15 puta niže od uobičajenih (15).

Samo su se u nekoliko studija analizirale mogućnosti sustava Twisted File™ i Revo-S® da zadrže morfologiju korijenskih kanala. S pomoću CBCT-a u ovom smo istraživanju pokušali odrediti centriranje obaju sustava i međusobno ih usporediti.

Materijali i metode

Odabir i priprema uzoraka

Odabrano je 40 bukomezijalnih kanala ekstrahiranih ljudskih prvih maksilarnih kutnjaka (dužine 20 – 21mm) iz zbirke zuba Odjela za protetiku i orofacijalnu kirurgiju (Department of Prosthetics and Oral and Facial Surgery) Stomatološkog fakulteta Federalnog sveučilišta u Pernambucu. Korištenje je odobrilo Etičko povjerenstvo Centra za zdravstvene znanosti te visokoškolske ustanove. Odabrani bukomezijalni korijeni imali su potpuno formirane apekse i znatnu zakrivljenost kanala – od 25° do 30° u odnosu na tehniku pristupnog kuta (16). Pripremljeni su pristupni kaviteti i određena radna dužina (WL) instrumenta #10 Senseus-Flexofile (Dentsply/Maillefer, Ballaigues, Švicarska) kojim se

file for root canal preparation called the Twisted File™ (SybronEndo, California, USA). These files have a triangular cross-section with constant tapers of .04, .06, .08, .10, and .12. They are available in five tip sizes from 25 to 50. The manufacturer claims that the three new manufacturing processes of these files, namely R-phase heat treatment, twisting of the metal, and special surface conditioning, significantly increase the instrument's resistance to cyclic fatigue and flexibility, even with .06-, .08-, .10-, and .12-tapered instruments, maintaining the original canal center and minimizing canal transportation even in severely curved root canals (5,9-12).

A new NiTi file sequence has been developed by Micro-Mega®. Its purpose is to simplify the initial endodontic treatment and to optimise the cleaning. The asymmetrical cutting profile of the Revo-S® (Micro-Mega, Besançon, France) facilitates penetration by a snake-like movement, and offers a root canal shaping which is adapted to the biological and ergonomic imperatives. This system promotes a thorough root cleaning, and also offers apical finishing which is closely adapted to the anatomical and ecological criteria of the canal. It is composed of only two instruments for apical penetration (SC1 and SC2), a recapitulating and cleaning instrument (SU), and apical finishing instruments (AS30, AS35, AS40) (13).

A nondestructive method to evaluate changes of root canal geometry after endodontic preparation is the high-resolution computerized tomography (CT) that allows three-dimensional evaluation of root canal geometry before and after preparation, yielding a mass of exact metric data (14). Cone-beam computed tomography (CBCT) systems have been designed for imaging of hard tissues of the maxillofacial region. CBCT is capable of providing sub-millimeter resolution in images of high diagnostic quality, with short scanning times (10-70 seconds) and radiation dosages reportedly up to 15 times lower than those of conventional scans (15).

There have been few studies published on the ability of the Twisted File™ and Revo-S® rotary systems to maintain root canal morphology. By means of the cone beam computed tomography, the present study set out to determine the centering ability of the Twisted File™ rotary system compared with the Revo-S® rotary system.

Materials and Methods

Selection and preparation of samples

Forty mesiobuccal canals of extracted human maxillary 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 severely curved root canals whose curvature ranged from 25° to 30° according to the canal access angle (CAA) technique (16). The access cavities were prepared, and to determine the working length (WL), a #10 Senseus-Flexofile (Dentsply/Maillefer, Ballaigues, Switzerland) was inserted into the me-

obrađivao bukomezijalni kanal dok se nije pokazao na apeksu korijena. Radna dužina (WL) uzeta je kao vrijednost od jednog milimetra manja od vizualno određene dužine.

Dobivanje predoperativnih radiogramskih prikaza

Zubi su pohranjeni u plastične posudice napunjene alginatnim hidrogelom (Jeltrade; Dentsply, Petropolis, Brazil) kako bi se, prema ranije opisanoj metodi, dobile što sličnije slike prije i poslije instrumentacije (17).

Kada se alginat stvrdnuo, svi su zubi skenirani CBCT-uređajem (i-Cat®, Imaging Sciences International, Hatfield, PA, SAD) radi utvrđivanja oblika korijenskog kanala prije instrumentiranja. Vrijeme ekspozicije iznosilo je 26,9 sekundi pri 120 kW i 7 mA. Za svaki zub dobivena su ukupno četiri horizontalna poprečna presjeka za svaki korijen. Prikazi su rezani na četirima točkama koje su se nalazile 15 milimetara (koronarni dio korijena) – (0), 9 milimetara (srednji dio korijena) – (1), 3 milimetra (2) i 1 milimetar (apikalni dio) – (3) od apeksa zubnog korijena. Svi su razvrstani i spremljeni za daljnju usporedbu.

