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Vívian Gehm Seballos

EFEITO DE DIFERENTES SOLUÇÕES IRRIGADORAS SOBRE A RESISTÊNCIA ADESIVA DE PINOS DE FIBRA DE VIDRO COM UTILIZAÇÃO DE CIMENTO AUTOADESIVO

Santa Maria, RS
2016

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Dissertação apresentada ao Curso de Mestrado do Programa de Pós-Graduação em Ciências Odontológicas, Área de Concentração em Odontologia, ênfase em **Prótese Dentária**, da Universidade Federal de Santa Maria (UFSM, RS), como requisito parcial para obtenção do grau de **Mestre em Ciências Odontológicas**.

Orientador: Prof. Dr. Osvaldo Bazzan Kaizer

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Aprovado em 25 de julho de 2016:

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Prof. Dr. Osvaldo Bazzan Kaizer (UFSM)
(Presidente da Banca/Orientador)

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Santa Maria, RS
2016

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RESUMO

EFEITO DE DIFERENTES SOLUÇÕES IRRIGADORAS SOBRE A RESISTÊNCIA ADESIVA DE PINOS DE FIBRA DE VIDRO COM UTILIZAÇÃO DE CIMENTO AUTOADESIVO

AUTORA: Vívian Gehm Seballos
ORIENTADOR: Osvaldo Bazzan Kaizer

Este estudo tem como objetivo avaliar o efeito de diferentes soluções irrigadoras sobre a resistência adesiva de pinos de fibra de vidro, cimentados com cimento autoadesivo RelyX U200. Foram utilizados 80 pré-molares inferiores humanos tiveram a coroa seccionada, padronizando-se o comprimento da raiz em 14 mm. Os condutos foram instrumentados com o sistema rotatório ProTaper até o instrumento F3, obturados com cimento endodôntico AH Plus e cones de guta-percha F3 do mesmo sistema, pela técnica do cone único. Os condutos foram desobturados até 10mm de profundidade, mantendo-se os 4mm apicais da obturação. As raízes foram aleatoriamente distribuídas em 8 grupos (n=10), de acordo com a solução irrigadora utilizada previamente à cimentação dos pinos: SS: solução salina 0,9% (grupo controle); CHX: clorexidina 2%; 1%NaOCl: hipoclorito de sódio 1%; 2,5%NaOCl: hipoclorito de sódio 2,5%; 5%NaOCl: hipoclorito de sódio 5%; 1%CaOCl: hipoclorito de cálcio 1%; 2,5%CaOCl: hipoclorito de cálcio 2,5%; e 5%CaOCl: hipoclorito de cálcio 5%. Para cada espécime, a irrigação foi realizada com 2ml da solução a cada troca de instrumento. Os pinos de fibra de vidro do Sistema Exacto Translúcido $n^0$2 foram silanizados e cimentados com o cimento resinoso autoadesivo RelyX U200. As raízes foram seccionadas na máquina de corte, de forma a obter 3 *slices* por espécime, sendo 1 *slice* para cada terço radicular. A seguir, os corpos de prova foram submetidos ao teste de *push-out* na máquina de ensaio universal EMIC. Para análise do padrão de falha, os espécimes foram analisados com microscopia óptica. A média de resistência adesiva de cada espécime foi calculada. Testes ANOVA e Bonferroni foram utilizados para analisar as diferenças entre os grupos. O grupo SS demonstrou a maior média de resistência adesiva, sendo superior aos grupos NaOCl e CaOCl *($P < 0.05$),* nos quais apresentaram valores semelhantes ao grupo CHX (7.56Mpa ± 2.47). As falhas adesivas cimento/dentina foram predominantes (58.33%). Concluímos que SS parece ser a solução mais adequada para limpeza do canal radicular previamente à cimentação de pinos de fibra cimentados com cimento autoadesivo RelyX U200. NaOCl e CaOCl diminuíram os valores de resistência adesiva dos pinos de fibra à dentina radicular e suas diferentes concentrações não afetaram este resultado.

Palavras-chave: Cimentos autoadesivos. Solução de hipoclorito de cálcio. Pinos de fibra de vidro. Resistência Adesiva.

ABSTRACT

NEGATIVE INFLUENCE OF DIFFERENT IRRIGANTS ON BOND STRENGH OF FIBER POSTS CEMENTED WITH A SELF-ADHESIVE CEMENT

AUTHOR: Vívian Gehm Seballos
ADVISOR: Osvaldo Bazzan Kaizer

The purpose of this study is to evaluate the effect of different irrigatins on bond strength of fiber posts cemented with RelyX U200. Eighty single-rooted premolars were sectioned at 14 mm from the apex, prepared with ProTaper Universal system until F3 instrument, and filled with F3 master cone and AH Plus sealer. Root canal filling was partially removed, remaining 4 mm of guta-percha at the apical third. Specimens were randomly divided into 8 groups (n=10), according to the irrigant used during root canal preparation and before fiber post cementation (dentin surface treatment), as described: SS: 0,9% saline solution (control group); CHX: 2% chlorhexidine; 1%NaOCl: 1% sodium hypochlorite; 2,5%NaOCl: 2,5% sodium hypochlorite; 5%NaOCl: 5% sodium hypochlorite; 1%CaOCl: 1% calcium hypochlorite; 2,5%CaOCl: 2,5% calcium hypochlorite; e 5%CaOCl: 5% calcium hypochlorite. For each group, irrigation was performed continuously with 2ml. Exacto N2 glass fiber posts were cemented with RelyX U200. The specimens were sectioned providing 3 slices, one for each root third and the push-out test was performed. Optical microscopy was used to analyze the failure mode. Bond strength means were calculated and ANOVA and Bonferroni tests were used for statistical analysis. SS showed higher mean of bond strength values (11.47MPa), than all NaOCl and CaOCl groups, which showed similar values to CHX (7.56Mpa ± 2:47). Adhesive failures at cement/dentin interface were predominant (58.33%). NaOCl and CaOCl negatively affect the bond strength of fiber posts to root dentine when cemented with sef-adhesive resin cement; however the concentration of NaOCl and CaOCl did not affect this outcome.

Key Words: Bond strength. Calcium hypochlorite. Glass fiber posts. Self-adhesive resin-cement.

SUMÁRIO

1 INTRODUÇÃO

A forma ideal de reabilitação de dentes tratados endodonticamente ainda gera discussões na Odontologia, principalmente quando se consideram as dificuldades para obter a adesão entre pinos de fibra e a dentina radicular. Há um consenso de que quando há perda de grande quantidade da estrutura coronária do dente a ser reconstruído, retentores intrarradiculares tornam-se necessários para criar retenção e estabilidade suficientes para a restauração (PERDIGÃO et al., 2007).

