Coll. Antropol. **37** (2013) 2: 431–435
Original scientific paper

Microleakage along Glass-Fibre Posts Cemented with Three Different Materials after Cyclic Loading: A Pilot Study

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ABSTRACT

The purpose of this in vitro study was to evaluate microleakage along glass-fibre posts cemented with three different cements after cyclic loading. After post-space preparation, fifty obturated root canals were randomly divided into three experimental groups and two control groups. In group 1, Glassix posts were cemented using Harvard cement, in group 2, Fuji PLUS cement was used and in group 3, Variolink II was used for post cementation. The specimens were artificially aged by loading in a special testing machine. Coronal leakage was evaluated using a fluid transport system. Posts cemented with Variolink II, showed significantly higher failure rate after loading, compared to group 1 and 2 (p=0.009). Comparing microleakage in samples that have not failed, specimens cemented with Variolink II showed significantly less fluid transport than specimens cemented with zinc phosphate and glass ionomer cements (p=0.04 and p=0.006, respectively). Variolink II cement exibited significantly less fluid movement compared with Harvard and Fuji PLUS cement.

***Key words**: cement, composite, glass-fibre, microleakage, post*

Introduction

Restoration with a post is often required after endodontic treatment[1]. Posts help protect the apical seal from bacterial contamination caused by the coronal leakage[2]. However, root canal filling remaining after the post placement still has to provide a bacteria tight seal for successful endodontic treatment[3].

Fiber posts are alternatives to cast and prefabricated metal posts and have several advantages, like aesthetics, bonding to the tooth structure and a modulus of the elasticity similar to that of dentin[4]. An advantage of glass fiber posts is that they distribute stress over a broad surface area, increasing the load threshold at which the post begins to show evidence of micro-fractures[5]. Glass fiber posts flex under load and, as a result, distribute stresses between the post and dentin[6] which results in favorable clinical behavior[7,8]. Glass fibre posts can also be expected to function efficiently against fatigue stress[9].

Types of cement for post cementation also affect microleakage. Different materials can be used for cementation of fibre posts but none fulfills all requirements. Zinc-phosphate cement does not adhere to the tooth structure[10]. On the other hand, glass-ionomer cements adhere to dentin via micromechanical and chemical bonding mechanisms[11]. Composite resin cement should establish a strong bond to the dentinal walls of the root canal and the post surface, increasing retention. When fiber posts are cemented following adhesive concepts, hibridization of the intraradicular dentin should also improve the coronal seal[12–14].

After post cementation, a unit made from several different materials: tooth structure, root canal filling material, post, luting cement, should provide adequate seal, although the interfaces of the various materials or tissues are the sites of possible leakage[15].

Received for publication December 9, 2010

During daily normal occlusal and masticatory function, both the natural and restored teeth are subjected to a number of cyclic loads and fatigue[9]. Fatigue is considered as one of the main causes of structural failure in restorative dentistry[16,17]. Fatigue tests can reveal the resistance level of each type of post under cyclic loading, which simulates the normal occlusal and masticatory function[18–20]. Furthermore, *in vitro* tests involving fatigue cycles have the potential to predict clinical outcome[21].

Rogic-Barbic et al.[22] performed a study on microleakage of glass fibre posts cemented with different materials, but there is little information on microleakage after cyclic loading of glass fibre posts cemented with different cements.

The aim of this *in vitro* pilot study was to evaluate microleakage along glass-fibre posts cemented with three different cements after cyclic loading.