Instrumentacija korijenskih kanala

Uzorci su nasumce podijeljeni u dvije skupine s po 20 korjenova u svakoj. Instrumentacija je obavljena prema preporukama proizvođača. Nakon slučajne raspodjele po skupinama, zubi su dodatno klasificirani, ovisno o stupnju zakrivljenosti kanala, u prosječno zakrivljene i one znatnije zakrivljene te su podjednako raspoređeni u obje skupine.

Skupina 1: strojni instrumenti Twisted File™. Korijenski kanali instrumentirani su s 300 rpm-a sljedećim slijedom: (a) instrument #25,08 korišten je u koronarnoj trećini korijenskog kanala, (b) instrument #25,06 rabio se do četiri milimetra kraće dužine od ustanovljenog WL-a, a (c) instrumenti #25,04 i #25,06 uporabljali su se do pune radne dužine (WL-a).

Skupina 2: strojni sustav Revo-S®. Korijenski kanali instrumentirani su s 300 rpm-a ovim redom: (a) instrument #25,06 (SC 1) korišten je u koronarnoj trećini korijenskih kanala, (b) instrumenti #25,04 (SC 2) i #25,06 (SU) rabili su se do pune radne dužine (WL-a).

Uzorci su stavljeni u škrip (Neboluz, São Paulo, Brazil) i učvršćeni kako bi bili nepomični tijekom instrumentacije. Nakon obrade sa svakim instrumentom kanali su irigirani s tri mililitra svježe pripremljene otopine 1-postotnog natrijeva hipoklorida (1% NaOCl) (Roval, Recife, Brazil). Tijekom rada je kao sredstvo za podmazivanje korišten Glyde™ (Dentsply, Maillefer, Ballaigues, Švicarska).

Sve kanale obrađivao je jedan operater vješt u strojnoj instrumentaciji korijenskih kanala. Svaki instrument promijenjen je nakon obrade pet korijenskih kanala, bez obzira na to što je nakon svakog korištenja pregledan i ispitan je li oštećen, a ako se pojavio kakav deformitet ili lom zamijenjen je i prije. Za rotaciju je korišten električni motor (Driller Endo-Pro Torque, Sao Paulo, Brazil) s brzinom vrtnje od 300 rpm-a.

Dobivanje postoperativnih radiogramskih prikaza

Nakon instrumentacije korijenskih kanala uzorci su postavljeni isto kao i predoperativni prikazi. Postoperativni prikaz snimljen je u kompjutor radi usporedbe.

siobuccal 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.

Obtaining the preoperative images

The roots 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 (17).

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. A total of 4 horizontal cross-sectional cut planes from each root were obtained. The images were sectioned into four points, located respectively at 15 mm (coronal level)-(0), 9 mm (mid-root level)-(1), 3mm (2), and 1mm (apical level)-(3) from the apex. The images were saved in a computer for later comparison.

Root canal preparation

The specimens were randomly divided into two groups with 20 root canals each. All instrumentation was performed according to each manufacturer's instructions. Random distribution of the groups considered the degree of canal curvature, allowing the average curvature, as well as the more severe cases, to be evenly allocated to each group:

Group 1: Twisted File™ Rotary System. The canals were instrumented at a rotational speed of 300 rpm as follows: (a) the #25.08 file was used up to the coronal one third of the root canal, (b) the #25.06 file was used up to 4 mm short of the WL, and (c) the #25.04 and #25.06 files were used up to the full WL.

Group 2: Revo-S® Rotary System. The canals were instrumented at a rotational speed of 300 rpm as follows: (a) the #25.06 (SC1) file was used up to the coronal one third of the root canal, and (b) the #25.04 (SC2) and #25.06 (SU) files were used up to the full WL.

The specimens were fastened to a morse (Neboluz, São Paulo, Brazil) to keep them immovable during preparation. 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.

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.

Procjenjivanje sposobnosti centriranja

Predoperativni i postoperativni 3D prikazi uspoređeni su Image Tool softwareom (University of Texas Health Science Center, Texas, SAD) (slika 1.). Gambill i suradnici (18) definirali su omjer mogućnosti centriranja kao svojstvo instrumenta da ostane u sredini kanala. Omjer je računat za svaki presjek korištenjem sljedeće jednadžbe (slika 2.):

D1: (X1 – X′1)/(X2 – X′2)

D2: (Y1 – Y′1)/(Y2 – Y′2)

Pritom je D1 bukolingvalna mjera, a D2 meziodistalna.

