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Komparativno istraživanje oblikovanja četiriju rotirajućih sustava

A Comparative Study of Shaping Ability of four Rotary Systems

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Sažetak

Svrha: U ovom istraživanju analizirali smo rezno područje, vrijeme instrumentacije, održavanje anatomije korijenskog kanala i neinstrumentirana područja dobivena korištenjem instrumenata F360®, Mtwo®, RaCe® i Hyflex® u ISO veličini 35. **Materijali i metode:** Odabrano je 120 zuba s jednim ravnim kanalom i podijeljeni su u četiri grupe. Radna duljina određena je radiološki. Zubi su rezani dijamantnim diskom, a presjeci su promatrani stereoskopskim mikroskopom Nikon SMZ-2T pod svjetiljkom Intralux 4000-1. Grupe su oblikovane predoperativnom analizom AutoCAD. Zubi su rekonstruirani s pomoću K-proširivača #10 i epoksi ljepila. Svaka grupa instrumentirana je jednim od četiriju sustava. Vrijeme instrumentacije mjereno je kronometrom s točnošću od 1/100. Područja u trećinama analizirana su za očuvanje anatomije korijena AutoCAD-om 2013., neinstrumentirana područja AutoCAD-om 2013. i stereomikroskopom SMZ-2T. Statistička analiza obavljena je Lavenovim i Bonferronijevim testom, ANOVA-om i Pearsonovim hi-kvadrat testom. **Rezultati:** Ista varijanca dobivena je Lavenovim testom ($P > 0,05$). ANOVA ($P > 0,05$) nije zabilježila značajne razlike. Značajna razlika bila je u vremenu instrumentacije ($p < 0,05$). U očuvanju anatomije korijenskog kanala i u neinstrumentiranim područjima nije bilo značajne razlike među sustavima ($P > 0,05$). **Zaključci:** Uporabom svih četiriju različitih rotacijskih sustava dobivena su slična rezna područja, a sačuvana je bila i anatomija korijenskih kanala i neinstrumentiranih područja. U određivanju vremena instrumentacije statistički je bio najbrži sustav F360®.

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Uvod

Glavni cilj endodontske terapije jest dobrom obradom i trodimenzionalnim punjenjem ukloniti i spriječiti infekciju korijenskog kanala (1,2). Instrumentacijom korijenskog kanala treba se sačuvati njegova anatomija, položaj apikalnog otvora i izvorna zakrivljenost (3, 4). Jedan od velikih napredaka tijekom 80-ih godina prošlog stoljeća u području obrade korijenskih kanal bio je razvoj nikal-titanijskih legura za izradu endodontskih instrumenata (5). Rotirajući NiTi instrumenti počeli su se upotrebljavati kako bi se poboljšala obrada korijenskih kanala jer omogućuju jednostavnije i brže oblikovanje (6).

Novi instrumenti F360® (Komet Dental, Lemgo, Njemačka) imaju 4-postotni konicitet i mogu se nabaviti u veličinama 25, 35, 45 i 55. U poprečnom presjeku modificirani su u S-oblik, izrađeni su od nikal-titanijske legure i kontinuirano rotiraju u smjeru kazaljke na satu (7).

Rotirajući instrumenti Mtwo® (VDW, München, Njemačka) također na poprečnom presjeku imaju S-oblik. Njihov nizak radijalni kontakt i gotovo okomiti rezni rubovi omogućuju dobru kontrolu napredovanja instrumenta (8).

Sustav RaCe® (FKG Dentaire, La Chaux-de-Fonds, Švicarska) elektrokemijski je poliran, što poboljšava mehanički učinak. Instrumenti su na poprečnom presjeku trokutasti, a zbog naizmjeničnoga heličnoga kuta i reznih rubova gotovo

Introduction

The main purpose of endodontic treatment is to remove and prevent infection of the root canal system through good endodontic preparation and three-dimensional obturation of the canals (1, 2). The root canal instrumentation needs to preserve the existing root anatomy, the position of the apical foramen and the original curvature (3, 4). One of the greatest advances of the 1980s in the field of root canal preparation was the development of the NiTi alloy for endodontic instruments (5). Rotary NiTi instruments were introduced to improve root canal preparation because they deliver simpler, faster shaping (6).

The recent F360® files (Komet Dental, Lemgo, Germany) have a 4% taper and are available in sizes 25, 35, 45 and 55. They have a modified S cross-section, are made of NiTi, and rotate continuously in a clockwise direction (7).

Mtwo® rotary files (VDW, Munich, Germany) also have an S-shaped cross-section. Their low radial contact and almost vertical cutting edges ensure good control of the instrument's progress. Several studies assessed different characteristics of these files and confirmed their superiority compared to other systems (8).

The RaCe® system (FKG Dentaire, La Chaux-de-Fonds, Switzerland) provides electrochemical polishing, which improves their mechanical performance. The files have a trian-

usporednih s uzdužnom osi, manja je vjerojatnost blokiranja ili učinka zavrtanja (9).

Sustav Hyflex® (Coltene-Whaledent, Allstetten, Švicarska) ima sličan poprečni presjek kao i EndoSequence® (Brasseler, Savannah, SAD). Ovi nikal-titanijski instrumeni proizvode se inovativnom metodom koja omogućuje kontrolu nad memorijom materijala (10).

Cilj ovog istraživanja bio je usporediti obrađeno područje, vrijeme instrumentacije, održavanje anatomije korijenskog kanala i neinstrumentirana područja instrumentima F360®, Mtwo®, RaCe® i Hyflex® veličine 35.

Materijali i metode

Nasumično je u četiri grupe (n = 30) podijeljeno 120 izvađenih trajnih zuba. Kriteriji za odabir bili su gornji i donji središnji sjekutići s jednim ravnim korijenom i korijenskim kanalom. Pritom su odbačeni bočni sjekutići, očnjaci, pretkutnjaci i kutnjaci. Endodontski pristup omogućen je dijamantnim svrdlom uz vodeno hlađenje, te kada je otvorena pulpna komora i svrdlom Endo-Z. Radna dužina određivala se radiografski K-proširivačem #15 (Dentsply Maillefer, Ballaigues, Švicarska). Vodootpornim markerom (Paper Mate, Atlanta, SAD) povučene su dvije orijentacijske crte – vestibularno crna i oralno crvena. Korištenjem pomične mjerke s finim podešavanjem 532 Vernier (Mitutoyo America Corporation, Illinois, SAD), ovisno o dužini korijena, izračunata su i određena mjesta na korijenu gdje su i prerezani.