Materials and Methods

Fifty human upper central incisors, stored in 10% formalin solution, were used for this study. The teeh were extracted for periodontal reasons. After mechanical cleaning, the teeth were stored in deionized water with a few thymol crystals (SIGMA Ltd, Poole, UK) at 100% humidity and 37 °C[23]. Prior to the study, the crowns of the teeth were removed at the cemento-enamel junction using a water-cooled diamond drill (GV878K.314.014, Diacut, Edenta, Switzerland). To ensure that all specimens were of the same length, they were resected 15 mm from the apex. All specimens were randomly divided into three experimental and two control groups (n=10 per group). A size #15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) was introduced into each canal until it was just visible at the apical foramen and the working length was determined by withdrawing the instrument 1 mm. The root canals were instrumented using the step-back technique to the size #40 K-file (Dentsply Maillefer, Ballaigues, Switzerland) at the apical stop and with a serial step-back up to the size #80 K-file (Dentsply Maillefer, Ballaigues, Switzerland). After the use of each file, canal was irrigated with 2.5 mL of 2.5% sodium hypochlorite solution (NaOCl) using a disposable syringe and 27-gauge needle. To remove the smear layer, root canals were rinsed with 5 mL 17% EDTA (pH 7.7) for 3 min[24,25]. Final irrigation of the samples was carried out with 10 mL of 2.5% NaOCl, after which the canals were dried using paper points size # 40 (META Dental Corp., Seoul, Korea). All specimens in the three experimental groups and negative control group were obturated using a cold lateral condensation technique. The master gutta-percha cone size #40 (VDW GmbH, Munich, Germany) was coated with the AH Plus sealer (DeTrey Dentsply, Konstanz, Germany), gently seated to the full working length and laterally condensed with a finger spreader size #25 (VDW GmbH, Munich, Germany). Accessory gutta-percha cones size #25 (VDW GmbH, Munich, Germany), coated with the same sealer, were inserted until the finger spreader no longer penetrated deeper than two millimetres into the mass of gutta-percha. After obturation, excess was removed with hot pluggers 1 mm from the cemento-enamel junction. The specimens without temporary fillings (26) were stored in saline solution at the room temperature for two weeks. Radiographs of the obturated root canals were taken from two directions to confirm the quality of the root canal fillings. The specimens in the positive control group were obturated using gutta-percha cones without the sealer.

Coronal portions of the obturated root canals in experimental groups were prepared using a calibrated reamer for the Glassix posts No.3 (Harald Nordin SA, Chailly/ Montreux, Switzerland) to a depth of 11 mm: 4 mm of AH Plus/gutta-percha remained as the apical filling. After post-space preparation, in group 1, Glassix posts were cemented using Harvard cement (Richter & Hoffmann, Harvard Dental GmbH, Berlin, Germany), in group 2, Fuji PLUS cement (GC Corporation, Tokyo, Japan) was used and in group 3, Variolink II with Excite DSC (Vivadent, Schaan, Lichtenstein) was used for post cementation. All materials were used according to the manufacturers' instructions (Table 1). Exposed coronal parts of Glassix posts were 4 mm long. All specimens were stored at 100% humidity and 37 °C for the next 48 h to allow complete setting of the material.

Coronal abutments were restored with a composite core material in experimental groups (Clearfil core, Kuraray, Osaka, Japan) and cast metal crowns cemented with Harvard cement. Composite cores were made using hand instruments and abutments were prepared with a water-cooled diamond drills. Central parts of the palatal surfaces were cut at an angle of 130°, 2 mm form the margins of the core (Figure 1). Metal cast crowns were made 7 mm high in the form of maxillary central incisors. Specimens were embedded in acrylic resin 2 mm below the margin of metal crown restorations (Figure 2) and artificially aged by loading in a special testing machine (Đuro Đakovic d.o.o. Center for Research and Development, Slavonski Brod, Croatia). A load was applied at the palatal surface at an angle of 135° to the long axis of the tooth (Figure 3) with forces oscillating from 0 to 35 N. Each specimen was exposed to load aging of 700 000 cycles through the period of 148 h. After cyclic loading, specimens were prepared for the measurements of microleakage. The acrylic bases were removed and the metal crowns were cut off and removed together with the composite cores and the coronal parts of the Glassix posts. After this procedure, 15 mm long radices remained. The outer surfaces of the roots were than coated with two layers of nail varnish, except for the apical 2 mm of roots in experimental groups and positive control group[27]. The entire root surface of the specimens in the negative control group, including the orifices and foramina, were sealed with two layers of nail varnish.

Coronal leakage was evaluated using a fluid transport system[28]. The ends of a resin T-tube were warmed and fitted to the root end. The syringe, the capillary tube and the connections were glued with cyanoacrylate glue. The

TABLE 1
CHEMICAL COMPOSITION AND APPLICATION PROCEDURE OF FUJI PLUS, HARVARD, VARIOLINK II AND EXCITE DSC, ACCORDING TO THE MANUFACTURER

Chemical composition Application mode

Fuji Plus – distilled water, polyacrylic acid, HEMA Dentin conditioner is applied for 20 s in root canal, rinsed with UDMA, alumino-silicate glass water and dried with paper points. The cement is mixed and applied into the root canal with a post.

