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IZVORNI ZNANSTVENI RAD
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Procjena učinkovitosti eteričnih ulja u otapanju štapića od gutaperke u sustavu ProTaper Universal

Evaluation of Capacity of Essential Oils in Dissolving ProTaper Universal Gutta-Percha points

Zavod za protetiku te oralnu i maksilofacijalnu kirurgiju Stomatološkog fakulteta Federalnog sveučilišta Pernambuco, Recife, Brazil
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Sažetak

Cilj: Za uklanjanje materijala za punjenje iz korijenskih kanala mogu se upotrijebiti otapala. Svrha ovog istraživanja *in vitro* bila je procijeniti i usporediti učinkovitost formuliranog narančina ulja, narančina ulja i formuliranog eukaliptola u otapanju štapića gutaperke F3 ProTaper Universal. **Materijal i metode:** Korišteno je 200 uzoraka podijeljenih u četiri skupine – po 50 uzoraka za svako otapalo. Uzorci su izvagani na analitičkoj vagi prije izlaganja otapalu i zatim stavljeni na satna stakla dimenzije 7 x 45 mm koja su uronjena u otopine u sljedećim vremenskim intervalima: 5, 10, 20, 25 i 30 minuta. Gubitak mase praćen je vaganjem nakon svake minute djelovanja otapala na štapiće. Podatci su statistički obrađeni Kruskal-Wallisovim testom na razini značajnosti od pet posto. **Rezultati:** Sva otapala u prvih pet minuta djelovanja imala su najveću snagu otapanja. Ksilol (kontrolna skupina) je pokazao znatno veću učinkovitost u otapanju u usporedbi s ostalim otapalima, uz statistički značajne razlike. U svim skupinama zabilježen je kontinuirani učinak otapanja. Formulirano narančino ulje bilo je učinkovitije u otapanju u odnosu prema narančinu ulju i formuliranom eukaliptolu, no nije bilo statistički značajne razlike. **Zaključak:** S obzirom na dobivene rezultate i primijenjenu metodologiju, može se zaključiti da je ksilol bio najučinkovitiji u otapanju štapića gutaperke, a slijedili su formulirano narančino ulje te narančino ulje i formulirano eukaliptusovo ulje.

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Ključne riječi
korijenski kanal, liječenje; gutaperka; otapala; ksileni; eterična ulja; narančino ulje; eukaliptusovo ulje

Uvod

Glavni uzrok neuspjeha endodontske terapije jest perzistencija infekcije u sustavu korijenskog kanala ili u periradikularnom području (1). Kada primarno endodontsko liječenje ne uspije, indicirana je endodontska revizija (2). Ključ uspješne revizije jest, osim temeljitog čišćenja kanalnog sustava od inficiranog sadržaja, i učinkovito uklanjanje materijala za punjenje (3). Organska otapala kemijski su spojevi kojima se koristimo kao pomoćnim sredstvima za uklanjanje materijala za punjenje iz korijenskog kanala (4, 5, 6).

Učinkovitost različitih organskih otapala u otapanju različitih materijala za punjenje korijenskog kanala istraživana je u uvjetima *in vitro* (5, 6, 7).

Pokazalo se da ksilol otapa većinu materijala za punjenje korijenskog kanala, ali sumnja se da ima kancerogeno i citotoksično djelovanje (7). Eterična ulja, kao što su narančino i eukaliptusovo ulje, navode se kao sigurnija i djelotvornija u tu svrhu (5, 8, 9).

Trenutačno nema istraživanja koja pokazuju učinkovitost tih otapala na štapiće gutaperke F3 ProTaper Universal. Stoga je svrha ovog istraživanja bila usporediti i vrjednovati učinkovitost različitih otapala, kao što su formulirano narančino

Introduction

The major cause of failure of root canal treatment is the persistence of microbial infection in the root canal system and/or in the periradicular region (1). When the primary treatment fails, a non-surgical endodontic retreatment is indicated (2). The key to successful endodontic retreatment is to thoroughly debride the canal system of infected or necrotic pulp tissue and microorganisms and to efficiently remove the filling materials from the root canal system (3). Organic solvents are chemical compounds which have been shown to aid in removal of the root canal filling materials (4, 5, and 6).