X1 je najkraća udaljenost iz bukalnog smjera korijena do ruba neinstrumentiranog kanala. X'1 je najkraća udaljenost iz bukalnoga smjera korijena do ruba instrumentiranog kanala. X2 najkraća je udaljenost iz lingvalnoga smjera korijena do ruba neinstrumentiranog kanala. X'2 najkraća je udaljenost iz lingvalnoga smjera korijena do ruba instrumentiranog kanala. Y1 je najkraća udaljenost iz mezijalnog smjera korijena do ruba neinstrumentiranog kanala. Y'1 najkraća je udaljenost iz mezijalnog smjera korijena do ruba instrumentiranog kanala. Y2 najkraća je udaljenost iz distalnoga smjera korijena do ruba neinstrumentiranog kanala. Y'2 najkraća je udaljenost iz distalnog smjera korijena do ruba instrumentiranog kanala.

Prema toj formuli **rezultat 1**, označava savršenu mogućnost centriranja.

Evaluation of centering capacity

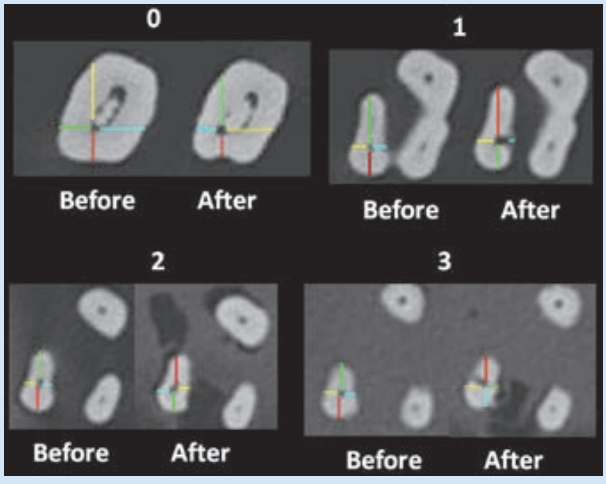
Using the Image Tool software (University of Texas Health Science Center, Texas, USA) the preoperative and postoperative images were compared (Figure 1). Gambill *et al.* (18) defined centering ratio as the measurement of the ability of the instrument to stay centered in the canal. This ratio was calculated for each section using the following ratio (Figure 2):

D1: (X1 – X′1)/(X2 – X′2)

D2: (Y1 – Y′1)/(Y2 – Y′2)

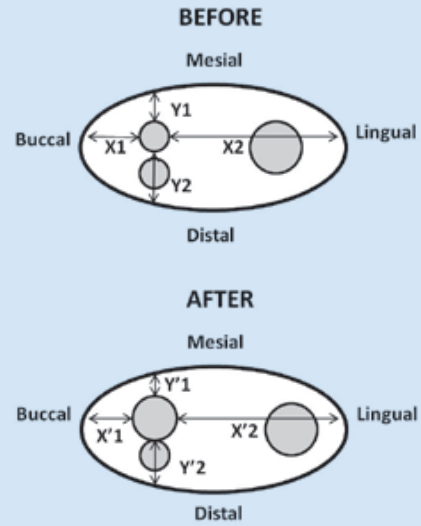
Where D1= the buccolingual measurement and D2 = the mesiodistal measurement.

X1=shortest distance from the buccal aspect of the root to the periphery of the uninstrumented canal. X'1= shortest distance from the buccal aspect of the root to the periphery of the prepared canal. X2=shortest distance from the lingual aspect of the root to the periphery of the uninstrumented canal. X'2= shortest distance from the lingual aspect of the root to the periphery of the prepared canal. Y1=shortest distance from the mesial aspect of the root to the periphery of the uninstrumented canal. Y'1= shortest distance from the mesial aspect of the root to the periphery of the prepared canal. Y2=shortest distance from the distal aspect of the root to the periphery of the uninstrumented canal. Y'2= shortest distance from the distal aspect of the root to the periphery of the prepared canal. According to this formula, a result of 1 indicates a perfect centering ability.



Slika 1. Prikazi koronarne, središnje i apikalne trećine prije i poslije instrumentacije korijenskih kanala sustavom Revo-S®

Figure 1 Image taken of the coronal, mid-root and apical region before and following root canal preparation with the Revo-S® rotary system



Slika 2. Shematski prikaz kako su dobiveni omjeri za centriranje na zubu

Figure 2 Schematic representation of the image showing how centering ratios of the tooth were derived

Statistička analiza podataka

Podaci su zbrojeni s pomoću apsolutne frekvencije i relativnog postotka, a numerički podaci dobiveni su deskriptivnom statistikom lokalizacije i rasipanja. Rezultati su statistički analizirani korištenjem *t*- i Mann-Whitneyjeva testa. Stupanj značajnosti postavljen je na 0,05, a rabio se statistički paket za društvene znanosti, verzija 13 (SPSS, Chicago, SAD).