Harvard-zinc oxide, magnesium oxide, phosporic The cement is mixed and applied into the root canal with a post.

acid

Variolink II Bis-GMA, UDMA, TEGDMA, Phosphoric acid gel (37%) is applied for 10–15 s, removed with barium glass, ytterbium trifluoride, Ba-Al fluorosilicate water spray for 5 s and the root canal id dried with air and paper glass, spheroide oxide, catalysts, stabilizers, pigments points. The adhesive is applied, Variolink II is mixed and applied in root canal. After the placement of the post, halogene lamp is used for polymerization for 40 s.

Excite DSC- HEMA, dimethacrylates, phosphonic acid The adhesive is applied to root canal, gently agitated for 10 s acrylate, silicone dioxide, initiators, stabilizers, alcohol and the root canal dried with paper points.

solution

Bis-GMA: Bisphenol A-glycidyl methacrylate; HEMA: hydroxyethylmethacrylate; 4-META: 4-methacryolxyethyl trimellitate anhydride; UDMA: urethane dimethacrylate monomer; TEGDMA: triethylenglycol dimethacrylate.

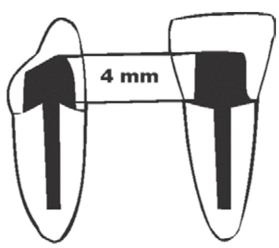

Fig. 1. Preparation of specimens with central parts of the palatal surfaces cut at an angle of 130°, 2 mm form the margins of the core.

Fig. 2. Specimens with metal cast crowns embedded in acrylic resin.

Fig. 3. Cyclic loading in the testing machine, with the load applied at the palatal surface.

seals were checked under water by placing the system under air pressure from the end of the capillary tube. A plastic tube filled with deionized water was connected to the coronal end of the filled root. This connection was closed tightly by twisting a piece of stainless steel wire, 0.3 mm in diameter. Water was sucked back with the syringe for approximately 3 mm in the open end of the glass capillary tube and then connected to the piece of plastic tube filled with water. In this way, an air bubble was created in the capillary tube. Applying a head space pressure of 10 kPa (0.1 atm) from the coronal side of the filled root, it forced the water through the voids along the root canal filling and displaced the air bubble in the capillary tube by transporting the water. The volume of transported fluid was measured by observing the movement of the air bubble over a 5 min time period. Measurements were performed 4 times for each specimen, and the mean values were recorded.

The failure rate of posts were analyzed using the test of differences between proportions while the data on microleakage obtained for all experimental groups were analyzed using the ANOVA. The level of significance was set at 5%.

Results

Group 3, with posts cemented with Variolink II, showed significantly higher failure rate regarding staying in place after loading, compared to groups 1 and 2 ($p=0.009$). In group 3, 60% of specimens exibited failure after cyclic loading, while in group 1 and 2 no specimens showed failure.

The results of the quantitative evaluation of the microleakage in all three experimental groups are shown in Table 2. Comparing microleakage in samples that have not failed, specimens in group 3 showed significantly less fluid transport than specimens from group 1 and 2 ($p=0.04$ and $p=0.006$, respectively). There was no statistically significant difference in microleakage between specimens in groups 1 and 2 ($p>0.05$).

TABLE 2
THE MICROLEAKAGE VALUES FOR THE EXPERIMENTAL AND CONTROL GROUPS

Group	N	Mean±SD
Fuji Plus cement	10	0.55±0.21
Harvard cement	10	0.67±0.32
Variolink II	10	0.22±0.08
positive control	10	2.06±0.26
negative control	10	0

N – number of specimens, SD – standard deviation

Discussion

In this *in vitro* pilot study, none of the materials for glass fibre post cementation exhibited fluid-tight seal after cyclic loading. Glassix posts cemented with composite resin-based cement resulted in significantly less microleakage measured by the fluid transport than the zinc--phosphate and glass-ionomer cements. However, over half of specimens cemented with Variolink II exhibited failure regarding staying in place after cyclic loading. Loss of retention may result from failure of the bond to root canal dentin, which was proven to be less reliable than adhesion at the coronal level[29–33]. Another possible explaination for failure in composite resin based cement specimens is delamination between luting material and adhesive[34]. The exceedingly high C-factors that are encountered in deep and narrow post-space preparation cavities can influence the integrity of resin-dentin bonds created in post and root canal dentin walls[35]. Furthermore, application of dentin bonding systems can result in de-bonding over time, with aging of the restorations[36]. Aging of the samples in the present study was simulated by cyclic fatigue. Cementation of fiber posts with resin--based cements in root canals obturated with AH Plus and gutta-percha, like in the present study, cannot provide an adhesive bond and a »monoblock«, which could explain the failure of specimens with Glassix posts cemented with composite resin cement after cyclic loading. Moreover, Albashaireh et al.[37] showed in their study an adhesive failure mode at the resin cement glass fiber post interface under the stereomicroscope.