The effectiveness of different organic solvents against various types of root canal filling materials has been shown in some i*n vitro* studies (5, 6, and 7).

Xylol has been shown to dissolve the root filling materials most effectively but it was reported to have carcinogenic potential and toxicity to tissues (7). Essential oils, such as orange oil and eucalyptus oil, have been reported to be safe and useful for this purpose (5, 8, and 9).

Currently, there are no studies which show the effectiveness of these solvents on F3 ProTaper Universal Gutta-percha points. Hence, the purpose of this study was to compare

ulje te narančino ulje i formulirani eukaliptol u otapanju štapića gutaperke F3 ProTaper Universal.

Materijali i metode

Provedeno je komparativno laboratorijsko istraživanje u kojemu je korištena jedna vrsta štapića gutaperke, tj. F3 gutaperke iz sustava ProTaper Universal™ (Dentsply Maillefer, Ballaigues, Švicarska) unutar roka trajanja. Korišteno je 200 uzoraka koji su nasumično podijeljeni u četiri skupine – po 50 za svako otapalo (tablica 1.). Formulirano narančino ulje (Oleo de Laranja, Phormula Ativa, Recife, Brazil), narančino ulje (Citrol, Biodinamica, Ibipora, Brazil) i formulirani eukaliptol (Eucaliptol, Nectar Plus, Campina Grande, Brazil) ispitani su kao otapala u usporedbi sa ksilolom (Xileno PA, ISOFAR, Duque de Caxias, Brazil) (kontrolna skupina). Nakon toga, štapići su izvagani na analitičkoj vagi (AUY120, Shimadzu, Japan), a vrijednosti su zabilježene na četiri decimalna mjesta kako bi se izmjerila početna masa svakog uzorka prije djelovanja otapala. Zatim je svaki štapić gutaperke stavljen na satno staklo dimenzije 7 x 45 mm koje je uronjeno u pokusnu otopinu na sobnoj temperaturi sa sljedećim vremenskim intervalima: 5, 10, 20, 25 i 30 minuta.

and asses the dissolving efficacy of various endodontic solvents such as formulated orange oil, orange oil and formulated eucalyptol on F3 ProTaper Universal Gutta-percha points.

Materials and methods

This was a comparative and laboratory study employing one commercial brand of F3 ProTaper Universal™ gutta-percha points (Dentsply Maillefer, Ballaigues, Switzerland), within expiration date. Two-hundred samples were randomly divided into four experimental groups and further subdivided in fifty samples for each solvent (Table 1). Formulated orange oil (Oleo de Laranja, Phormula Ativa, Recife, Brazil), orange oil (Citrol, Biodinamica, Ibiporã, Brazil) and formulated eucalyptol (Eucaliptol, Nectar Plus, Campina Grande, Brazil) were tested as solvents and compared with xylol (Xileno PA, ISOFAR, Duque de Caxias, Brazil) – (control group). After that, the points were weighed on an analytical balance (AUY120, Shimadzu, Japan) and the values were recorded considering four decimal places after the decimal point to identify the baseline weights of each specimen prior to solvent action. Subsequently, each gutta-percha point was put onto watch glass, 7X45mm in length, which was immersed into experimental solution at room temperature for the following immersion times: 5, 10, 20, 25 and 30 minutes.

Tablica 1. Eksperimentalne skupine
Table 1 Experimental Groups

Skupina • Group	Otapalo • Solvent	Uzorci • Specimens	Gutaperka • Gutta-Percha
Skupina1 • Group 1	Narančino ulje • Orange Oil	50	F3
Skupina 2 • Group 2	Formulirani eukaliptol • Formulated Eucalyptol	50	F3
Skupina 3 • Group 3	Formulirano narančino ulje • Formulated Orange Oil	50	F3
Skupina 4 (kontrolna) • Group 4 (control)	Ksilol • Xylol	50	F3

Uzorci su, nakon što su određeno vrijeme bili uronjeni, uklonjeni iz staklene posudice, isprani u 100 ml redestilirane vode i ostavljeni da se suše 72 sata na sobnoj temperaturi.