Korijenovi su razrezani 0,17-milimetarskim dijamantnim diskom da bi se dobili rezovi u koronarnoj, središnjoj i apikalnoj trećini. Svaka trećina promatrana je i fotografirana stereomikroskopom Nikon SMZ-2T (Nikon, Tokio, Japan) opremljenim fotoaparatom D70 m (Nikon, Tokio, Japan) te izvorom svjetlosti Intralux 4000-1 (Volpi, Schlieren, Švicarska). Zubi su rekonstruirani K-proširivačem #15 koji je umetnut kroz endodontski otvor na kruni u dijelove kanala u pojedinim trećinama.

Uz korijen obilježen vodootpornim linijama, dijelovi su mezijalno i distalno spojeni epoksi ljepilom.

Predoperativna analiza potvrdila je da su sve grupe namještene pravilno – i po trećinama i općenito. Meziodistalna širina koronarne trećine zuba #4 izmjerena je pomičnom mjerkom te je ta mjera (5 mm) uvrštena u program AutoCAD-a da bi se prije biomehaničke obrade dobio pravilan omjer veličina i područja kanala korijenskih trećina. Za statističku analizu predoperativnih površina odabran je program SPSS 18 s pouzdanošću od 95 posto (P < 0,05), Lavenovim testom procjenjivala se varijanca, a ANOVA-om su se uspoređivale aritmetičke sredine. Ako su bile pronađene značajne razlike u uzorcima, ti uzorci su izbačeni i zamijenjeni novima kako bi se grupe uravnotežile.

Prohodnost je postignuta K-proširivačem #15, a za njezino održavanje korišten je proširivač #10. U stankama između umetanja instrumenata, korijenski kanali ispirani su 5,25-postotnom otopinom natrijeva hipoklorita (NaClO) kroz bočno otvorene igle. Vrijeme instrumentacije mjerilo se

gular cross-section. Owing to their alternate helical angles and to cutting edges that are almost parallel to their longitudinal axis, there is less likelihood of blocking or screw-in effects (9).

The Hyflex® system (Coltene-Whaledent, Allstetten, Switzerland) has a similar cross-section to EndoSequence® (Brasseler, Savannah, USA). These NiTi files are manufactured by an innovative method that gives control over the material's memory (10).

The aim of this study was to compare the cutting area, instrumentation time, root canal anatomy preservation and non-instrumented areas of F360®, Mtwo®, RaCe® and Hyflex® files of size 35.

Materials and Methods

A total of 120 extracted permanent teeth were divided randomly with no preference into 4 groups (n = 30). The criteria for teeth selection were: upper and lower central incisors with a single straight root and root canal. The exclusion criteria were: lateral incisors, canines, premolars and molars.

The endodontic opening was made with a round diamond bur with water cooling, followed by the use of an Endo-Z bur once the pulp chamber was reached. The working length was calculated with digital radiographs with a #15 K-file (Dentsply Maillefer, Ballaigues, Switzerland). A black line on each vestibular side and a red line on each palatine/lingual side were drawn with indelible markers (Paper Mate, Atlanta, USA). Using a series 532 Vernier caliper with fine adjustment (Mitutoyo America Corporation, Illinois, USA), the root lengths and the points at which they were to be sectioned were calculated according to their length.

The roots were sectioned into coronal, middle and apical thirds with a handpiece and a 0.17 mm thick diamond disk. Each third was observed and photographed through a Nikon SMZ-2T stereoscopic microscope (Nikon, Tokyo, Japan) fitted with a Nikon D70 camera (Nikon, Tokyo, Japan) and an Intralux 4000-1 light source (Volpi, Schlieren, Switzerland). The teeth were reconstructed with the aid of a #10 K-file inserted through the endodontic aperture made in the crown and through the canal in each third of the root. The lines previously marked on the teeth assisted in adjusting the tooth sections, which were mesially and distally joined with epoxy glue.

A preoperative analysis confirmed that all groups were adjusted, both by thirds and generally. The mesiodistal width of the coronal third of tooth #4 was measured with the caliper and this measurement (5 mm) was entered into the AutoCAD 2013 program in order to scale up and calculate the canal areas of the radicular thirds prior to biomechanical preparation. The statistical analysis of the preoperative areas was carried out with the SPSS 18 program at a 95% confidence level ($P < 0.05$), using Levene's test to assess variances and ANOVA to compare means. If significant differences had been found, some samples would have been discarded and other added to balance the groups.

The glide path was made with a #15 K-file and used a #10 K-file for patency filing. The root canals were flushed

štopericom s točnošću od 1/100 sekunde od unošenja do vađenja instrumenata iz korijenskog kanala. Redoslijedi instrumentacijskih sljedova bili su:

1. Grupa 1: F360® 25/04 i 35/04 instrumenti pri 300 okretaja/minuti i 1,8 Ncm
2. Grupa 2: Mtwo® instrumenti u sljedećem slijedu: 10/04, 15/05, 20/06, 25/06, 30/05 i 35/04, uz 10/04 i 15/05 pri 1,3 Ncm, 20/06, 25/06 i 30/05 pri 2,3 Ncm i 35/04 pri 280 okretaja/minuti i 1,2 Ncm
3. Grupa 3: RaCe® 15/06, 25/04, 30/04 i 35/04 instrumenti pri 600 okretaja/minuti i 1,5 Ncm
4. Grupa 4: Hyflex® instrumenti u sljedećem slijedu: 25/08 (slično ProTaper® SX file (Dentsply Maillefer, Ballaigues,Švicarska)), 20/04, 25/04, 20/06, 30/04 i 35/04, pri 500 okretaja/minuti i 2,5 Ncm.