Statistical analysis of the data

The categorical data were summarized by means of absolute frequency and relative percentage and the numeric data by means of the usual descriptive statistics of location and dispersion. The results were statistically analyzed using the *t* test and the Mann-Whitney test. A level of significance of .05 was adopted, using the Statistical Package for the Social Sciences, version 13 (SPSS, Chicago, USA).

Rezultati

Tablica 1. predstavlja deskriptivnu statistiku bukolingvalnih (D1) i meziodistalnih mjerenja (D2), ovisno o korištenom strojnom sustavu i instrumentiranom dijelu korijenskog kanala i to na udaljenostima od 15 milimetara (0), devet milimetara (1), tri milimetra (2) i jedan milimetar (3) od apeksa zubnog korijena. Tablica pokazuje srednje vrijednosti D1 koje su se kretale od 0,40 do 1,45 te D2 od 0,20 do 1,35. Nije bilo statistički značajne razlike između dviju skupina. Oba strojna sustava – i Twisted File™ i Revo-S® Rotary, uzrokovali su devijaciju kanala.

Results

Table 1 presents the main descriptive statistics of the buccolingual measurement (D1) and mesiodistal measurement (D2) according to the rotary system used and the root segment instrumented at distances of 15 mm (0), 9 mm (1), 3mm (2), and 1mm (3) from the apex.

This table shows that the means of D1 ranged from 0.40 to 1.45, and the means of D2 ranged from 0.20 to 1.35. There were no statistically significant differences ($p > 0.05$) between the two groups. Both Twisted File™ and Revo-S® Rotary Systems produced canal deviation.

Tablica 1. Srednja vrijednost i standardna devijacija bukolingvalne i meziodistalne mjere, ovisno o korištenom instrumentu i mjerenom dijelu korijenskog kanala
Table 1 Mean and standard deviation of the buccolingual and mesiodistal measurements according to the instrument used and the root segment instrumented.

Skupina • Group	Dio korijenskog kanala • Root segment	Mjera • Measurement	N	Srednja vrijednost • Mean	SD
1	0	D1	20	1.45	1.65
1	0	D2	20	0.76	0.76
1	1	D1	20	0.75	1.49
1	1	D2	20	0.82	1.00
1	2	D1	20	1.02	1.23
1	2	D2	20	1.35	1.63
1	3	D1	20	0.98	0.96
1	3	D2	20	0.28	0.49
2	0	D1	20	1.30	1.92
2	0	D2	20	0.51	0.64
2	1	D1	20	0.75	1.23
2	1	D2	20	0.22	0.67
2	2	D1	20	0.40	0.52
2	2	D2	20	0.20	0.35
2	3	D1	20	1.20	2.04
2	3	D2	20	0.58	0.98

N – broj uzoraka • number of specimens
SD – standardna devijacija • standard deviation
D1 – bukolingvalna dimenzija • buccolingual measurement
D2 – meziodistalna dimenzija • mesiodistal measurement

Rasprava

Oblikovanje korijenskog kanala jedna je od osnovnih faza endodontske preparacije (2) pri čemu zakrivljenost otežava njihovu instrumentaciju. Na obradu zakrivljenih korijenskih kanala utječe nekoliko čimbenika, poput savitljivosti i promjera endodontskih instrumenata, tehnike rada, smještaja apikalnog foramena i tvrdoće dentina. Stvaranje stepenice, nastanak začepljenja ili perforacije, devijacije i transportacija apikalnog foramena, neželjene su posljedice koje se mogu dogoditi pri instrumentaciji zakrivljenih korijenskih kanala (19).

Uporaba instrumenata od nikal-titanija (NiTi) omogućila je sigurniju i jednostavniju obradu kanala složenih anatomskih svojstava (20). U endodonciji se počelo primjenjivati nekoliko strojnih sustava od toga materijala (NiTi) (8). Oni su savitljiviji i otporniji na torzijsko puknuće negoli instrumenti od nehrđajućeg čelika (11). Zbog toga se njima lakše prati zakrivljenost kanala, čak i onih jako zavinutih.

Discussion

Root canal shaping comprises one of the fundamental stages of endodontic treatment (2). However, the presence of curvatures may pose difficulty in root canal instrumentation. The results of instrumenting curved root canals are influenced by several factors, such as flexibility and diameter of the endodontic instruments, instrumentation techniques, location of the foramen, and hardness of the dentin. Ledge formation, blockages, perforations, deviations, and apical transportation are undesirable accidents that have occurred during preparation of curved root canals (19).