Ponovno su izvagani kako bi se usporedio i izračunao gubitak mase. Maseni gubitak zabilježen je vaganjem nakon svake minute djelovanja otapala na štapiće. Količina otapanja gutaperke izračunata je na temelju razlike između njezine početne i konačne mase primjenom sljedeće jednadžbe: M = Mf – Mi pri čemu je:

Mf = masa nakon uranjanja u otapalo;

Mi = masa prije uranjanja u otapalo.

Aritmetičke sredine i standardne devijacije gubitka mase izračunate su za svaki vremenski interval za svaku skupinu uzoraka. Podatci su tablično prikazani i statistički obrađeni Kruskal-Wallisovim testom u programu SPSS 21 (statistički paket za društvene znanosti) za Windowse (SPSS INCO., Chicago, SAD). Razina statističke značajnosti postavljena je na 0,05.

The samples were removed from a glass vial after the specified immersion period, washed in 100 mL of double-distilled water, and allowed to dry for 72 h at room temperature.

A new weighing was performed in order to compare and calculate the weight loss. The mass loss was recorded by weighing which was performed after every minute of action of the solvent on the points. The dissolving rate of gutta-percha was calculated from the difference between the original weight of gutta-percha and its final weight using the following formula: M= Mf-Mi

where:

Mf = post-immersion weight;

Mi = pre-immersion weight.

Means and standard deviations of weight loss were calculated at each time interval for each group of specimens. The data were tabulated and statistically analyzed by Kruskal-Wallis test using the SPSS (Statistical Package for the Social Sciences) 21 data analysis software for Windows (SPSS Inco., Chicago, USA) with the value of statistical significance set at 0.05.

Tablica 2. Maseni gubitak štapića gutaperke uronjenih u četiri različita otapala od 5 do 30 minuta
Table 2 Weight loss of gutta-percha points immersed in four different solvents at 5 to 30 minutes.