Ideally, cementation of posts should create gap free interfaces that produce high, immediate interfacial strengths and do not allow microleakage. Resin cement should establish a strong bond to the dentinal walls of the root canal and the post surface, increasing retention and minimizing the microleakage. The monoblock concept of achieving total bonding that extends from the post surface to the intraradicular dentin was proposed initially as the retention mechanism of fiber posts[38]. Glass ionomer cements have also been proposed for fibre post cementation[31]. Although glass ionomer cements shrink during setting, their viscoelastic properties render them more favorable to the preservation of bond integrity than the stiffer resin-based cements[39]. Moreover, postmaturation hygroscopic expansion of glass ionomer cements offsets their initial setting shrinkage which may result in more intimate cement-substrate adaptation as these bonds mature[40,41]. However, glass-ionomer cements in the present study exhibited higher microleakage in comparison to resin-based cement. Resin-modified glass ionomer cements, like Fuji Plus used in this study, release fluoride and contain resin components for improved physical and mechanical properties[42–44]. Modulus of elasticity parameters relate to resistance to cement deformation and to marginal gap formation[45,46]. A cement with a high modulus of elasticity is important to prevent microleakage[45,46]. It has been suggested that luting agents should have a modulus of elasticity value similar to that of dentin[47]. Attar et al.[48] found that composite resin cement has higher modulus of elasticity in comparison to resin modified glass ionomer cement, which could explain less microleakage along fibre posts cemented with Variolink II in comparison to posts cemented with Fuji Plus in the present study.

A study by Rogic-Barbic et al.[22] reported similar results to the results of the present study, with Variolink II cement exibiting the least microleakage of the cements tested. However, glass-ionomer cement provided better seal in comparison to zinc-phosphate cement according to Rogic-Barbic et al.[22] which is contrary to the results of our study with no difference in microleakage between specimens cemented with Fuji Plus and Harvard cement. Possible explanation is the influence of cyclic loading on microleakage along glass fibre posts cemented with different materials. In a study by Bachicha et al.[49], examining the fluid microleakage along carbon fibre posts, zinc--phosphate cement exhibited higher leakage in comparison to composite resin cement, which is in accordance with the results of the present study.

In this pilot study, only specimens with glass-fibre posts cemented with Variolink II showed failure after cyclic loading. None of the materials for glass fibre post cementation provided a fluid-tight seal. Variolink II cement exhibited significantly less fluid movement compared with Harvard and zinc-phosphate cements. Further studies, including larger number of specimens, are necessary to evaluate microleakage along glass-fibre posts cemented with different cements and failure rate after cyclic loading.

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MIKROPROPUŠTANJE UZDUŽ VLAKNIMA POJAČANIH STAKLENIH KOLČIĆA NAKON CIKLIČKOG OPTEREĆENJA: PILOT ISTRAŽIVANJE

S A Ž E T A K

Svrha istraživanje bila je ispitati mikropropuštanje uzduž vlaknima pojačanih staklenih kolčića cementiranih s tri različita cementa nakon cikličkog opterećenja. Nakon preparacije za postavljanje kolčića, pedeset korijena su slučajnim odabirom podijeljeni u tri eksperimentalne i dvije kontrolne skupine. U skupini 1, Glassix kolčići su cementirani Harvard cementom, u skupini 2 koristio se Fuji PLUS cement, a u skupini 3 Variolink II cement. Starenje uzoraka je postignuto cikličkim opterećenjem u posebnom uređaju za testiranje. Za ispitivanje koronarnog propuštanja, koristio se model za prijenos tekućine. Kolčići cementirani Variolink II cementom su pokazali statistički značajno veći neuspjeh nakon cikličkog opterećenja u usporedbi s kolčićima u skupinama 1 i 2 (p=0,009). U uzorcima koji se nisu odcementirali nakon cikličkog opterećenja, a koji su bili cementirani Variolink II cementom, mikropropuštanje je bilo statistički značajno manje u usporedbi s uzorcima koji su cementirani cink fosfatnim i staklenoionomernim cementom (p=0,04 i p=0,006). Variolink II cement je pokazao manje propuštanje u usporedbi s Harvard i Fuji PLUS cementom.