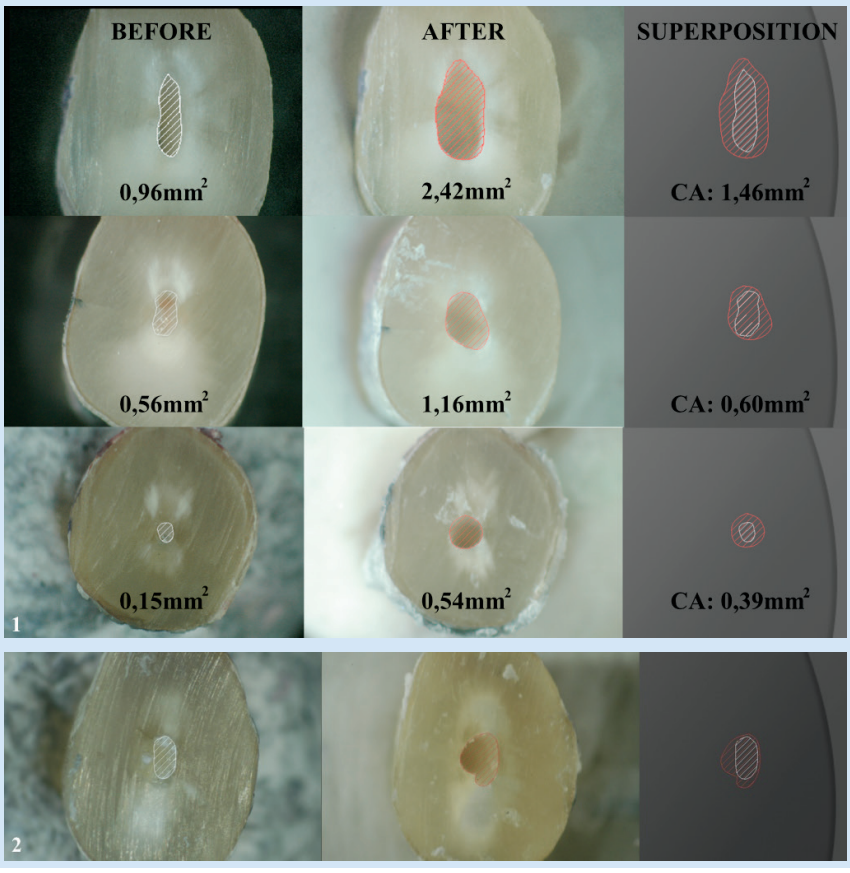
Završni protokol irigacije za sve grupe bio je: 2 mL 0,9-postotne fiziološke otopine, 17 posto etilendijamenetetratične kiseline (EDTA) tijekom jedne minute, 2 mL 0,9-postotne fiziološke otopine, 2 mL 5,25-postotne otopine NaOCl-a i 2 mL 0,9-postotne fiziološke otopine. Korjenovi su na kraju ponovno prerezani i promatrani stereomikroskopom SMZ-2T te fotografirani uz povećanje od 15 puta. Korijenski kanali ponovno su nakon biomehaničke obrade izmjereni po trećinama prema prije izračunatom omjeru. Obrađene površine kvantificirane su izračunavanjem razlike između predoperativnih i poslijeoperativnih područja (slika 1.). Održavanje anatomije korijenskog kanala proučavalo se preklapanjem predoperativnih i poslijeoperativnih područja s pomoću sustava AutoCAD-a 2013. (slika 2). Na kraju su

with 5.25% sodium hypochlorite (NaClO) between files, using a side opening syringe. The instrumentation time was measured with a 1/100 second chronometer from the moment files entered the canals until they got out. The root canal instrumentation sequences were:

1. Group 1: F360® 25/04 and 35/04 files at 300 rpm and 1.8 Ncm.
2. Group 2: Mtwo® files in the following sequence: 10/04, 15/05, 20/06, 25/06, 30/05 and 35/04, with 10/04 and 15/05 at 1.3 Ncm, 20/06, 25/06 and 30/05 at 2.3 Ncm and 35/04 at 280 rpm and 1.2 Ncm.
3. Group 3: RaCe® 15/06, 25/04, 30/04 and 35/04 files at 600 rpm and 1.5 Ncm.
4. Group 4: Hyflex® files in the following sequence: 25/08 (similar to the ProTaper® SX file (Dentsply Maillefer, Ballaigues, Switzerland)), 20/04, 25/04, 20/06, 30/04 and 35/04, at 500 rpm and 2.5 Ncm.

The final irrigation protocol for all the groups was 2 mL of 0.9% saline solution, 17% ethylenediamenetetracetic acid (EDTA) for one minute, 2 mL of 0.9% saline solution, 2 mL of 5.25% NaClO and 2 mL of 0.9% saline solution.

Lastly, the root thirds were sectioned and observed under an SMZ-2T stereoscopic microscope, taking photographs at x15 magnification. The root canal areas of each third after biomechanical preparation were measured using the scale calculated previously. The cutting areas were quantified by calculating the difference between the preoperative and postoperative areas (Figure 1). Root canal anatomy preservation was studied by superimposing the preoperative and postop-



Slika 1. AutoCAD analiza po trećinama
Figure 1 AutoCAD analysis of thirds.

Slika 2 Primjer negativnog održavanja anatomije korijenskog kanala
Figure 2 Example of negative of root canal anatomy preservation.

neinstrumentirana područja promatrana stereomikroskopom Nikon SMZ-2T pod povećanjem od 15 puta te potvrđena sustavom AutoCAD-a 2013.

Za statističku obradu s normalnom distribucijom korišten je program SPSS 18 s 95-postotnom granicom pouzdanosti (P < 0,05), procjena varijance obavljena je Levenovim testom, a ANOVA-om su uspoređene aritmetičke sredine obrađenih površina i vrijeme instrumentacije. Tijekom instrumentacije korišteni su Levenov i Bonferronijev test, te ANOVA. Za mjerenje očuvanosti anatomije korijenskog kanala i neobrađene površine korišten je Pearsonov hi-kvadrat test.