The introduction of NiTi instruments allowed a safer and easier preparation of canals with complex anatomic characteristics (20). Several NiTi rotary instrument systems have been introduced to endodontics (8). These instruments offer greater flexibility and more resistance to torsional separation than stainless steel files (11). Because of these features, they are better able to maintain curvature even in severely curved

Ako se izvorni kanal uspije sačuvati koliko god je moguće, mogu se izbjeći mnoge jatrogene komplikacije nakon čišćenja i oblikovanja korijenskih kanala (21).

Kako bi se smanjile kanalne aberacije, razvijeni su novi nikal-titanijski (NiTi) instrumenti, poput sustava koje smo uspoređivali u ovom istraživanju. Odabrani su zbog svojih posebnosti u odnosu na druge sustave, kao što su proizvodni postupak i asimetričan rezni profil.

U literaturi postoje podaci za korištenje nekoliko metoda za određivanje učinkovitosti endodontskih instrumenata u korijenskim kanalima (1,3–8,18,21,22). Jedna od njih koristi se radiografskom platformom (21,23,24). No to omogućuje samo dvodimenzionalni uvid u biomehaničku instrumentaciju i ne može se vidjeti treća dimenzija korijenskih kanala. Tehnika serijskih rezova uobičajena je, ali zahtijeva složeno rezanje zuba te se mogu pojaviti nepoznate promjene i gubitak u materijalu (4, 18). Analiza CT-om neinvazivna je metoda koja omogućuje raščlambu geometrije kanala i učinkovitost tehnika instrumentacije (5, 14, 25). Na taj se način može usporediti anatomija kanala i struktura prije instrumentacije i poslije postupka. CBCT i specijalizirani programski paket (i-CAT Cone Beam) uspješno su primijenjeni u ovom istraživanju za mjerenje korijenskih kanala prije i poslije instrumentacije te za računanje centriranja dvaju proučavanih strojnih sustava od nikal-titanija tijekom čišćenja i oblikovanja korijenskih kanala.

U ovom istraživanju procijenili smo učinak strojnih sustava Twisted File™ i Revo-S® na anatomiju korijenskih kanala s pomoću CBCT-a. CBCT-analiza pokazala je da oba sustava – i Twisted File™ i Revo-S® – uzrokuju otklone od izvorne anatomije kanala. Korištenu je metodologiju opisao Sanfelice sa suradnicima (17) i, prema njegovim riječima, pokazala se pouzdanom. Zbog rezanja nije bilo ni destruktivnog segmentalnog rezanja uzoraka ni gubitka materijala korijena. Osim ovog istraživanja CBCT se može uporabiti i za određivanje unutarnje morfologije zuba (26).

U ovom istraživanju, kao i u usporednima (1,4,5,8,14,21,24,25), korišteni su ljudski ekstrahirani zubi. Glavni je razlog za takav izbor to što oni bolje simuliraju kliničke uvjete od bilo kojih akrilnih blokova. Akrilna smola nije pogodan materijal za testiranje strojnih instrumenata jer ne oponaša pravilno mikrotvrdoću dentina i česte anatomske varijacije prirodnih zuba (proširenja, ovalne kanale i sl.), pa ih se ne može jednostavno simulirati (27). Korišteni su bukomezijalni korijeni izvađenih maksilarnih molara jer su obično jako zakrivljeni (28). Krune su zadržane kako bi uvjeti bili što bliži kliničkima kod kojih dentinska interferencija u cervikalnom dijelu kanala ponekad stvara napetost na instrumentima tijekom obrade (29). Odabrane su četiri točke (redom: 15, 9, 3 i 1 milimetar od vrška korijena) koje predstavljaju koronarnu, središnju i apikalnu trećinu korijenskog kanala kod kojih zakrivljenost, ako postoji, pogoduje neželjenim posljedicama instrumentacije.

U mnogim istraživanjima stručnjaci su se koristili Schneiderovom metodom (30) za određivanje stupnja zakrivljenosti korijenskog kanala (5, 14, 21, 28). U ovom je radu izmjerena CAA-metodom jer je učinkovita poput Schneiderova kuta u procjeni stupnja zakrivljenosti, ali je pogodnija

canals. By preserving the original canal as far as possible, iatrogenic complications arising from cleaning and shaping can be avoided (21). To reduce canal aberrations, new NiTi instruments have been developed, such as the systems investigated in this study. The choice of the instruments used for this study took into account several factors that make them different from other systems, such as manufacturing processes and asymmetrical cutting profile.