A partir da década de 1990, pinos de fibras de vidro têm sido amplamente utilizados para a restauração de dentes endodonticamente tratados, devido a certas vantagens em relação a sistemas de pinos pré-fabricados e núcleo metálico fundido, tais como uma melhor estética (FERRARI 2008), por sua maior facilidade de adesão (TEIXEIRA et al., 2009) e por apresentar propriedades biomecânicas próximas às da estrutura dentária, especialmente o módulo de elasticidade similar ao da dentina (MONTICELLI et al. 2008; FERRARI et al., 2000; MALFERRARI et al., 2003), proporcionando uma distribuição de carga mais adequada na raiz e reduzindo a porcentagem de fraturas catastróficas de raízes (COELHO et al. 2009).

Para a otimização da técnica de cimentação, há ampla variedade de cimentos resinosos no mercado. A difícil seleção de uma estratégia de cimentação está associada às dificuldades intrínsecas de adesão no interior do canal radicular (BITTER et al. 2012), tais como a presença de resíduos de cimento endodôntico e de guta-percha no conduto (PERDIGÃO et al. 2007), a dificuldade na remoção adequada da camada de *smear layer* (BONFANTE et al., 2008), a dificuldade de secagem do excesso de umidade do conduto (NAGAS et al., 2012), bem como de polimerização completa do sistema adesivo e do cimento resinoso (PEREIRA et al. 2010). Os cimentos resinosos autoadesivos visam simplificar a técnica, e minimizar erros no protocolo adesivo, além de economizar tempo (IBARA et al. 2007), já que não é exigido um pré-tratamento na superfície dentária (MONTICELLI et al. 2008).

Segundo o fabricante do cimento RelyX U200 (3M ESPE; St. Paul, MN, EUA), este possui, em relação à geração anterior do mesmo, alta resistência de união em esmalte e dentina, maior fluidez, baixa solubilidade e menor sensibilidade pós operatória. Seu mecanismo de adesão se dá pela retenção micromecânica e adesão química entre o agente de cimentação e o substrato dental (GERTH et al., 2006;

ZICARI et al. 2008). Segundo Manso et al. 2011, a acidez do cimento é suficientemente forte para promover a hibridização com a estrutura dentária.

Para obtenção de uma adesão suficiente, a remoção de *smear layer*, a qual contém restos de cimento e de gutta-percha, microorganismos e resíduos de dentina resultantes da instrumentação, é indispensável para a penetração completa do cimento resinoso dentro dos túbulos dentinários (EDEMIR et al. 2004; SERAFINO et al. 2004; HAYASHI et al. 2005). Apesar dos monômeros ácidos contidos no cimento RelyX U200 (3M ESPE; St. Paul, MN, EUA) auxiliarem na dissolução da *smear layer* (Manso et al., 2011), é indispensável o uso de diferentes soluções irrigadoras durante o preparo dos canais radiculares para a remoção destes resíduos orgânicos e inorgânicos da *smear layer* (SCOTTI et al. 2013).

O hipoclorito de sódio em concentrações variadas é a solução irrigadora mais amplamente utilizada no preparo químico-mecânico dos canais radiculares (CLARKSON et al. 2003) por ser bactericida, fungicida e possuir capacidade de dissolver os tecidos pulpares (RUTALA et al. 1998), bem como remover a camada inorgânica de *smear layer* (SERAFINO et al. 2004 e CLARKSON et al, 2006). Porém, o hipoclorito de sódio também é um agente oxidante que pode gerar uma camada rica em oxigênio na parede da dentina radicular, inibindo a polimerização e aumentando a infiltração, bem como resultando em menores valores de resistência de união (MORRIS et al. 2001, ARI et al. 2003, ERDEMIR et al. 2004, SANTOS et al. 2006, WESTON et al. 2007).

Assim como o hipoclorito de sódio, a solução de digluconato de clorexidina 2% (CHX) é utilizada com o propósito de desinfecção dos condutos, tendo sua eficiência comprovada (KATALINIC et al 2013; WANG et al. 2013), pois possui sua ação de amplo espectro, baixa citotoxicidade (da SILVA et al. 2005) e relevante substantividade (BASRANI et al. 2002), capacidade que a CHX tem de permanecer ativa no local de ação por um período de tempo (MARION et al. 2013).

Outra solução que está sendo recentemente estudada é o hipoclorito de cálcio (CaOCl), uma substância relativamente estável, pois permanece inalterado por um período considerado longo, usada na esterilização industrial e tratamentos de purificação de água há muitos anos (WHITTAKER e MOHLER, 1912). Segundo Twomey et al. (2003), o hipoclorito de cálcio é uma substância antibacteriana, com grande poder de dissolução orgânica, equivalendo-se ao hipoclorito de sódio (DUTTA et al. 2012). De Almeida et al. (2014) demonstraram que a irrigação passiva de hipoclorito de cálcio aliada a irrigação ultrassônica passiva (PUI) pode auxiliar no preparo químico-mecânico, contribuindo de forma significativa para a redução do teor microbiano durante o tratamento do canal radicular.

Recentes estudos relatam a alta alcalinidade do hipoclorito de cálcio, assim como a maior quantidade de cloro disponível quando comparado ao hipoclorito de sódio (LEONARDO et al. 2016). No entanto, não foram encontrados estudos demonstrando a interação do hipoclorito de cálcio frente à adesão de pinos de fibra de vidro e cimentados com cimentos resinosos autoadesivos.

O presente trabalho, que será apresentado em formato de artigo, intitulado "**Negative influence of different irrigants on bond strengh of fiber posts cemented with a self-adhesive cement** " e visa avaliar o efeito de substâncias irrigadoras como o hipoclorito de sódio, hipoclorito de cálcio ou clorexidina sobre a resistência adesiva de pinos de fibra de vidro cimentados com cimento resinoso autoadesivo RelyX U200. Assim como comparar os valores de resistência adesiva entre os diferentes grupos testados; descrever e ilustrar, com o auxílio de microscopia óptica, os padrões de falha apresentados após o teste de resistência adesiva.

2 ARTIGO- NEGATIVE INFLUENCE OF DIFFERENT IRRIGANTS ON BOND STRENGH OF FIBER POSTS CEMENTED WITH A SELF-ADHESIVE CEMENT

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NEGATIVE INFLUENCE OF DIFFERENT IRRIGANTS ON BOND STRENGH OF FIBER POSTS CEMENTED WITH A SELF-ADHESIVE CEMENT

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Negative influence of different irrigants on bond strength of fiber posts cemented with a self-adhesive cement

Short title: *Bond strength of fiber posts cemented with RelyX U200*

Clinical significance:

When cementing fiber posts with self-adhesive cement *RelyX U200*, NaOCl and CaOCl solutions decreased the bond strength values and their concentrations did not play any role on fiber posts adhesiveness to root dentine.