Rezultati

Tablica 1. pokazuje aritmetičke sredine površina prije instrumentacije i uklonjene površine (mm²). U tablici 2. nalazi se statistička analiza područja. Tablica 3. pokazuje aritmetičke sredine vremena instrumentacije (s) i statističku analizu.

erative areas with AutoCAD 2013 system (Figure 2). Finally, non-instrumented areas were observed with Nikon SMZ-2T stereoscopic microscope at x15 magnification and confirmed with AutoCAD 2013 system.

The SPSS 18 program at a 95% confidence level (P < 0.05) was used for statistical analysis with normality of distribution, using Levene's Test to assess variances and ANOVA to compare means of the cutting area and instrumentation time. For the instrumentation time Levene´s Test, ANOVA and Bonferroni Test were used. For root canal anatomy preservation and non-instrumented areas, Pearson´s Chi-square Test was used.

Results

Table 1 shows the means of pre-instrumentation and cutting areas (mm²). Table 2 shows the statistical analysis of the areas. Table 3 shows the means of instrumentation time (s) and the statistical analysis. Table 4 shows the percentages of

Tablica 1. Aritmetičke sredine površina prije instrumentacije i uklonjenih površina (mm²)
Table 1 Means of preinstrumentation and cutting areas (mm²).

		Prije instrumentacije • Preinstrumentation		Uklonjena površina • Cutting area	
Trećine • Third	Sustav • System	Ar. sred.±SD • Mean±SD	Min-maks • Min-Max	Ar. sred.±SD • Mean±SD	Min-maks • Min-Max
Koronarna • Coronal	F360	1.04±0.22	0.82-1.26	1.54±0.32	1.23-1.85
	Mtwo	1.08±0.20	0.88-1.28	1.62±0.33	1.29-1.95
	RaCe	1.09±0.25	0.84-1.34	1.65±0.27	1.38-1.92
	Hyflex	1.22±0.27	0.95-1.49	1.58±0.22	1.36-1.80
Srednja • Middle	F360	0.67±0.16	0.51-0.83	0.45±0.09	0.36-0.54
	Mtwo	0.59±0.10	0.49-0.69	0.55±0.10	0.45-0.65
	RaCe	0.55±0.12	0.43-0.67	0.47±0.05	0.42-0.52
	Hyflex	0.52±0.10	0.42-0.62	0.55±0.09	0.46-0.64
Apikalna • Apical	F360	0.29±0.07	0.22-0.36	0.29±0.09	0.20-0.38
	Mtwo	0.29±0.07	0.22-0.36	0.37±0.05	0.32-0.42
	RaCe	0.22±0.04	0.18-0.26	0.37±0.06	0.31-0.43
	Hyflex	0.24±0.04	0.20-0.28	0.39±0.06	0.33-0.45
Općenito • Global	F360	0.67±0.11	0.56-0.78	0.76±0.16	0.60-0.94
	Mtwo	0.66±0.11	0.55-0.77	0.85±0.16	0.69-1.01
	RaCe	0.62±0.12	0.50-0.74	0.83±0.15	0.68-0.98
	Hyflex	0.66±0.13	0.53-0.79	0.84±0.13	0.71-0.97

Tablica 2. Statistička analiza područja
Table 2 Statistical analysis of areas.

	Prije instrumentacije • Preinstrumentation		Uklonjeno područje • Cutting area	
Trećine • Third	Levene	ANOVA	Levene	ANOVA
Koronarna • Coronal	0.128	0.718	0.381	0.953
Srednja • Middle	0.100	0.318	0.126	0.201
Apikalna • Apical	0.166	0.199	0.509	0.159
Ukupno • Global	0.736	0.948	0.782	0.839

Tablica 3. Aritmetičke sredine vremena instrumentacije (s) i statistička analiza
Table 3 Means of instrumentation time (s) and statistical analysis.

Sustav • System	Vrijeme • Time	Leveneov test • Levene´s Test	ANOVA	Bonferronijev test • Bonferroni
F360 (F)	27.23	0.095	0.018	F vs M 0.011*
Mtwo (M)	58.76			F vs R 0.035*
RaCe (R)	46.53			F vs H 0.010*
Hyflex (H)	60.45			M vs R 0.033*
				M vs H 0.097
				R vs H 0.028*

* značajna razlika – P < 0,05 • Significant differences – *P* < 0.05

Tablica 4. Održavanje anatomije korijenskog kanala, neinstrumentirana područja (%) i statistička analiza
Table 4 Root canal anatomy preservation and non-instrumented areas (%) and statistical analysis.

	Korišteni sustav • Preparation system	Koronarna • Coronal	Srednja • Middle	Apikalna • Apical	Ukupno • Global
Održavanje anatomije korijenskog kanala • Root canal anatomy preservation	F360	93.33	90	100	94.44
	Mtwo	100	96.67	100	98.89
	RaCe	96.67	93.33	96.67	95.56
	Hyflex	96.67	96.67	100	97.78
	hi-kvadrat • Chi-square	0.558	0.644	0.388	0.328
Neinstrumentirana područja • Non-instrumented areas	F360	13.33	13.33	0	8.89
	Mtwo	3.33	13.33	6.67	7.78
	RaCe	3.33	3.33	0	2.22
	Hyflex	10	6.67	0	5.56
	hi-kvadrat • Chi-square	0.356	0.440	0.107	0.254

U tablici 4. su postotci zuba i statistička analiza očuvanja anatomije korijenskih kanala i neobrađenih područja.

Tijekom istraživanja nije puknuo ni jedan instrument.