Vrijeme (min) • Time (min)	Skupina • Group	Vrjednovanje • Evaluation		Prosječni gubitak mase • Means of weight loss
		Prije uranjanja • Pre-immersion	Nakon uranjanja • Post-Immersion	
		Srednja vrijednost ± SD (medijan) • Means± SD (Median)	Srednja vrijednost ± SD (medijan) • Means± SD (Median)	
• 5'	Narančino ulje • Orange oil	0.0841 ± 0.0007 (0.0841)	0.0795 ± 0.0043 (0.0808) (A)	0.0046 (A)
	Formulirani eukaliptol • Formulated Eucalyptol	0.0846 ± 0.0009 (0.0848)	0.0808 ± 0.0030 (0.0816 (AD)	0.0038 (A)
	Formulirano narančino ulje • Formulated Orange Oil	0.0849 ± 0.0013 (0.0849)	0.0820 ± 0.0016 (0.0823) (BD)	0.0028 (A)
	ksilol (kontrolna skupina) • Xylol (control)	0.0849 ± 0.0007 (0.0848)	0.0726 ± 0.0047 (0.0740) (C)	0.0123 (B)
	Vrijednost P • P value	$p^{(2)} = 0.164$	$p^{(2)} < 0.001$*	$p^{(2)} < 0.001$*
• 10'	Narančino ulje • Orange oil	0.0858 ± 0.0040 (0.0848)	0.0817 ± 0.0019 (0.0818) (A)	0.0040 (A)
	Formulirani eukaliptol • Formulated Eucalyptol	0.0839 ± 0.0006 (0.0838)	0.0810 ± 0.0021 (0.0812) (A)	0.0029 (A)
	Formulirano narančino ulje • Formulated Orange Oil	0.0846 ± 0.0008 (0.0844)	0.0791 ± 0.0080 (0.0821) (A)	0.0055 (A)
	ksilol (kontrolna skupina) • Xylol (control)	0.0847 ± 0.0007 (0.0848)	0.0628 ± 0.0117 (0.0646) (B)	0.0219 (B)
	Vrijednost P • P value	$p^{(2)} = 0.093$	$p^{(2)} = 0.002$*	$p^{(2)} = 0.002$*
• 20'	Narančino ulje • Orange oil	0.0867 ± 0.0062 (0.0853)	0.0834 ± 0.0057 (0.0820) (A)	0.0034 (A)
	Formulirani eukaliptol • Formulated Eucalyptol	0.0844 ± 0.0011 (0.0840)	0.0816 ± 0.0010 (0.0813 (A)	0.0028 (A)
	Formulirano narančino ulje • Formulated Orange Oil	0.0842 ± 0.0005 (0.0842)	0.0770 ± 0.0087 (0.0814) (A)	0.0072 (A)
	ksilol (kontrolna skupina) • Xylol (control)	0.0847 ± 0.0009 (0.0850)	0.0558 ± 0.0206 (0.0534) (B)	0.0289 (B)
	Vrijednost P • P value	$p^{(2)} = 0.383$	$p^{(2)} < 0.001$*	$p^{(2)} < 0.001$*
• 25'	Narančino ulje • Orange oil	0.0861 ± 0.0037 (0.0854)	0.0813 ± 0.0046 (0.0813) (A)	0.0048 (A)
	Formulirani eukaliptol • Formulated Eucalyptol	0.0842 ± 0.0011 (0.0842)	0.0796 ± 0.0023 (0.0801 (A)	0.0045 (A)
	Formulirano narančino ulje • Formulated Orange Oil	0.0845 ± 0.0009 (0.0845)	0.0780 ± 0.0050 (0.0811) (A)	0.0065 (A)
	ksilol (kontrolna skupina) • Xylol (control)	0.0849 ± 0.0008 (0.0846)	0.0474 ± 0.0170 (0.0453) (B)	0.0375 (B)
	Vrijednost P • P value	$p^{(2)} = 0.296$	$p^{(2)} < 0.001$*	$p^{(2)} < 0.001$*
• 30'	Narančino ulje • Orange oil	0.0857 ± 0.0046 (0.0844)	0.0767 ± 0.0112 (0.0806) (A)	0.0900 (A)
	Formulirani eukaliptol • Formulated Eucalyptol	0.0842 ± 0.0009 (0.0843)	0.0781 ± 0.0043 (0.0796 (A)	0.0061 (A)
	Formulirano narančino ulje • Formulated Orange Oil	0.0843 ± 0.0007 (0.0845)	0.0749 ± 0.0123 (0.0809) (A)	0.0094 (A)
	ksilol (kontrolna skupina) • Xylol (control)	0.0850 ± 0.0007 (0.0851)	0.0369 ± 0.0219 (0.0410) (B)	0.0481 (B)
	Vrijednost P • P value	$p^{(2)} = 0.097$	$p^{(2)} < 0.001$*	$p^{(2)} < 0.001$*

(*): statistički značajna razlika na razini 0,05 • Statistically significant differences at level .05.
(1): Kruskal-Wallisov test • Kruskal Wallis test
Ako su sva slova u zagradama različita, postoji statistički značajna razlika između otapala u svakom trenutku evaluacije. • If all the letters in parentheses are different it is demonstrated a significant difference between the solvents in each evaluation time.

Rezultati

Učinkovitost otapala ksilola, formuliranog narančina ulja, narančina ulja i formuliranog eukaliptola prikazana je u tablici 2. Prikazane su standardne devijacije i prosječni gubitak mase štapića gutaperke F3 ProTaper Universal.

Na temelju primijenjene metodologije bilo je moguće identificirati otapala s većom učinkovitošću otapanja štapića gutaperke F3 ProTaper Universal unutar razdoblja promatranja. S obzirom na gubitak mase gutaperke koju je svako otapalo uzrokovalo tijekom 30 minuta, ksilol (kontrona skupina) je pokazao najveću učinkovitost, a slijedili su formulirano narančino ulje, narančino ulje i formulirani eukaliptol. Re-

Results

The solvent action of xylol, formulated orange oil, orange oil and formulated eucalyptol are summarized in Table 2. Also, the standard deviation and mean weight loss of F3 ProTaper Universal gutta-percha point is presented.