Abstract

The purpose of this study is to evaluate the effect of different irrigatins on bond strength of fiber posts cemented with RelyX U200. Eighty single-rooted premolars were sectioned at 14 mm from the apex, prepared with ProTaper Universal system until F3 instrument, and filled with F3 master cone and AH Plus sealer. Root canal filling was partially removed, remaining 4 mm of guta-percha at the apical third. Specimens were randomly divided into 8 groups (n=10), according to the irrigant used during root canal preparation and before fiber post cementation (dentin surface treatment), as described: SS: 0,9% saline solution (control group); CHX: 2% chlorhexidine; 1%NaOCl: 1% sodium hypochlorite; 2,5%NaOCl: 2,5% sodium hypochlorite; 5%NaOCl: 5% sodium hypochlorite; 1%CaOCl: 1% calcium hypochlorite; 2,5%CaOCl: 2,5% calcium hypochlorite; e 5%CaOCl: 5% calcium hypochlorite. For each group, irrigation was performed continuously with 2ml. Exacto N2 glass fiber posts were cemented with RelyX U200. The specimens were sectioned providing 3 slices, one for each root third and the push-out test was performed. Optical microscopy was used to analyze the failure mode. Bond strength means were calculated and ANOVA and Bonferroni tests were used for statistical analysis. SS showed higher mean of bond strength values (11.47MPa), than all NaOCl and CaOCl groups, which showed similar values to CHX (7.56Mpa ± 2:47). Adhesive failures at cement/dentin interface were predominant (58.33%). NaOCl and CaOCl negatively affect the bond strength of fiber posts to root dentine when cemented with sef-adhesive resin cement; however the concentration of NaOCl and CaOCl did not affect this outcome.

Negative influence of different irrigants on bond strengh of fiber posts cemented with a self-adhesive cement

INTRODUCTION

Restorative strategies of endodontically treated teeth still generates discussions in dentistry, especially when it comes to difficulties in obtaining the adhesion between fiber post and root dentin[32]. From the 90's, glass fiber posts have been widely used for the restoration endodontically treated teeth due to some advantages over metal systems, improving the aesthetics[14], for its ease adhesion and display biomechanical properties similar to tooth structure, especially the modulus of elasticity similar to that of dentin[15,25,28], providing a better load distribution at the root and reducing the percentage of catastrophic fracture roots[9].

The difficulties of bonding into the root canal, the presence of sealer and gutta-percha adhered to the canal walls[32], the difficulty *smear layer* removal[4], the difficulty of drying the excess of moisture into the root canal[30], as well as the complete cure of the adhesive system and resin cement are the main difficulties to obtain great fiber post adhesion to root dentin. Thefore adhesive resin cements are intended to simplify the technique, because they are easy to handle and timesaving, once a pre-treatment of the root surface is not required[19,28]. Its mechanism of adhesion is based on micromechanical retention and chemical bonding between the cement agent and the dental substrate[17,46]. The cement acidity is strong enough to promote hybridization with the tooth structure[26].

To obtain sufficient adhesion, the removal of smear layer, which contains inorganic and organic components, sealer and gutta-percha remnants, microorganisms, and infectious deteriorated dentin is necessary for the penetration of resin cement into the dentin tubules[13,18,39]. Root canal irrigation is mandatory to eliminate debris and bacteria from the root canal system[38].

NaOCl is the most commonly used irrigant in the chemical-mechanical preparation of root canals[7]. It is bactericidal, fungicidal and presents the ability to dissolve the pulp tissues and remove organic portion of *smear layer*[8,39]. However, NaOCl is an oxidizing agent that may create an oxygen-rich layer on the dentine wall that inhibits polymerization and increases microleakage, resulting in lower bond strength values of the various adhesive systems in the root canals[1,13,29,37.]

Chlorhexidine gluconate, in gel or liquid form, has been recommended as an endodontic irrigant and as root canal dressing due its antimicrobial action, low toxicity, substantivity, and ability to remain active on the site of action[2,10]. CHX preserve the durability of bond strength up to 12 months, inhibiting MMPs[6].

A recently solution investigated to irrigate canal system is calcium hypochlorite (CaOCl-). It consists in a relatively stable substance, normally used for industrial sterilization and water purification treatments[45]. CaOCl is an antibacterial substance[41] and has the ability to promote soft-tissue dissolution, equivalent to NaOCl[12]. CaOCl associated to passive ultrasonic irrigation can significantly reduce the microbial content during the root canal treatment[11]. Recent studies report the high alkalinity of CaOCl, as well as the amount of available chlorine greater than compared to sodium hypochlorite[11,12,22].

Therefore, the main goal of this *ex vivo* study was to evaluate the effect of different irrigants used after post space preparation on bond strength between root dentine and fiber posts cemented with RelyX U200. The null hypothesis tested was that different irrigants have no influence on bond strength of fiber posts to root dentine.

METHOD AND MATERIALS

Experimental design

Roots (N = 80) were randomly allocated (www.random.org) into 8 groups (n = 10), considering 1 factor (irrigant solutions) at eight levels. The main outcome was the ‘push-out bond strength’ and the experimental unit was the ‘root’. The operators were blinded for intracanal solutions applications, post cementations, push-out tests, and failure analyses.

Tooth selection

This study was submitted and approved by the Ethical Committee of the Federal University of Santa Maria (number *#984.334*). Eighty single-rooted premolars with similar dimensions were selected and stored in a 0.9% saline solution at 4°C until use. Periapical radiographs were taken to confirm the presence of one root canal, in order to exclude incomplete root formation, root resorption, external cracks and coronal root canal diameter greater than 2 mm, as measured with a digital caliper (Starrett 727; Starrett, Itu, SP, Brazil).

Dental crowns were sectioned using a diamond blade (Komet, Santo André, SP, Brazil) under cool water and the remaining root were 14 mm long.

Endodontic procedures

Working length (WL) was established with a size 10 K-file (Dentsply Maillefer, Chemin du Verger, Ballaigues, Switzerland), and was set a 1mm from the apex, followed by PathFile 1, 2, 3 (Dentsply Maillefer) instruments. Root canals were instrumental with ProTaper Universal System (Dentsply Maillefer). Initially, S1, SX, and S2 instruments were inserted to 2/3 of the WL. Afterwards, S1, S2, F1, F2, and F3 instruments were sequentially used to the full WL.