Kad je riječ o površinama prije instrumentacije, nije bilo značajnih razlika među grupama, što potvrđuje da su bile stabilne (p > 0,05, tablica 2.). U područjima obrađenima sustavom RaCe® bilo je uklonjeno više površina (1,65 ± 0,27mm²) u koronarnoj trećini negoli s ostalim sustavima; sustavima Mtwo® i Hyflex® uklonjena je ista površina u središnjoj trećini s malom graničnom razlikom devijacije (0,55 ± 0,10 mm² i 0,55 ± 0,09 mm²); u apikalnoj trećini sustav Hyflex® ostvario je 0,39 ± 0,0 6 mm². Ukupno je Mtwo® bio bolji od ostalih sustava (0,85 ± 0,16 mm²) (tablica 1.). U uklonjenim površinama, kao i prije instrumentacije, nije pronađena značajna razlika među sustavima (P > 0,05, tablica 2.).

U brzini instrumentacije najbrži je bio sustav F360® (27,23 s), a Hyflex® najsporiji (60,45 s). Među svim sustavima nije bilo značajne razlike (P < 0,05, tablica 3.), osim između Mtwoa® i Hyflexa® (P > 0,05, tablica 3.).

U očuvanju anatomije korijenskog kanala sustavom Mtwo® postignuti su bolji rezultate negoli s ostalim sustavima u koronarnoj trećini (100 %), sustavima Mtwo® i Hyflex® u središnjoj trećini (96,67 %), te sustavima F360®, Mtwo® i Hyflex® u apikalnoj trećini (100 %). Nije nađena značajna razlika (P > 0.05, tablica 4.).

U mjerenju neinstrumentiranih područja sustavima Mtwo® i RaCe® ostvaren je najmanji postotak u koronarnoj trećini (3,33 %), sustavom RaCe® u središnjoj (3,33 %), a sustavima F360®, RaCe® i Hyflex® u apikalnoj trećini (0 %). Nije nađena značajna razlika (P > 0,05, tablica 4.).

Rasprava

Streromikroskopom SMZ-2T i AutoCAD-om 2013. uspoređena su četiri instrumentacijska sustava istog koniciteta, veličine i rotacijskih pokreta, ali različita po dizajnu, broju instrumenata, brzini i okretnom momentu. Provjeravala su se i uspoređivala obrađena područja, očuvanje anatomije korijenskih kanala i neinstrumentirana područja. Posljednjih godina su autori nekoliko istraživanja istaknuli da su dobili različite rezultate za sustave instrumentacije. Semaan i suradnici (11) objavili su 2009. članak o evoluciji rotirajućih sustava za instrumentacije, uz objašnjenje pojedinih

teeth and the statistical analysis of the root canal anatomy preservation and non-instrumented areas. No files were fractured during the study.

With respect to the pre-instrumentation areas, there were no significant differences between the four groups, determining that the groups were stabilized (P > 0.05, Table 2). Regarding the cutting area, RaCe® made a higher cutting area (1.65±0.27mm²) than the other systems in the coronal third, Mtwo® and Hyflex® made the same cutting area in the middle third with a small difference in the margin of error (0.55±0.10mm² and 0.55±0.09mm²), in the apical third it was Hyflex® (0.39±0.06mm²). On the whole, Mtwo® was better than the other systems (0.85±0.16mm²) (Table 1). Similarly to the pre-instrumentation areas, no significant differences were found between the systems (P > 0.05, Table 2).

Regarding the instrumentation time, F360® was the fastest system (27.23s) and Hyflex® was the slowest (60.45s), and there were significant differences between all systems (P < 0.05, Table 3) except Mtwo® with Hyflex® (P > 0.05, Table 3).

For root canal anatomy preservation, Mtwo® had a higher percentage than the other systems in the coronal third (100%), Mtwo® and Hyflex® in the middle third (96.67%) and F360®, Mtwo® and Hyflex® in the apical third (100%). However, there were no significant differences (P > 0.05, Table 4).

For non-instrumented areas, Mtwo® and RaCe® achieved the smallest percentage in the coronal third (3.33%), RaCe® in the middle third (3.33%) and F360®, RaCe® and Hyflex® in the apical third (0%). Nevertheless, no significant differences were found (P > 0.05, Table 4).

Discussion

Using an SMZ-2T stereoscopic microscope and the AutoCAD 2013 system, the effects of four present-day instrumentation systems that had the same taper, size and rotation motion but differed in their designs, numbers of files, speeds and torques were compared in the cutting area, preservation of the root canal anatomy and non-instrumented areas.

In recent years, several studies have examined the different results of instrumentation systems. In 2009, Semaan et al. (11) published a paper on the evolution of rotary instrumentation systems, explaining the individual characteristics

svojstava, tehnike oblikovanja i načina rada Nabrojili su i prednosti te nedostatke svakog sustava i načine kako ispraviti pogreške.

U ovom istraživanju proučavali smo uklonjenu površinu, održavanje anatomije korijenskog kanala te neinstrumentirane površine korištenjem četiriju različitih rotacijskih sustava (F360®, Mtwo®, RaCe® i Hyflex®) jednakih veličina i koniciteta.

Procjena instrumentacije može se obavljati na plastičnim blokovima ili izvađenim ljudskim zubima. Plastični blokovi ne odražavaju djelovanje rotacijskih instrumenata kao izvađeni ljudski zubi jer ih može omekšti toplina koju stvaraju instrumenti (12, 13). Zato su za ovo istraživanje odabrani izvađeni ljudski zubi.

Godinma su se znanstvenici koristili različitim metodama za procjenu učinka instrumentacije kanala rotirajućim sustavima. Ove metode uključuju AutoCAD, mikrokompjutoriziranu tomografija (μ-CT), radiološke slike i fotografije snimljene elektronskim ili stereomikroskopom (12, 14, 15). U ovom istraživanju korišten je stereomikroskop Nikon SMZ-2T i sustav AutoCAD 2013. jer su fotografije dovoljno visoke rezolucije i točnosti da se mogu iskoristiti u AutoCAD-u koji upotrebljavaju i arhitekti za osmišljavanje zgrada i njihovih struktura.