Based on the methodology employed, it was possible to identify the solvents with higher power of dissolving F3 ProTaper Universal gutta-percha points within the periods of evaluation. With regards to the means weight loss provoked by each solvent at 30 minutes of immersion time, xylol (control) showed the greatest weight loss, followed by formulated orange oil, orange oil and formulated eucalyp-

zultati gubitka mase gutaperke u svakoj minuti mogu se vidjeti u tablici 2.

Uzimajući u obzir dobivene rezultate, ksilol (kontrolna skupina) je pokazao najveću učinkovitost otapanja gutaperke u usporedbi s formuliranim narančinim uljem, narančinim uljem i formuliranom eukaliptolom u svakoj vremenskoj točki pokusa, sa statistički značajnom razlikom.

S obzirom na ukupan gubitak mase, svako otapalo izazvalo je najveće ukupno otapanje gutaperke nakon 30 minuta.

Rasprava

Za procjenu tehnika endodontske revizije predloženo je bezbroj metoda. Predloženi su različiti načini učinkovitog čišćenja sustava korijenskih kanala, uključujući ručne instrumente od nehrđajućeg čelika (2, 10), rotirajuće instrumente (11), recipročne sustave (12), ultrazvučne instrumente (3) i korištenje otapala za gutaperku (13).

U literaturi postoji samo nekoliko radova u kojima se procjenjuje učinkovitost otapala na štapiće gutaperke većega konusnog kuta, iako se takvi štapići naširoko primjenjuju u endodontskom punjenju korijenskog kanala. Svrha ovog istraživanja bila je procijeniti učinak nekoliko otapala na štapiće gutaperke F3 ProTaper Universal. Metode koje su odabrane u ovom istraživanju u skladu su s mnogobrojnim temeljnim istraživanjima provedenima s otapalima gutaperke u kojima se učinkovitost otapala procjenjuje na temelju razlike između izvorne mase gutaperke prije uranjanja u otapalo i mase nakon uranjanja (8, 14, 15).

Ksilol se ubraja u otapala s velikim kapacitetom otapanja gutaperke (8, 14,16). Rezultati ovog istraživanja bili su u skladu sa studijama drugih autora jer je ksilol (kontrolna) pokazao veliku učinkovitost u otapanju gutaperke u svim vremenskim točkama ispitivanja, uz statistički značajno bolje rezultate u usporedbi s eukaliptolom i narančinim uljem od prve do pete minute.

Podatci iz ovog istraživanja upućuju na to da su štapići gutaperke F3 ProTaper Universal™ u otapalima topivi do različitog stupnja. Ksilol je bio najučinkovitije otapalo, a zatim su slijedila eterična ulja (eukaliptol i narančino ulje). I u dosadašnjim istraživanjima ksilol se pokazao najučinkovitijim (6, 17). No narančino ulje i eukaliptol zasigurno su biokompatibilnije alternative ksilolu (18). Drugi autori (19) navode da su kloroform i eukaliptol jako citotoksična otapala, ali moguće je da nisu čimbenik koji povećava razinu oštećenja DNK u stanicama sisavaca.

U skladu s rezultatima ovog istraživanja, Gomes i suradnici (14) pokazali su da ksilol ima veliku učinkovitost u otapanju gutaperke u svim vremenskim točkama ispitivanja, ali su razlike u odnosu prema eukaliptolu i narančinu ulju bile statistički značajne od prve do pete minute.

U ovom istraživanju, kod svih otapala, najveći postotak otapanja zabilježen je nakon pet minuta. Važno je istaknuti da su štapići gutaperke sastavljeni od gutaperke, cinkova oksida, voskova, smola i drugih spojeva, ali otapala djeluju samo na gutaperku. Prema tome, čini se da se najveći postotak otapanja dogodio u prvih pet minuta jer je u preostalom vre-

tol. The results of the loss at each minute are presented in Table 2.

Taking into consideration these results, xylol (control) exhibited greater capacity of dissolution than formulated orange oil, orange oil and formulated eucalyptol at all experimental periods of time, with a statistically significant difference.