As aforementioned, specimens were randomly divide into eight groups, according to the irrigating solution used during the preparation of the roots as described: **SS** (control group- 0,9% saine solution), **CHX** (chlorhexidine 2%), **1% NaOCl** , **2,5% NaOCl**, **5% NaOCl**, **1% CaOCl**, **2,5% CaOCl**, **5% CaOCl** .

The irrigants were delivered in the canals using Ultradent syringes (Ultradent Products Inc., South Jordan, UT, USA) and 30G EndoEzeTip needles (Ultradent Products Inc). The irrigation protocols for all experimental and control group was: (1) root canals were rinsed with 2 ml of the irrigant corresponding to each group after each instrument change. (2) final continuous irrigation was performed during 3 minutes with 5 mL of 17% EDTA in all groups. Finally, they were dried using size 30 paper points (Dentsply Maillefer).

Root canal filling

After root canal preparation, all roots were filled using single cone technique with size F3 ProTaper gutta-percha points (Dentsply Maillefer), and AH Plus (Dentsply Maillefer). The endodontic sealer was mixed according to the manufacturer's instructions and placed in working length by using a 25mm Lentulo spiral (Dentsply Maillefer). Excess gutta-percha was removed with a heated plugger, and the access cavity was sealed with Filtek Z350 (3M ESPE) composite resin. Roots were stored for 1 week at 37°C and 100% humidity to allow the sealer completely set.

Cementation procedures

Root canal filling was partially removed using sizes 2, 3, 4 Largo drills (Dentsply Malleifer), in 10 mm length, remaining 4 mm of apical guta-percha. Periapical radiographs were performed to confirm root filling removal. Next, post space preparation was completed using the Exacto Translúcido Angelus N2 (Angelus, Londrina, PR, Brazil) bur at 10 mm.

Apical root portions were included in a chemically cured acrylic resin (Dencrilay Dencril, Pirassununga, SP, Brazil) block. The specimens were fixed on a parallelometer, with the long axes of the teeth and the resin block parallel to each other and perpendicular to the ground.

The irrigants were placed into the canals using Ultradent syringes (Ultradent Products Inc., South Jordan, UT, USA) and 30G EndoEzeTip needles (Ultradent Products Inc). The final irrigation was performed during 3 minutes, with 5 ml of the solution corresponding to each group aforementioned.

Specimens were dried with paper points. Exacto Translúcido N2 (Angelus, Londrina, PR, Brazil) fiber posts were cleaned with ethyl alcohol 70% and coated with silane (Angelus).

RelyX U200 was mixed and inserted into root canal using lentulo spiral (Dentsply Maillefer) and immediately, the fiber post was inserted in to the root canal, and vibratory movements were performed. The cement excess was removed with *microbrush* (KG Sorensen, SP- Brazil), and light-cured for 40 s using an LED light-curing unit (Radii Cal; SDI, Melbourne, Australia) previously calibrated. A single operator performed all procedures. The coronal access was sealed with composite resin (Filtek Z350; 3M ESPE). Roots were stored for 48 hours at 37°C.

Push-out test

A cutting machine (Extec Labcut 1010, Enfield, CT, USA) was used for sectioning transversally the roots, providing 3 slices, one for each root third. The first cervical slice (approximately 1 mm thick) was discarded due the excess of cement, which could negatively influence the adhesive resistance.

Three other slices per specimen (thickness: 2 ± 0.3 mm) were obtained. Each slice was positioned on a metallic device with a central opening (Ø=3 mm) larger than the canal diameter. The most coronal portion of the specimen was marked and placed downward. For push-out test, a metallic cylinder (Ø extremity = 0.8 mm) induced a load on the post in an apical to coronal direction, without any pressure to the cement and/or dentin.

Push-out test was performed in a universal testing machine (Emic DL-2000; Emic, Sao Jose dos Pinhais, PR, Brazil) at a speed of 0,5 mm/min. Bond strength values (σ) in MPa were obtained as followed[42]: **σ=F/A**, where **F** = load for specimen rupture (N) and **A** = bonded area (mm^2). To determine the bonded interface area, a formula was used: **A=2πg(R1 + R2)**, where **π=3.14**, **g**= slant height, **R1**= smaller base radius, **R2**= larger base radius. To determine the slant height, the following calculation was used: **g2=(h2 + [R2- R1]2)**, where **h**= section height. **R1** and **R2** were obtained by measuring the internal diameters of the smaller and larger base, respectively, which corresponded to the internal diameter between the root canal walls. The diameters and **h** were measured using a digital caliper (Starrett 727, Starrett, Itu, SP, Brazil).

Failure mode analysis

Dentin slices were selected and analyzed on optical microscopy (OM) in order illustrate the failure modes. The failure modes were categorized as follow: Ac/d = Predominant Adhesive at cement/dentin interface failure; Ac/p = Predominant Adhesive at cement/post interface failure; C= cohesive failure. Specimens which presented cohesive fractures of the fiber post was excluded from the study once these type of failures do not represent real push-out bond strength.

Data Analysis

The Kappa test was used to analyze the agreement between the readings of the examiner regarding failure mode at different times.

The mean of bond strength distribution was checked with Shapiro Wilk test. One-way ANOVA and Bonferroni tests (SPSS 12.0; SPSS Inc., Chicago, IL, USA) were used for statistical analysis. The significance level was set at 5%.

Results

The Kappa test value was 0.84. After push-out test, some dentine cohesive failures were observed and those specimens were excluded from the bond strength calculations.

Table 1 presents the mean of bond strength values and failure modes distribution. One-way ANOVA revealed a significant difference among the groups (P = 0.0023). SS showed the higher mean of bond strength values, higher than all concentrations of NaOCl and CaOCl (P<0.05). CHX presented intermediary bond strength values, similar to those obtained in NaOCl and CaOCl groups (P>0.05).

Adhesive failures between cement/dentin (Ac/d) were predominant (58.33%), followed by cohesive (C) failures of dentin, cement or post (22.92%) and adhesive failures between cement/post (Ac/p) (18.75%). **Figure 1** represents the failure modes using optical microscopy at **7.5** magnification.

DISCUSSION

The present study evaluated the effect of different concentrations of NaOCl, CaOCl, CHX and SS on bond strength of fiber posts cemented using RelyX U200. The highest mean of bond strength values was found in SS group ($P < 0.05$). The bond strength values presented by NaOCl, CaOCl and CHX were similar ($P>0.05$), irrespective of the concentration used for naOCl and CaOCl. CHX presented intermediate values of bond strength. Thus, null hypothesis was rejected.