A number of methods for investigating the effectiveness of endodontic instruments in instrumenting root canals have been used (1,3-8,18,21,22). One of these methods is the use of the radiographic platform (21,23,24). It merely provides, however, a two-dimensional image of the biomechanical preparation, precluding observation of the three-dimensional conformation of root canals. The serial sectioning technique is a commonly used method. This technique requires a complicated setup and a physical sectioning of the teeth before preparation can result in unknown tissue changes and loss of material (4,18). Another method of analysis is CT, a noninvasive method for analyzing canal geometry and the efficiency of shaping techniques (5,14,25). With this technique, it is possible to compare the canal's anatomic structure before and after instrumentation. 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 two NiTi rotary systems during cleaning and shaping of the root canals. The present study evaluated the effects of Twisted File™ and Revo-S® on root canal anatomy by using CBCT. CBCT analysis showed that the Twisted File™ and Revo-S® Rotary Systems produced canal deviation. The use of this methodology was based on the study of Sanfelice *et al.* (17), which showed it to be reliable, without destructive sectioning of the specimens or loss of the root material during sectioning. Besides, CBCT can be used as a good method for initial identification of dental internal morphology (26).

In the present study, as in others, human teeth were used (1,4,5,8,14,21,24,25). The main reason for choosing human teeth is that they simulate clinical conditions better than acrylic blocks. Acrylic resin is not an optimal material for testing rotary instruments because it does not reproduce the microhardness of dentin and the frequently encountered anatomic variations (enlargements, oval root canals, etc.) that cannot be easily simulated (27). Mesiobuccal root canals of extracted human maxillary molars were used herein because they usually present an accentuated curvature (28). Crowns were maintained to simulate clinical conditions in which the interference of cervical dentin projections would create tensions on the files during canal instrumentation (29). Four levels (ie, 15, 9, 3, and 1 mm from the root apex) were chosen representing the coronal, middle, and apical thirds of root canal in which curvatures, highly susceptible to iatrogenic mishaps, usually exist.

Many studies have used the Schneider (30) method to determine root canal curvature (5,14,21,28). In the present study, curvature was measured by the CAA method, because this method is as effective as the Schneider angle in evalu-

za mjerenje mogućnosti centriranja instrumenata za obradu korijenskog kanala (16).

Prema navodu u literaturi, Duran-Sindreu i kolege (31) tvrde da su instrumentima Twisted File™ poboljšana svojstva u odnosu na ostale instrumente. Rezultati ovog istraživanja pokazali su da uzrokuju morfološke promjene poput apikalne devijacije. Ti rezultati nisu u skladu s ranijim istraživanjem (32) u kojem se tvrdi da se instrumenti Twisted Filea™ mogu koristiti u svim kliničkim slučajevima, bez obzira na anatomiju zuba. Gergi i suradnici (5) usporedili su centriranje Twisted Filea™, Pathfile-ProTapera™ i ručnih čeličnih K-instrumenata i za to su se koristili kompjutoriziranom tomografijom. Pronašli su da je manja transportacija i bolje centriranje s pomoću strojnih instrumenata Twisted File™. Stern i kolege (33) također tvrde da se Twisted Fileom™ može postići centrirana preparacija.

Diemer i suradnici (34) izvijestili su da strojni sustav Revo-S® omogućuje brzo oblikovanje, dobro čišćenje te očuvanje izvornog smjera i položaja kanala, što nije u skladu s rezultatima našeg istraživanja, ni s onima Hashema i njegovih kolega (29), jer je Revo-S® uzrokovao devijacije na koronarnoj, središnjoj i apikalnoj trećini korijenskog kanala.

U ovom istraživanju svi testirani sustavi prouzročili su devijacije (otklone) korijenskih kanala na svim ispitanim razinama. Ni jedan od procijenjenih instrumenata nije bio potpuno učinkovit u biomehaničkoj preparaciji korijenskih kanala jer su kod svih uočene morfološke promjene.

Zbog ograničenja u provedenom istraživanju i zato što su sustavi strojne instrumentacije Twisted File™ i Revo-S® razmjerno novi među endodontskim alatkama, potrebna su daljnja istraživanja kako bi se dobile dodatne informacije.

Zaključak

Ni jedan od analiziranih sustava instrumenata u ovom istraživanju nije bio potpuno učinkovit u biomehaničkoj preparaciji korijenskih kanala jer je svaki uzrokovao odstupanje (devijaciju) od izvornog kanala.

ating root canal curvature and is better able to measure the centering ability of root canal instruments (16).

According to Duran-Sindreu *et al.* (31), the Twisted File™ instruments were designed to improve properties in relation to root canal preparation as compared with other instruments. However, the results of the current study showed that the Twisted File™ rotary systems produced morphological changes as apical deviation. These results are in disagreement with a previous study (32), which stated that the Twisted File™ rotary system can be used in any clinical case, regardless of the anatomical aspect of the tooth. Gergi *et al.* (5) compared the centering ability of the Twisted File™, Pathfile-ProTaper™, and stainless steel hand k-files by using computed tomography and observed less transportation and better centering ability with the Twisted File™ rotary instruments. Stern *et al.* (33) also related that the Twisted File™ was capable of producing centered preparations.