Mnogi istraživači koristili su se AutoCAD-om za proučavanje različitih parametara. Tako su Günday i suradnici (16) procjenjivali okretni moment (tork) i ciklički zamor, Kim i njegovi kolege (17) upotrijebili su ga za izračun zakrivljenosti korijena, a Durán-Sindreu i njegov tim (18) za promatranje transportacije apeksa. Grande i suradnici su (19) AutoCAD-om 2000 uspoređivali EndoEZE AET® (Ultradent, South Jordan, SAD) i ProTaper® te su zaključili da postoje značajne razlike u koronarnoj i središnjoj trećini, ali ne i u apikalnoj. Al-Manel i njegovi kolege (20) proučavali su rad sustava Twisted Files® (SybronEndo, Orange, Kanada) i Profile GTX® (Dentsply Maillefer, Ballaigues, Švicarska) u zakrivljenim kanalima te istaknuli kako nema značajnih razlika. U našem istraživanju korišten je sustav AutoCAD 2013. za procjenu uklonjenih područja i očuvanje anatomije korijenskih kanala različitih sustava, ali za razliku od Grandea i suradnika, zaključili smo da nema značajnih razlika, baš kao što su to učinili i Al-Manel i suradnici. Zabilježili smo i visok postotak očuvanja anatomije korijenskog kanala.

Prema našim rezultatima u uklonjenom području (tablica 1.), sustav RaCe® imao je najveću srednju vrijednost u koronarnoj trećini – 1,65 ± 0,27 mm^2, Mtwo® je postigao 1,62 ± 0,33 mm^2, Hyflex® 1,5 8 ± 0,22 mm^2, a F360® 1,54 ± 0,32 mm^2. Mtwo® i Hyflex® ostvarili su gotovo iste srednje vrijednosti – u središnjoj trećini 0,55 ± 0,10 mm^2 i 0,55 ± 0,09 mm^2, uz jedinu razliku u standardnoj devijaciji. U ovoj središnjoj trećini sustavom F360® ostvareno je 0,45 ± 0,09 mm^2, a RaCeom® 0,47 ± 0,05 mm^2. U apikalnoj trećini Hyflex® je bio najbolji sa srednjom vrijednošću od 0,39 ± 0,06mm^2, slijedi F360® s 0,29 ± 0,09 mm^2, te Mtwo® s 0,37 ± 0,05 mm^2 i RaCe® s 0,37 ± 0,06 mm^2. U zadnjem mjerenom svojstvu sustav Mtwo® ukupno je imao najvišu srednju vrijednost (0,85 ± 0,16 mm^2), a F360® najnižu (0,76 ± 0,16 mm^2), RaCe® je imao 0,83 ± 0,15 mm^2, a Hyflex® 0,84 ± 0,13 mm^2.

of each, the shaping techniques, modes of action and advantages and disadvantages of each system, and the error correction methods. In the present study, the cutting area, root canal anatomy preservation and non-instrumented areas were investigated in 4 different rotary systems (F360®, Mtwo®, RaCe® and Hyflex®) with a common size and taper.

The instrumentation achieved with the different rotary systems can be assessed in resin blocks or extracted human teeth. However, resin blocks do not reflect the action of the rotary systems in the same way as extracted human teeth, as the heat generated by the instruments can soften the resin (12, 13). Therefore, extracted human teeth were used for this study.

Over the years, researchers have used different methods to assess the root canal instrumentation effected by rotary systems. These methods include AutoCAD, micro-computed tomography (μ-CT), X-rays and photographs taken with a stereoscopic light microscope or an electronic microscope (12, 14, 15). In the present study, a Nikon SMZ-2T stereoscopic microscope and the AutoCAD 2013 system were used because the pictures have high quality and the measurements are accurate and even architects use AutoCAD system to design buildings and structures.

A number of researchers have used AutoCAD to study different parameters. Günday et al. (16) used AutoCAD to assess torque and cyclic fatigue, Kim et al. (17) to calculate root curvature, and Durán-Sindreu et al. (18) to study apical transportation. Grande et al. (19) used AutoCAD 2000 to compare the EndoEZE AET® (Ultradent, South Jordan, USA) and ProTaper®, and they found significant differences in the coronal and middle thirds, but not in the apical third. Al-Manel et al. (20) examined Twisted Files® (SybronEndo, Orange, CA) and Profile GTX® (Dentsply Maillefer, Ballaigues, Switzerland) systems in curved canals and found no significant differences. In the present study, the AutoCAD 2013 system was used to assess the cutting area and root canal anatomy preservation of different systems, and unlike Grande et al., we determined the absence of significant differences similar to Al-Manel et al. and high root canal anatomy preservation percentages.

Regarding the results in the cutting area (Table 1), RaCe® obtained the highest mean, 1.65±0.27mm^2, in coronal third but, Mtwo® got 1.62±0.33mm^2, Hyflex® 1.58±0.22mm^2 and F360® 1.54±0.32mm^2. Mtwo® and Hyflex® obtained the same mean in middle third, 0.55±0.10mm^2 and 0.55±0.09mm^2 respectively, the only difference was the margin of error. In this third, F360® made 0.45±0.09mm^2 and RaCe® 0.47±0.05mm^2. In apical third, Hyflex® was the best with a mean of 0.39±0.06mm^2. In this third, F360® realized 0.29±0.09mm^2, Mtwo® 0.37±0.05mm^2 and RaCe® 0.37±0.06mm^2. In the last point, Mtwo® got the highest mean and F360® the lowest mean globally, 0.85±0.16mm^2 and 0.76±0.16mm^2 respectively, and RaCe® obtained 0.83±0.15mm^2 and Hyflex® 0.84±0.13mm^2.