The manufacturer of the self-adhesive resin cement RelyX U200 recommends the use of NaOCl previously to fiber post cementation; however the criteria used for choosing this irrigant is not clear.

NaOCl ionized in aqueous solution releases hypochlorous acid (HOCL) and hydroxyl ions (OCl-), making acid the solution pH[12]. NaOCl is able to interact whit the organic portion of the dentine, but has a collagen degradation potential, which could adversely affect the bond strength. This fact was observed by Katalinic et al. (2013), where NaOCl was associated to lower bond strength values, but there was no difference between this solution, chlorhexidine and ozone gas. According to Da Silva et al. (2005), CHX promoted superior bond strength values when compared to the EDTA-NaOCl group.

It is known that CaOCl mechanism of action is given by the dissociation of calcium hydroxide and HOCl, suggesting that the high pH of this irrigant is due the dissolution of precipitated particles of calcium hydroxide[22]. CaOCl presents greater stability compared to NaOCl, because it presents higher concentration of active chlorine, in the same period and same conditions of storage[22]. Moreover, the released ions and the high chlorine level appears to explain the high antimicrobial effect[12]. De Almeida (2014) found lower values in microbial contamination groups using CaOCl associated to passive ultrasonic irrigation (PUI) for root canal disinfection, when compared to NaOCl with and without PUI. However, there was no statistical difference between the groups. Nevertheless, there is a lack of consistent information regarding the chemical properties of CaOCl at different concentrations, as well as their interaction with dentinal properties.

It is well established that CaOCl modified the root canal dentin roughness similarly to NaOCl, at the same concentrations, and both at a concentration of 5% significantly altered dentin roughness, overcoming EDTA association[31]. The present study stated that the concentration factor of the irrigants did not affect the average bond strength, once that NaOCl and CaOCl showed no statistical difference intra and inter-group ($P>0.05$). These findings may be explained by the fact that these specimens were subjected to different concentrations for the same short period. The specimens that presented higher concentrations were not exposed to a long period in contact with these solutions. Thus, no further degradation of the collagen was observed in these groups, resulting similar bond strength values.

CHX presents a wide spectrum of action, active against gram-positive and gram-negative microorganisms, as well as low cytotoxicity. However, it is not capable to dissolve organic tissue. Their substantivity is due to the combination of chlorhexidine to hydroxyapatite of the dentine, which assures the gradual release of the substance for long periods, capable to act until 120 days[40]. Recent studies have shown that CHX improves the longevity of composite adhesive bonding to dentin by inhibiting hybrid layer, collagen-degrading enzymes metalloproteinases (MMPs)[6].

According to Lindblad et al. (2010), CHX enhanced the bond strength of fiber posts to root dentine and significantly reduce the number of adhesive failures. The present results in accordance to Lindblad et al. (2010), as the CHX presented intermediate values of bond strength, but lower than SS group. However, Wang et al. (2013) showed that CHX 2% was not able to improve bond strength between fiber posts and root dentin when dual resin cement combined with different adhesive systems were used. In addition, it affected negatively the bond strength especially in the apical root third. However, Leitune et al. (2010) stated that CHX had no influence on bond strength of glass fiber posts cemented with resin cement. Kul et al. (2016) reported that prepared teeth with NaOCl + EDTA showed higher bond strength values when compared to CHX.

SS presents no antimicrobial and chelating properties. Therefore, it is used associated to CHX during root canal preparation in Endodontics. Da Silva et al. (2005) used SS associated to 2% CHX gel, and obtained the highest bond-strength values, statistically different to NaOCl-EDTA and control group (SS). The present study used SS as irrigant, and obtained the highest bond strength values, indicating that SS does not to contribute to collagen degradation.

No differences regarding the bond strength between different concentrations of NaOCl and CaOCl were found in this study (P>0.05). CHX showed intermediate values of bond strength compared to the other groups. This is in accordance to the study of Cecchin et al. (2015), when NaOCl demonstrated significant reduction in the flexural strength of dentin, in comparison to CHX. According to the authors, this results occurs because the morphological disorganization and loss of organic structure, mainly collagen, adversely affecting the mechanical properties of root dentin. The similarity of chemical composition of both hypochlorite formulations (NaOCl and CaOCl) seems to be associated with their similar behavior in root dentin, both capable to remove inorganic layer of dentin, as collagen, decreasing bond strength.

A negative factor associated to bond strength in root dentin is the limited capacity of the resin cements to dissipate tensions generated in polymerization shrinkage. The cavity configuration factor (C-factor) is related to the ratio of the adhesion area to the free area, being unfavorable in the root canal, responsible to created gaps between cement and dentine, affecting the sealing ability of resin cement[33]. Therefore, the cement-dentin interface is more susceptible to dentin adhesive failure, compared to cement-post interface. As expected, this fact was observed in this study, since the highest values founded was in cement-dentin group (58.33%), followed by cohesive failure (22.92%). Cement-post failures represented 18.75% of the specimens.

Representative specimens of adhesive and cohesive failures were illustrated by optical microscopy (Figure 1). In this study, it was used to illustrated and record the failure modes of the specimens. Presented as (A) Ac/d = Predominant Adhesive at cement/dentin failure; (B) Ac/p = Predominant Adhesive at cement/post interface failure; (C) C - Cohesive failure.

One of the limitations of this study was that samples were not submitted to thermal and mechanical cycling, to simulate intra-oral conditions more precisely. Another limitation it was that SS group does not correspond to clinical reality of Endodontics, once it has no antibacterial potential. Moreover, detailed information about the chemical properties of CaOCl are required.

Future studies should be conducted in order to establish the relation between chemical irrigating solutions and self-adhesive resin cements.

CONCLUSIONS

NaOCl and CaOCl negatively affect the bond strength of fiber posts to root dentine when cemented with self-adhesive resin cement; however the concentration of NaOCl and CaOCl did not affect this outcome. Despite the better results presented by control group (SS), this irrigant alone has no effect on root canal disinfection and must not be used alone during canal preparation.

Conflict of Interest

The authors claim none conflict of interest.