Considering the total weight loss provoked by each solvent, all solutions caused the highest dissolution of gutta-percha at immersion time of 30 minutes.

Discussion

Numerous methodologies have been proposed to evaluate retreatment techniques. It has been suggested that hand file (2, 10) including stainless steel hand file (2, 10), rotary instruments (11), reciprocating systems (12), ultrasound (3) and immersion of gutta-percha point in the solvent solution (13) can be used to effectively clean the root canal system. Although gutta-percha points have been widely used in endodontics for root canal filling, there are few reports in the literature that evaluated solvent capacity on the great taper gutta-percha points. The goal of the present study was to evaluate the dissolving effect of solvents on F3 ProTaper Universal gutta-percha points. The methods used in this study are similar to those used in numerous basic studies conducted on gutta-percha solvents in which the dissolving efficacy of solvents was assessed by the difference between the original pre-immersion weight and the post-immersion weight (8, 14, and 15).

According to the classification of residual solvents, xylol is a solvent with major capacity of dissolution of gutta-percha (8, 14, and 16). The results of the present study are in agreement with those obtained by previous authors, because xylol (control) showed a significantly higher dissolution rate of gutta-percha in all tested periods of time. Also, the result obtained for xylol is statistically more significant than the results obtained for eucalyptol and orange oil (ranging from 1 - 5 minutes).

The data of the present research reveal that the F3 ProTaper Universal™ gutta-percha points were soluble to various degrees in the aforementioned solvents. Our results show that xylol was the most effective solvent followed by essential oils (eucalyptol and orange oil). Several recent studies have also reported that xylol is the most effective solvent (6, 17). However, some researchers stated that orange oil and eucalyptol are safe and more biocompatible alternatives to Xylol (18). Unlike these results, a study (19) showed that both chloroform and eucalyptol are strong cytotoxic solvents. However, the authors do not consider them to be a factor that increases the level of DNA lesions in mammalian cells.

In accordance with the present research, Gomes et al. (14) showed that xylol has a high dissolving rate of gutta-percha in all tested times. The rate obtained for xylol was statistically more significant than that obtained for eucalyptol and orange oil (ranging from 1 - 5 minutes).

In the present study, all solvents exhibited the greatest percentage of dissolution at five minute interval. It is note-

menu ostala manja količina gutaperke na koju bi moglo djelovati otapalo. Drugi rezultati pokazuju da je nakon pet minuta otapalo učinkovitije nego nakon deset minuta, što znači da se otapalo mora ostaviti da djeluje najmanje pet minuta.

Što se tiče korištenih otapala, nekoliko je istraživanja koja dokazuju njihovo svojstvo otapanja. Tanomaru-Filho i suradnici (16) zaključili su da otapala ksilol, eukaliptol i narančino ulje otapaju gutaperku. Ksilol je učinkovitiji u uklanjanju konvencionalne gutaperke, a ostala otapala bolje uklanjaju termoplastične gutaperke. U skladu s rezultatima Tanomaru-Filhoa i suradnika (20), Magalhães i njegovi kolege (8) procjenjivali su učinkovitost ksilola, eukaliptola, kloroforma i narančina ulja i izvijestili da je ksilol najučinkovitije otapalo, a s ostalima su postignuti slični rezultati. Aguiar i suradnici (20) također su uočili da su i eukaliptol i narančino ulje bili učinkoviti u uklanjanju punjenja iz korijenskih kanala, što se ne podudara s rezultatima Karlovića i suradnika (21) koji su utvrdili da najveća količina preostalog punjenja u korijenskom kanala zaostaje nakon revizije s narančinim uljem, zatim s halotanom, a najbolji rezultat ostvaren je s eukaliptusovim uljem. Rezultati dobiveni u ovom istraživanju pokazali su da je ksilol bio najučinkovitiji u otapanju gutaperke, a slijedilo je formulirano narančino ulje, narančino ulje i formulirani eukaliptol.