In the same way as in our study, Talati et al. (21) used the AutoCAD system to compare instrumentation systems, in this case RaCe® and Mtwo® in curved canals, and they observed better cleaning of the canals by Mtwo® with significant

Kao i mi, i Talati i suradnici (21) koristili su se AutoCAD-om za usporedbu instrumentacijskih sustava, u ovom slučaju sustavima RaCe® i Mtwo® u zakrivljenim kanalima u kojima su uočili bolje čišćenje kanala sustavom Mtwo® sa značajnom razlikom. Sadeghi (22) je u svojem istraživanju radiološki usporedio Mtwo®, FlexMaster® i K-Flexofile u akrilatnim blokovima sa zakrivljenim kanalima 1, 3, 5, 7 i 9 milimetara od vrška. Pritom je pronašao značajnu razliku između unutarnjeg i vanjskog zakrivljenja svih sustava, osim FlexMastera® pri 9 mm i K-Flexofilea pri 5 mm od vrška. Yang i suradnici (23) usporedili su ProTaper® i Mtwo® s pomoću µ-CT u zubima sa zakrivljenim kanalima, no nisu pronašli značajnu razliku. Herrero Moraes i njegovi kolege (24) obavili su istraživanje na sustavima ProTaper®, Mtwo® i K3® s pomoću mjerenja izbrušenog materijala analitičkom vagom (Bioprecisa, São Paulo, Brazil) u gramima. Rezultati su pokazali značajnu razliku, pa su zaključili da je ProTaper® najbolji sustav. Bürklein i suradnici (25) usporedili su svojstvo oblikovanja i učinkovitost čišćenja sustava Wave One® (Dentsply Maillefer, Ballaigues, Švicarska) i Reciproc® (VDW Dental, München, Njemačka) sa sustavima ProTaper® i Mtwo®, a pritom su se koristili različitim veličinama i skening elektronskim mikroskopom. Zaključili su da su značajne razlike nastale u apikalnoj trećini te da Mtwo® nije bolji od ostalih sustava kad je riječ o obrađenoj površini, što su dokazali stereomikroskopom Nikon SMZ-2T i AutoCAD-om. Površinu su izraačunavali u kvadratnim milimetrima poput Talatija i suradnika, umjesto radiološki, analitičkom vagom ili µ-CT-om.

Marceliano-Alves i suradnici (26) usporedili su Hyflex® s Reciprocom®, Wave Oneom® i Twisted Filesom® s pomoću µ-CT-a i nisu pronašli značajne razlike. Zhao i njegovi kolege (27) objavili su istraživanje u kojem su usporedili Hyflex®, Twisted Files® i K3® (SybronEndo, Orange, Kanada) s pomoću µ-CT-a, a zaključak i je bio isti kao Marceliano-Alvesov i naš. No mi smo se tijekom ispitivanja uklonjenoga obrađenog područja koristili stereomikroskopom Nikon SMZ-2T i AutoCAD-om (mm^2) umjesto µ-CT-om (mm^2) .

Mi smo, uspoređujući instrumente istog 0,04 koniciteta (F360®, Mtwo®, RaCe® i Hyflex®) dobili rezultate kao Fayyad i suradnici (28) koji nisu pronašli značajnu razliku u promjenama volumena nakon korištenja sustava One Shape® (MicroMega, Besançon, Francuska), ProTaper® i TF Adaptive® s istim 0,06 konicitetom mjereći kompjutorskom tomografijom, premda smo se mi za mjerenje koristili drukčijim sustavom.

Vrijeme instrumentcije važno je u endodontskoj terapiji jer, ako se ono skrati, doktor dentalne medicine ima više vremena za dezinfekciju irigantom. U ovom segmentu je F360® bio najbrži sa središnjom vrijednosti od 27,23 sekunde, Hyflex® je bio najsporiji – 60,45 sekundi, Mtwo je postigo 58,76 sekundi, a RaCe 46,53 sekunde (tablica 3.).

Bürklein i suradnici (29) usporedili su vrijeme instrumentacije za Hyflex®, Mtwo i Revo-S® (MicroMega, Besançon, Francuska). Autori su zaključili da postoji značajna razlika u usporedbi sustava Hyflex® i Mtwo® sa sustavom Revo-S®, ali nisu našli značajnu razliku između Hyflexa® i Mtwoa. Saber i njegovi kolege (30) proučavali su vrijeme instrumentacije za Wave One, Reciproc® i One Shape. Istaknuli differences. In another study, Sadeghi (22) compared Mtwo®, FlexMaster® and K-Flexofile by X-ray in resin blocks with curved canal at 1, 3, 5, 7 and 9mm of apex. In results, significant differences were found between the inner curve and the outer curve to all systems, except FlexMaster® at 9mm and K-Flexofile at 5mm of apex. Yang et al. (23) contrasted ProTaper® and Mtwo® with µ-CT in teeth with curved canals, and found no significant differences. In turn, Herrero Moraes et al. (24) published an investigation of ProTaper®, Mtwo® and K3® using an analytical balance (Bioprecisa, São Paulo, Brasil) which calculated the cutting area in grams. The results showed significant differences and concluded that ProTaper® was the best system. Bürklein et al. (25) compared the shaping ability and cleaning effectiveness of Wave One® (Dentsply Maillefer, Ballaigues, Switzerland) and Reciproc® (VDW Dental, München, Germany) in comparison to ProTaper® and Mtwo®, using different sizes with scanning electron microscopy, and they found significant differences in the apical third. In contrast, Mtwo® was not better than the other systems in this study, no significant differences were found in cutting area compared to Yang et al., using Nikon SMZ-2T stereoscopic microscope and AutoCAD system that calculated the cutting area in mm^2 like Talati et al., instead of X-ray, analytical balance or µ-CT.

Moreover, Marceliano-Alves et al. (26) compared Hyflex® with Reciproc®, Wave One® and Twisted Files® using µ-CT, and they did not find significant differences for all systems. Zhao et al. (27) published a study in which Hyflex®, Twisted Files® and K3® (SybronEndo, Orange, CA) were compared with µ-CT, and they reached similar conclusions as Marceliano-Alves et al. and us, but Nikon SMZ-2T stereoscopic microscope and AutoCAD system (mm^2) were used in this investigation to examine the cutting area instead of µ-CT (mm^2).

In addition, on comparing the instruments with the same 0.04 taper (F360®, Mtwo®, RaCe® y Hyflex®), we achieved the same results as Fayyad et al. (28) who observed an absence of significant differences on comparing changes in volume using One Shape® (MicroMega, Besançon, France), ProTaper® and TF Adaptive® with the same 0.06 taper with computed tomography, although we used other systems.