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Figures

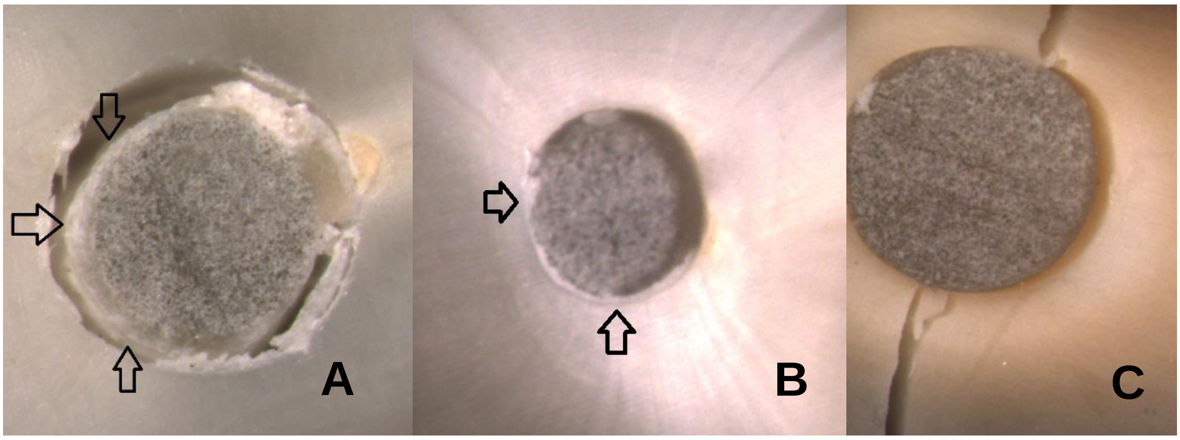

Figure 1- Optical microscopy of fiber post/self-adhesive resin cement and self-adhesive resin cement/root dentin interfaces. Failure modes are illustrated in A, B and C images. (A) Ac/d = Predominant Adhesive at cement/dentin failure (7.5x); (B) Ac/p = Predominant Adhesive at cement/post interface failure (7.5x); (C) DC - Dentin cohesive failure (7.5x).

Table

Table 1 - Mean of bond strength values and failure modes distribution after push-out test for the irrigants used previously to the post cementation

Groups	Bond strength	Ac/d	Ac/p	C	TOTAL
1% CaOCl	5.96 ± 2.62^b	21	6	3	30
1% NaOCl	5.74 ± 5.18^b	15	3	12	30
2.5% CaOCl	5.16 ± 3.39^b	17	13	0	30
2.5% NaOCl	6.10 ± 2.57^b	17	6	7	30
5% CaOCl	5.0 ± 2.38^b	20	7	3	30
5% NaOCl	5.85 ± 4.05^b	15	3	12	30
CHX	7.56 ± 2.47^b	18	5	7	30
SS	11.47 ± 5.32^a	17	2	11	30
	TOTAL	**140 (58.33 %)**	**45 (18.75 %)**	**55 (22.92%)**	**240 (100%)**

Different superscript letters identify statistically significant differences at the $P < .05$ level. Failure modes: Ac/d = Predominant Adhesive at cement/dentin interface failure; Ac/p = Predominant Adhesive at cement/post interface failure; C = Cohesive failures of dentin.

3 CONCLUSÃO

Diferentes soluções irrigadoras são utilizadas durante o tratamento endodôntico, e muitos estudos ainda foram realizados para avaliar o efeito que estas soluções exercem sobre a dentina (BITTER et al., 2012; Da SILVA et al., 2005; KATALINIC et al, 2013; KUL et al., 2016) . Entretanto, algumas soluções mais recentemente introduzidas, como o hipoclorito de cálcio (CaOCl), necessitam de evidências científicas sobre sua influência na resistência adesiva de pinos de fibra de vidro, cimentados com cimento resinoso autoadesivo, mais especificamente o RelyX U200.

Sabe-se que o hipoclorito de sódio (NaOCl) é uma solução capaz de remover a camada inorgânica de *smear layer* (SERAFINO et al., 2004; CLARKSON et al., 2006) e agir na porção orgânica da dentina. E por apresentar potencial de degradação do colágeno, poderia afetar negativamente a resistência adesiva (KATALINIC et al. 2013). O CaOCl possui alto nível de cloro, o que parece explicar o seu elevado efeito antimicrobiano (LEONARDO et al. 2016), e também apresenta grande poder de dissolução orgânica, como o NaOCl (DUTTA et al. 2012). No presente estudo, as soluções de NaOCl e CaOCl apesar das diferentes concentrações, parecem ter sido capazes de modificar a estrutura da dentina radicular, diminuindo os valores de resistência adesiva.

A clorexidina (CHX) mostra-se uma solução de amplo espectro de ação e elevada substantividade (SOUZA et al. 2016), além de melhorar a longevidade na ligação adesiva de compósitos à dentina por inibição da camada híbrida (CECCHIN et al. 2011). No presente estudo a CHX apresentou valores intermediários de resistência adesiva, menor apenas que o grupo solução salina (SS). Porém, os achados de Wang et al. (2013), Leitune et al. (2010) e Kul et al. (2016) mostram que a CHX afetou negativamente a resistência adesiva entre pinos de fibra de vidro e a dentina radicular.

A SS normalmente é associada a outra solução irrigadora no preparo endodôntico, pois não apresenta potencial antimicrobiano. Porém, como grupo controle neste estudo, talvez por não ter causado degradação do colágeno, resultou em valores superiores de resistência adesiva.

Os cimentos resinosos autoadesivos, como o RelyX U200, têm seu mecanismo de adesão através da retenção micromecânica e adesão química entre o agente de cimentação e o substrato dental (GERTH et al., 2006). Seu uso dispensa o condicionamento ácido e aplicação de um sistema adesivo, sendo que para potencializar a adesão destes cimentos à dentina é necessária uma adequada remoção prévia da camada de smear layer.

Sob as condições apresentadas nesse estudo, podemos concluir que as soluções de NaOCl e CaOCl afetam negativamente a resistência adesiva de pinos de fibra á dentina radicular, quando cimentados com cimento resinoso auto-adesivo RelyX U200. Assim como as diferentes concentrações de NaOCl e CaOCl não interferem neste resultado. O uso de SS parece ser adequado para lavagem do canal, prévia à cimentação de pinos de fibra de vidro cimentados com cimento resinoso autoadesivo RelyX U200. Porém, apesar de apresentar os melhores resultados, somente esta solução não é eficaz sobre a desinfecção do canal radicular e não deve ser usada sozinha durante a preparação do canal.

Entretanto, ainda se faz necessário a obtenção de mais informações á respeito das propriedades químicas e mecânicas do CaOCl sobre as propriedades dentinárias, bem como novos estudos precisam ser conduzidos a fim de estabelecer a relação entre soluções irrigadoras e os cimentos resinosos autoadesivos.