Diemer *et al.* (34) reported that the Revo-S® rotary system enables a fast shaping quality, a real cleaning and maintain of the original canal path, which is not in accordance with the results of the present research and with the results observed by Hashem *et al.* (29) since the Revo-S® rotary system produced canal deviation at the coronal, middle, and apical regions of the root canal.

In this study, all tested rotary systems resulted in canal deviation at all examined levels. None of the instruments evaluated in this study were totally effective in performing the biomechanical preparation of the root canals, with morphologic changes observed.

Within the limitations of this study and the fact that the Twisted File™ and the Revo-S® are new to the array of endodontic tools, further investigations are required to provide more information on these new instruments.

Conclusions

None of the instruments evaluated in this study were totally effective in performing biomechanical preparation of the root canals, because each of them produced canal deviation.

Abstract

Purpose: The present study set out to determine the centering ability of the Twisted File™ rotary system compared with the Revo-S® rotary system by means of the cone beam computed tomography. **Material and methods:** Forty mesiobuccal canals of human maxillary first molars the curvature of which ranged from 25° to 30° were divided into two groups with 20 root canals each according to the instruments used: Group 1, Twisted File™ rotary system; Group 2, Revo-S® rotary system. All teeth were scanned by cone beam computed tomography to determine the root canal shape before and after instrumentation. The images were captured digitally for further analysis using the Image Tools Software. Canal centering ratio was calculated. The results were statistically analyzed using the *t* test and the Mann-Whitney test. A level of significance of .05 was adopted. **Results:** The perfect centering ability was not observed in either rotary system, and there were no statistically significant differences ($p > 0.05$) between the two groups in terms of centering ability. **Conclusion:** None of the instruments evaluated in this study were totally effective in performing biomechanical preparation of the root canals, because each of them produced canal deviation.

Received: May 14, 2012
Accepted: July 23, 2012

Address for correspondence
Prof. Dr. Carlos Menezes Aguiar,
Rua Aristides Muniz, 70/501,
Boa Viagem, Recife PE 51020-150 Brazil.
Tel: (+55) 81 3467 6821.
cmaguiar.ufpe@yahoo.com.br

Key words
Cone-Beam Computed Tomography; Dental Instruments; Endodontics; Root Canal Preparation