Zaključak

S obzirom na dobivene rezultate i primijenjenu metodologiju, može se zaključiti da je ksilol bio najučinkovitiji u otapanju štapića gutaperke F3, a slijedili su formulirano narančino ulje, narančino ulje i formilirani eukaliptol. Nije bilo statistički značajne razlike između učinkovitosti u otapanju formuliranog narančina ulja te formuliranog eukaliptola i narančina ulja, što potvrđuje da se ta otapala mogu upotrebljavati kao alternative tijekom endodontske revizije.

Sukob interesa

Autori navode da u vezi s ovim istraživanjem nisu bili u sukobu interesa.

worthy that although gutta-percha points are composed of gutta-percha itself, zinc oxide, waxes, resins and other compounds, the solvents acted only on gutta-percha. Accordingly, it seems that the greatest percentage of dissolution occurred in a time interval of five minutes because in the remaining time there would have been a smaller amount of gutta-percha within the point, hence a smaller area of action for the solvent. The results of some studies have shown that after five minutes, the solvents exhibited a higher dissolution rate than after 10 minutes, suggesting that the solution must be used for at least 5 minutes.

There are few studies confirming the solvent capacity of the tested solvents. Tanomaru-Filho et al. (16) concluded that solvents such as xylol, eucalyptol, and orange oil showed a good solvent capacity. Xylol was more efficient for conventional gutta-percha removal, whereas other solvents were more efficient for thermoplastic gutta-percha removal. In agreement with Tanomaru-Filho et al. (20), Magalhães et al. (8) evaluated the solvent capacity of xylol, eucalyptol, chloroform and orange oil and reported that xylol was the most efficient solvent, while other solvents acted in a similar fashion. Aguiar et al. (20) also observed that both eucalyptol and orange oil were effective in the removal of filling material from root canals, which does not comply with the results of the study obtained by Karlović et al. (21) who reported that the greatest amount of remaining root canal filling was found after retreatment with orange oil, followed by halothane. The results of their study also showed that eucalyptus oil exhibited the best dissolving capacity. The results obtained in the present study demonstrated that xylol was the most effective solvent in dissolving gutta-percha points, followed by formulated orange oil, orange oil and formulated eucalyptol oil.

Conclusion

Considering the results obtained and the methodology employed, it can be concluded that xylol was the most effective in dissolving F3 gutta-percha points, followed by formulated orange oil, orange oil, and eucalyptol. There were no statistically significant differences between the solvent capacity of formulated orange oil and formulated eucalyptol and orange oil, thus confirming the fact that they can be used in endodontic retreatment as alternative solutions to replace xylol.

Conflict of interest

The authors deny any conflicts of interest related to this study.

Abstract

Purpose: Solvents may be used to remove the filling materials. The purpose of this *in vitro* study was to evaluate and compare the efficacy of formulated orange oil, orange oil and formulated eucalyptol in dissolving F3 ProTaper Universal Gutta-percha points. **Material and methods:** 200 samples were used and divided into four groups, further divided in fifty samples for each solvent. The samples were weighed on an analytical balance before being subjected to the action of solvents. Subsequently, they were put onto watch glasses, 7X45mm in length, and immersed into solutions for the following times: 5, 10, 20, 25 and 30 minutes. The loss of mass was recorded by weighing samples after every minute of action of the solvent on the points. Data were statistically analyzed by Kruskal-Wallis test at a significance level of 5%. **Results:** All solvents showed that the first five minutes of action was the period of greatest dissolving power. In terms of immersion time, xylol (control group) exhibited a markedly superior ability in dissolving the gutta-percha points compared to other solvents and, also, showed statistically significant differences. A continuous dissolution was observed in all groups. Formulated orange oil presented a markedly superior solvent effect on filling materials compared to orange oil and formulated eucalyptol; however, there were no statistically significant differences. **Conclusion:** Considering the results obtained and methodology employed, it can be concluded that xylol was the most effective solvent in dissolving gutta-percha points, followed by formulated orange oil, orange oil and formulated eucalyptol oil.

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Key words
Root Canal Therapy; Gutta-percha; Solvents; Xylenes; Oils, Volatile; orange oil; eucalyptol

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