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ANEXO A - PARECER DE APROVAÇÃO DO COMITÊ DE ÉTICA EM PESQUISA (CEP)

UNIVERSIDADE FEDERAL DE SANTA MARIA/ PRÓ-REITORIA DE PÓS-GRADUAÇÃO E

Plataforma Brasil

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Efeito de diferentes soluções irrigadoras sobre a resistência adesiva de pinos de fibra de vidro, com utilização de cimento autoadesivo.

Pesquisador: Osvaldo Bazzan Kaizer

Área Temática:

Versão: 3

CAAE: 40740215.7.0000.5346

Instituição Proponente: Universidade Federal de Santa Maria/ Pró-Reitoria de Pós-Graduação e

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 984.334

Data da Relatoria: 31/03/2015

Apresentação do Projeto:

O projeto esta vinculado ao Programa de Pos-Graduacao em Ciencias Odontologicas e corresponde a uma dissertacao de mestrado. Trata-se de um estudo experimental in vitro, controlado, com mascaramento para os avaliadores.

Os pesquisadores irao utilizar 70 dentes doados pelo Banco de Dentes Permanentes Humanos da UFSM que serao submetidos a tratamento endodontico para posterior cimentacao de pino de fibra de vidro. Os especimes serao divididos em 7 grupos de acordo com a solucao usada para irrigacao do canal radicular antes da cimentacao de pino de fibra de vidro. As solucoes irrigadoras testadas serao hipoclorito de sodio e hipoclorito de calcio em diferentes concentracoes. Apos a cimentacao do pino, os dentes serao seccionados e submetidos a teste de resistencia adesiva e a microscopia eletronica de varredura para analise do padrao de falha.

Segundo revisao bibliografica apresentada, o hipoclorito de calcio com ultrassom pode auxiliar no preparo quimico-mecanico, contribuindo de forma significativa para a reducao do teor microbiano durante o tratamento do canal radicular. Porem, ainda nao existem estudos demonstrando se o hipoclorito de calcio de alguma forma interfere na adesao entre pinos de fibra de vidro e cimentos

Endereço: Av. Roraima, 1000 - prédio da Reitoria - 2º andar
Bairro: Camobi **CEP:** 97.105-970
UF: RS **Município:** SANTA MARIA
Telefone: (55)3220-9362 **E-mail:** cep.ufsm@gmail.com

para toda a comunidade cientifica, alem de oferecer tratamento adequado aos pacientes".

Comentários e Considerações sobre a Pesquisa:

O projeto de pesquisa esta muito bem escrito e detalhado. Apresenta tema atual e relevante pois novos materiais estao constantemente sendo lancados, o que exige pesquisas para que seu comportamento clinico seja testado. Os resultados devem oferecer maior seguranca aos pacientes quando da utilizacao dos referidos materiais.

Considerações sobre os Termos de apresentação obrigatória:

Registro do GAP e folha de rosto foram apresentados de maneira adequada.

Os pesquisadores apresentam tres autorizacoes institucionais: do coordenador do Curdo, do Chefe do Departamento de Odontologia Restauradora e do Coordenador do Programa de Pos-Graduacao em Ciencias Odontologicas.

O Termo de Confidencialidade esta redigido de maneira adequada e contem todas as informacoes necessarias.

Os pesquisadores propoe dispensa de TCLE pois irao utilizar dentes humanos doados pelo Banco de Dentes. A justificativa e aceitavel. O documento do Banco de Dentes comprometendo- se com a doacao dos dentes foi anexado pelos pesquisadores.

Recomendações:

Veja no site do CEP - http://w3.ufsm.br/nucleodecomites/index.php/cep - na aba "orientacoes gerais", modelos e orientacoes para apresentacao dos documentos. Acompanhe as orientacoes disponiveis, evite pendencias e agilize a tramitacao do seu projeto.

Conclusões ou Pendências e Lista de Inadequações:

O projeto como reapresentado não apresenta pendências.

Situação do Parecer:

Aprovado

Necessita Apreciação da CONEP:

Não

ANEXO B – NORMAS PARA A PUBLICAÇÃO NO PERIÓDICO OPERATIVE DENTISTRY

Authors Guide for publication on Operative Dentistry:

Manuscript submission General Requirements

Operative Dentistry requires electronic submission of all manuscripts. All submissions must be sent to Operative Dentistry using the Allen Track upload site. A mandatory and nonrefundable $25.00 fee is required at submission. Your manuscript will only be considered officially submitted after it has been approved through our initial quality control check, and any quality problems have been resolved. You will have 6 days from when you start the process to submit and approve the manuscript. After the 6 day limit, if you have not finished the submission, your submission may be removed from the server. You are still able to submit the manuscript, but you must start from the beginning. Be prepared to submit the following manuscript files in your upload:

• A Laboratory or Clinical Research Manuscript file must include: a title; a running (short) title; a clinical relevance statement; a concise summary (abstract); Current as of: introduction, methods & materials, results, discussion and conclusion; references (see Below).

• The manuscript body MUST NOT include any: o Author identifying information such as: ♣ Authors names or titles ♣ Acknowledgements ♣ Correspondence information ♣ Response to reviewer files should also NOT include any author identifying information, such as a signature at the end, etc. Figures, Graphs, Tables.

• An acknowledgement, disclaimer and/or recognition of support (if applicable) must in a separate file and uploaded as supplemental material.

• All figures, illustrations, graphs and tables must also be provided as individual files. These should be high-resolution images, which are used by the editor in the actual typesetting of your manuscript. Please refer to the instructions below for acceptable formats and sizes.

• All other manuscript types use this template, with the appropriate changes as listed below.

Complete the online form (which includes complete author information, copyright release and conflict of interest), and select the files you would like to send to Operative Dentistry. Manuscripts that do not meet our formatting and data requirements listed below will be sent back to the corresponding author for correction.

Important Information

• All materials submitted for publication must be submitted exclusively to Operative Dentistry.

• The editor reserves the right to make literary corrections.

• Currently, color will be provided at no cost to the author if the editor deems it essential to the manuscript. However, we reserve the right to convert to gray scale if color does not contribute significantly to the quality and/or information content of the paper.

• The author(s) retain(s) the right to formally withdraw the paper from consideration and/or publication if they disagree with editorial decisions.

• International authors whose native language is not English must have their work reviewed by a native English speaker prior to submission. Manuscripts that are rejected before peer-review for English correction should be entered as a new manuscript upon resubmission. In the manuscript comments box the comment, “this is a resubmission of manuscript number XX-XXX” should be noted. Manuscripts that are rejected after peer-review are not eligible for resubmission. Manuscripts that have major revisions requested (i.e. For English correction) are entered as a resubmission of the original article.

• Spelling must conform to the American Heritage Dictionary of the English Language, and SI units for scientific measurement are preferred.