On the other hand, the instrumentation time is important when the endodontic treatment is performed, because if this time is reduced, the dentist will have more time to disinfect with irrigants. In this section, F360® was the fastest system with 27.23s of mean, Hyflex® got 60.45s, the slowest system, and Mtwo and RaCe obtained 58.76s and 46.53s respectively (Table 3). Bürklein et al. (29) compared the instrumentation time of Hyflex®, Mtwo and Revo-S® (MicroMega, Besançon, France). The authors found significant differences with Hyflex® and Mtwo® versus Revo-S®, but they did not find significant differences between Hyflex® and Mtwo®. Saber et al. (30) examined the instrumentation time of Wave One®, Reciproc® and One Shape®. In turn, the authors found significant differences between Reciproc® and Wave One®, and One Shape® versus Reciproc® and Wave One®. In our results, we also observed significant differences between all systems except Mtwo® versus Hyflex®.

su značajnu razliku između Reciproca® i Wave Onea, te One Shapea® u usporedbi sa sustavima Reciprou® i Wave One. Mi smo također smo zabilježili značajnu razliku između svih sustava, osim između Mtwoa® i Hyflexa.

Očuvanje anatomije korijenskog kanala vrlo je važno za trodimenzionalno punjenje i za uspješnost endodontske terapije. Prema našim rezultaimta Mtwo® je najdosljedniji sustav i postigao je 98,89 posto, za razliku od F360® – postigao je 94,44 posto, RaCe® – 95,56 posto i Hyflex® – 97,78 posto (tablica 4.). Yoo i suradnici (31) objavili su istraživanje u kojemu su usporedili Reciproc, Wave One, ProTaper, Profile i K-proširivače, preklapanjem mikroskopske slike prije instrumentacije i poslije toga postupka. Pri usporedbi nisu pronašli značajnu razliku u očuvanju anatomije korijenskog kanala. U našoj usporedbi s drugim sustavima pronađen je visok postotak očuvanja anatomije, no ne i značajna razlika među svim sustavima, kao što to ističu Yoo i suradnici.

Uspjeh endodontske terapije može biti ugrožen ako nakon instrumentacije u kanalu ostanu neinstrumentirana područja. U našem istraživanju je sustav RaCe® s ukupnih 2,22 posto bio najbolji, F360® imao je najveći postotak – 8,89 %, a slijede Mtwo® – 7,78 % i Hyflex® – 5,56 % (tablica 4.). Paqué i suradnici (32) usporedili su na µ-CT-u ProTaper® s tri različita oblika H-pilica i pronašli visok postotak neinstrumentiranih područja, što se razlikuje od naših rezultata – mi smo istaknuli da su postotci vrlo niski i bez značajnih razlika.

Na kraju, sva četiri rotirajuća sustava uklonila su sličnu površinu, podjednako su sačuvala anatomiju korijenskog kanala te su i statistički imala slične iznose za neinstrumentirane površine. Statistički je najbrži bio sustav F360®.

Zahvale

Zahvaljujemo na stipendiji UBK-ANEO-u, te tvrtkama VDW, Komet Dental, Endovations-FKG Dentaire i Coltene koje su nam osigurale instrumente.

Sukob interesa

Nije bilo sukoba interesa.

Root canal anatomy preservation is very important for three-dimensional obturation and for the success of the endodontic treatment. Regarding our results, Mtwo® was the most constant system obtaining a percentage of 98.89%. In contrast, F360®, RaCe® and Hyflex® obtained lower percentages: 94.44%, 95.56% and 97.78% respectively (Table 4). Yoo et al. (31) published a study in which they compared Reciproc®, Wave One®, ProTaper®, Profile® and K-files, by superimposing the preoperative and postoperative images with microscope, and they did not find any significant differences in root canal anatomy preservation on comparing. In the present study with other systems, high percentages of preservation and no significant differences were found for all the systems examined similarly to Yoo et al.

The success of the endodontic treatment can be jeopardized if the canal instrumentation leaves non-instrumented areas. In this investigation, RaCe® obtained 2.22% overall, the best percentage. However, F360® got the highest percentage on the whole, 8.89%, and Mtwo® and Hyflex® obtained 7.78% and 5.56% respectively (Table 4). Paqué et al. (32) compared ProTaper® with 3 different shapes and H-files using µ-CT. The authors found high percentages of non-instrumented areas, but in our results all the systems obtained very low percentages and there were no significant differences.

In conclusion, the four different rotary systems produced similar cutting area, root canal anatomy preservation and non-instrumented areas statistically. F360® was the fastest system statistically.

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Conflict of interest

None declared

Abstract

Purpose: This study compared the cutting area, instrumentation time, root canal anatomy preservation and non-instrumented areas obtained by F360®, Mtwo®, RaCe® and Hyflex® files with ISO size 35. **Material and Methods:** 120 teeth with a single straight root and root canal were divided into 4 groups. Working length was calculated by using X-rays. The teeth were sectioned with a handpiece and a diamond disc, and the sections were observed with Nikon SMZ-2T stereoscopic microscope and an Intralux 4000-1 light source. The groups were adjusted with a preoperative analysis with AutoCAD. The teeth were reconstructed by a #10 K-File and epoxy glue. Each group was instrumented with one of the four file systems. The instrumentation time was calculated with a 1/100 second chronometer. The area of the thirds and root canal anatomy preservation were analyzed with AutoCAD 2013 and the non-instrumented areas with AutoCAD 2013 and SMZ-2T stereoscopic microscope. The statistical analysis was made with Levene's Test, ANOVA, Bonferroni Test and Pearson´s Chi-square. **Results:** Equal variances were shown by Levene's Test ($P > 0.05$). ANOVA ($P > 0.05$) showed the absence of significant differences. There were significant differences in the instrumentation time ($P < 0.05$). For root canal anatomy preservation and non-instrumented areas, there were no significant differences between all systems ($P > 0.05$). **Conclusions:** The 4 different rotary systems produced similar cutting area, root canal anatomy preservation and non-instrumented areas. Regarding instrumentation time, F360® was the fastest system statistically.

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