References

1. Aguiar CM, Mendes Dde A, Câmara AC, Figueiredo AP. Assessment of canal walls after biomechanical preparation of root canals instrumented with Protaper Universal rotary system. J Appl Oral Sci. 2009 Nov-Dec;17(6):590-5.
2. Schilder H. Cleaning and shaping the root canal. Dent Clin North Am. 1974 Apr;18(2):269-96.
3. Câmara AC, Aguiar CM, Poli de Figueiredo JA. Assessment of the deviation after biomechanical preparation of the coronal, middle, and apical thirds of root canals instrumented with three HERO rotary systems. J Endod. 2007 Dec;33(12):1460-3.
4. Hata G, Uemura M, Kato AS, Imura N, Novo NF, Toda T. A comparison of shaping ability using ProFile, GT file, and Flex-R endodontic instruments in simulated canals. J Endod. 2002 Apr;28(4):316-21.
5. Gergi R, Rjeily JA, Sader J, Naaman A. Comparison of canal transportation and centering ability of twisted files, Pathfile-ProTaper system, and stainless steel hand K-files by using computed tomography. J Endod. 2010 May;36(5):904-7.
6. Madureira RG, Forner Navarro L, Llena MC, Costa M. Shaping ability of nickel-titanium rotary instruments in simulated S-shaped root canals. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010 Feb;109(2):e136-44.
7. Ersev H, Yilmaz B, Ciftçioğlu E, Ozkarsli SF. A comparison of the shaping effects of 5 nickel-titanium rotary instruments in simulated S-shaped canals. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010 May;109(5):e86-93.
8. Karabucak B, Gatan AJ, Hsiao C, Iqbal MK. A comparison of apical transportation and length control between EndoSequence and Guidance rotary instruments. J Endod. 2010 Jan;36(1):123-5.
9. Gambarini G, Grande NM, Plotino G, Somma F, Garala M, De Luca M et al. Fatigue resistance of engine-driven rotary nickel-titanium instruments produced by new manufacturing methods. J Endod. 2008 Aug;34(8):1003-5.
10. Kim HC, Yum J, Hur B, Cheung GS. Cyclic fatigue and fracture characteristics of ground and twisted nickel-titanium rotary files. J Endod. 2010 Jan;36(1):147-52.
11. Larsen CM, Watanabe I, Glickman GN, He J. Cyclic fatigue analysis of a new generation of nickel titanium rotary instruments. J Endod. 2009 Mar;35(3):401-3.
12. Hilfer PB, Bergeron BE, Mayerchak MJ, Roberts HW, Jeansonne BG. Multiple autoclave cycle effects on cyclic fatigue of nickel-titanium rotary files produced by new manufacturing methods. J Endod. 2011 Jan;37(1):72-4.
13. Zouiten SS, Hammo M, Ourfelli S, Douki N, Jammali B, Baccouch C. An innovation for the initial endodontic treatment-Revo-S®. Dent News. 2010;17(2):19-24.
14. Versiani MA, Pascon EA, de Sousa CJ, Borges MA, Sousa-Neto MD. Influence of shaft design on the shaping ability of 3 nickel-titanium rotary systems by means of spiral computerized tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008 Jun;105(6):807-13.
15. Scarfe WC, Farman AG, Sukovic P. Clinical applications of cone-beam computed tomography in dental practice. J Can Dent Assoc. 2006 Feb;72(1):75-80.
16. Günday M, Sazak H, Garip Y. A comparative study of three different root canal curvature measurement techniques and measuring the canal access angle in curved canals. J Endod. 2005 Nov;31(11):796-8.
17. Sanfelice CM, da Costa FB, Reis Só MV, Vier-Pelisser F, Souza Bier CA, Grecca FS. Effects of four instruments on coronal pre-enlargement by using cone beam computed tomography. J Endod. 2010 May;36(5):858-61.
18. Gambill JM, Alder M, del Rio CE. Comparison of nickel-titanium and stainless steel hand-file instrumentation using computed tomography. J Endod. 1996 Jul;22(7):369-75.
19. Jain N, Tushar S. Curved canals: ancestral files revisited. Indian J Dent Res. 2008 Jul-Sep;19(3):267-71.
20. Walia HM, Brantley WA, Gerstein H. An initial investigation of the bending and torsional properties of Nitinol root canal files. J Endod. 1988 Jul;14(7):346-51.
21. Guelzow A, Stamm O, Martus P, Kielbassa AM. Comparative study of six rotary nickel-titanium systems and hand instrumentation for root canal preparation. Int Endod J. 2005 Oct;38(10):743-52.
22. Unal GC, Maden M, Savgat A, Onur Orhan E. Comparative investigation of 2 rotary nickel-titanium instruments: protaper universal versus protaper. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009 Jun;107(6):886-92.
23. Sydney GB, Batista A, de Melo LL. The radiographic platform: a new method to evaluate root canal preparation in vitro. J Endod. 1991 Nov;17(11):570-2.
24. Aguiar CM, Câmara AC. Radiological evaluation of the morphological changes of root canals shaped with ProTaper for hand use and the ProTaper and RaCe rotary instruments. Aust Endod J. 2008 Dec;34(3):115-9.
25. Paqué F, Balmer M, Attin T, Peters OA. Preparation of oval-shaped root canals in mandibular molars using nickel-titanium rotary instruments: a micro-computed tomography study. J Endod. 2010 Apr;36(4):703-7.
26. Baratto Filho F, Zaitter S, Haragushiku GA, de Campos EA, Abuabara A, Correr GM. Analysis of the internal anatomy of maxillary first molars by using different methods. J Endod. 2009 Mar;35(3):337-42.
27. Kum KY, Spängberg L, Cha BY, Il-Young J, Seung-Jong L, Chan-Young L. Shaping ability of three ProFile rotary instrumentation techniques in simulated resin root canals. J Endod. 2000 Dec;26(12):719-23.
28. Hartmann MS, Barletta FB, Camargo Fontanella VR, Vanni JR. Canal transportation after root canal instrumentation: a comparative study with computed tomography. J Endod. 2007 Aug;33(8):962-5.
29. Hashem AA, Ghoneim AG, Lutfy RA, Foda MY, Omar GA. Geometric analysis of root canals prepared by four rotary NiTi shaping systems. J Endod. 2012 Jul;38(7):996-1000.
30. Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral Surg Oral Med Oral Pathol. 1971 Aug;32(2):271-5.
31. Duran-Sindreu F, García M, Olivieri JG, Mercadé M, Morelló S, Roig M. A comparison of apical transportation between FlexMaster and twisted files rotary instruments. J Endod. 2012 Jul;38(7):993-5.
32. Mounce RE. Making endo fun again: Get twisted. Dent Econom. 2008 May;98(5):23.
33. Stern S, Patel S, Foschi F, Sherriff M, Mannocci F. Changes in centring and shaping ability using three nickel–titanium instrumentation techniques analysed by micro-computed tomography (μCT). Int Endod J. 2012 Jun;45(6):514-23.
34. Diemer F, Mallet JP. An instrument innovation for initial endodontic treatment: the Revo-S® sequence. Clinic. 2008 Nov;29(11):616-20.