• While we do not currently have limitations on the length of manuscripts, we expect papers to be concise; authors are also encouraged to be selective in their use of figures and tables, using only those that contribute significantly to the understanding of the research.

• Acknowledgement of receipt is sent automatically upon acceptance through quality control. This may take up to 7 days. If you do not receive such an acknowledgement, please check your author homepage at http://jopdent.allentrack.net if the paper does not appear there please resend your paper.

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Manuscript Type Requirements
All Manuscripts

CORRESPONDING AUTHOR must provide a WORKING / VALID e-mail address which will be used for all communication with the journal.
NOTE: Corresponding authors MUST update their profile if their e-mail or postal address changes. If we cannot contact authors within seven days, their manuscript will be removed from our publication queue.

AUTHOR INFORMATION must include:
- full name of all authors
- complete mailing address for each author
- valid email address for each author
- degrees (e.g. DDS, DMD, PhD)
- affiliation (e.g. Department of Dental Materials, School of Dentistry, University of Michigan)

MENTION OF COMMERCIAL PRODUCTS/EQUIPMENT must include:
- full name of product
- full name of manufacturer
- city, state and country of manufacturer

MANUSCRIPTS must be provided as Word for Windows files. Files with the .doc and .docx extensions are accepted.
TABLES may be submitted as either Word (.doc and .docx) or Excel (.xls and .xlsx) files. All tables must be legible, with fonts being no smaller than 7 points. Tables have the following size limitations: In profile view a table must be no larger than 7 x 9 inches; landscape tables should be no wider than 7 inches. It is the Editor's preference that tables not need to be rotated in order to be printed, as it interrupts the reader's flow.
ILLUSTRATIONS, GRAPHS AND FIGURES must be provided as TIFF or high resolution JPEG files with the following parameters:
• line art (and tables that are submitted as a graphic) must be sized with the short edge being no shorter than 5 inches. It should have a minimum resolution of 600 dpi and a maximum resolution of 17 Current as of: 1200 dpi. This means the shortest side should be no smaller than 3000 pixels.
• gray scale/black & white figures must be sized with the short edge being no shorter than 5 inches. It should have a minimum resolution of 300 dpi and a maximum of 400 dpi. This means the shortest side should be no smaller than 1500 pixels.
• color figures and photographs must be sized with the short edge being no shorter than 3.5 inches. It should have a minimum resolution of 300 dpi and a maximum of 400 dpi. This means that the shortest side should be no smaller than 1050 pixels.

Other Manuscript Type – Additional Requirements
CLINICAL TECHNIQUE/CASE STUDY MANUSCRIPTS must include as part of the narrative:
- a running (short) title
- purpose
- description of technique
- list of materials used
- potential problems
- summary of advantages and disadvantages
- references (see below)

LITERATURE AND BOOK REVIEW MANUSCRIPTS must include as part of the narrative:
- a running (short) title
- a clinical relevance statement based on the conclusions of the review
- conclusions based on the literature review…without this, the review is just an exercise and will not be published
- references (see below). References must be numbered (superscripted numbers) consecutively as they appear in the text and, where applicable, they should appear after punctuation. The reference list should be arranged in numeric sequence at the end of the manuscript and should include:

1. Author(s) last name(s) and initial (ALL AUTHORS must be listed) followed by the date of publication in parentheses.

2. Full article title.

3. Full journal name in italics (no abbreviations), volume and issue numbers and first and last page numbers complete (i.e. 163-168 NOT attenuated 163-68).

4. Abstracts should be avoided when possible but, if used, must include the above plus the abstract number and page number.

5. Book chapters must include chapter title, book title in italics, editors' names (if appropriate), name of publisher and publishing address.

6. Websites may be used as references, but must include the date (day, month and year) accessed for the information.

7. Papers in the course of publication should only be entered in the references if they have been accepted for publication by a journal and then given in the standard manner with "In press" following the journal name.

8. DO NOT include unpublished data or personal communications in the reference list. Cite such references parenthetically in the text and include a date.

9. References that contain Crossref.org's DOIs (Digital Object Identifiers) should always be displayed at the end of the reference as permanent URLs. The prefix http://dx.doi.org/ can be appended to the listed DOI to create this URL. i.e. http://dx.doi.org/10.1006/jmbi.1995.0238

Reference Style Guide

• Journal article-two authors: Evans DB & Neme AM (1999) Shear bond strength of composite resin and amalgam adhesive systems to dentin American Journal of Dentistry 12(1) 19-25.

• Journal article-multiple authors: Eick JD, Gwinnett AJ, Pashley DH & 19 Current as of: 3-Sep-14 Robinson SJ (1997) Current concepts on adhesion to dentin Critical Review of Oral and Biological Medicine 8(3) 306-335.

• Journal article: special issue/supplement: Van Meerbeek B, Vargas M, Inoue S, Yoshida Y, Peumans M, Lambrechts P & Vanherle G (2001) Adhesives and cements to promote preservation dentistry Operative Dentistry (Supplement 6) 119-144.

• Abstract: Yoshida Y, Van Meerbeek B, Okazaki M, Shintani H & Suzuki K (2003) Comparative study on adhesive performance of functional monomers Journal of Dental Research 82(Special Issue B) Abstract #0051 p B-19.

• Corporate publication: ISO-Standards (1997) ISO 4287 Geometrical Product Specifications Surface texture: Profile method – Terms, definitions and surface texture parameters Geneve: International Organization for Standardization 1st edition 1-25.

• Book-single author: Mount GJ (1990) An Atlas of Glass-ionomer Cements Martin Duntz Ltd, London.

• Book-two authors: Nakabayashi N & Pashley DH (1998) Hybridization of Dental Hard Tissues Quintessence Publishing, Tokyo.

• Book-chapter: Hilton TJ (1996) Direct posterior composite restorations In: Schwarts RS, Summitt JB, Robbins JW (eds) Fundamentals of Operative Dentistry Quintessence, Chicago 207-228.

• Website-single author: Carlson L (2003) Web site evolution; Retrieved online July 23, 2003 from: http://www.d.umn.edu/~lcarlson/cms/evolution.html

• Website-corporate publication: National Association of Social Workers (2000) NASW Practice research survey 2000. NASW Practice Research Network, 1. 3. Retrieved online September 8, 2003 from: http://www.socialworkers.org/naswprn/default

• Journal Article with DOI: SA Feierabend, J Matt & B Klaiber (2011) A Comparison of Conventional and New Rubber Dam Systems in Dental Practice. Operative Dentistry 36(3) 243-250, http://dx.doi.org/10.2341/09-283-C 20.

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