Acta Odontologica Scandinavica. 2014; 72: 376–379

ORIGINAL ARTICLE

Effect of gutta-percha solvents on the bond strength of two resin-based sealers to root canal dentin

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Abstract

Objective. To evaluate the effect of two gutta percha solvents on the bond strength of two resin-based sealers to root canal dentin. ***Materials and methods.*** Root canals of extracted single rooted human mandibular premolars (n = 60) were decoronated and instrumented with a rotary NiTi system to an apical size of 40 and randomly divided into three groups (n = 20) based on the chemical treatment: Group I, saline (control); group II, Xylene and group III, Endosolv E. All groups were divided into two sub-groups (n = 10) based on the root filling material: sub-group A, epoxy resin sealer (AH Plus); sub-group B, methacrylate resin sealer (Epiphany). Roots were then sectioned and push-out tests were performed. The data was analysed using two-way analysis of variance (ANOVA) and a multiple comparison test (p = 0.05). ***Results.*** There was a significant difference in bond strength of both sealers between the control and test groups ($p < 0.05$). The bond strength of the epoxy resin sealer (sub-group A) in group II was significantly lower than in group III ($p < 0.05$). However, there was no significant difference between groups II and III for the methacrylate resin sealer (sub-group b) ($p > 0.05$). ***Conclusions.*** Gutta Percha solvents had an adverse effect on bond strengths of resin sealers to root canal dentin. This was dependent on the chemistry of the solvent and the sealer.

Key Words: *AH plus, bond strength, Endosolv E, epiphany, xylene*

Introduction

Removal of root filling material is deemed necessary in cases of non-surgical endodontic re-treatment and prior to post placement. Gutta-percha is the most commonly used root filling material. Various methods to remove the gutta percha have been suggested which include the use of solvents, heat and mechanical instrumentation, either alone or in combination [1]. The removal of gutta percha is greatly simplified by organic solvents which soften and dissolve gutta percha and sealers in the root canal and also facilitate penetration and subsequent removal by hand instrumentation [2].

The most commonly used gutta percha solvents are chloroform and xylene [3]. Owing to its carcinogenic effect, the use of chloroform has been questioned in endodontics [4]. Xylene can be used as an alternative to chloroform as it is not considered as a potential carcinogen. Various other solvents like halothane, eucalyptol, turpentine, orange oil, Endosolv E and Endosolv R have been utilized for the same purpose [5].

During gutta percha removal, the root canal dentin is exposed to gutta percha solvents. This is of clinical significance, as these solvents may alter the physical and chemical properties of dentin [6]. The effects of several medications on bond strength to root canal dentin have been studied previously. The adverse effects of sodium hypochlorite and hydrogen peroxide on resin–dentin bond strength also have been reported [7,8], but there is sparse information in the literature about the side-effects of these solvents on dentin. It is of paramount importance to, therefore, test the effect of these solvents on dentin, as their injudicious use may cause problems during final restoration.

The purpose of this *in vitro* study was to evaluate the effect of these solvents on push out bond strength to root canal dentin. The null hypothesis was that these

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(Received 9 January 2013; accepted 29 August 2013)

ISSN 0001-6357 print/ISSN 1502-3850 online © 2014 Informa Healthcare
DOI: 10.3109/00016357.2013.841987

solvents have no effect on resin-radicular dentin bond strength.

Materials and methods

Human single-rooted maxillary canines ($n = 60$) were collected and thoroughly cleaned by removing the hard deposits using curettes and the soft deposits by soaking in 5.25% NaOCl for 10 min. The teeth were decoronated at the cemento–enamel junction using a diamond disc, under water-cooling. The root lengths were standardized to 15 mm. The teeth were radiographed (DSX 730, Owandy Dental Imaging, Champs sur Marne, France; Kodak 2100 X ray unit, Kodak Dental Systems, Atlanta, GA) at different angulations to confirm the presence of a single canal. Working length was established using a size 10 K-file (Mani Inc, Tochigi, Japan) to the root canal terminus and subtracting 0.5 mm from this measurement.

The root canals were instrumented using Mtwo nickel titanium rotary instruments (VDW GmbH, Munich, Germany) up to size 40, 0.04 taper. Irrigation was performed with 3% sodium hypochlorite, using a 5 mL disposable plastic syringe with a polypropylene capillary tip (Ultradent Products Inc., South Jordan, UT). The tip was placed passively into the canal, up to 2 mm from the apical foramen without binding. All root canals were irrigated with 5 mL of 17% EDTA (Pulpdent, Watertown, MA) for 1 min to remove the smear layer and then rinsed with 5 mL of distilled water.

The specimens were randomly divided into three groups ($n = 20$) based on the chemical treatment to be received. The root canals of specimens in Groups I, II and III were irrigated with saline, xylene and Endosolv E, respectively. The quantity of the solvents used was 5 mL for a duration of 5 min. The root canals were dried using paper points and further divided into two sub-groups ($n = 10$): specimens of sub-group A were filled with an epoxy resin sealer (AH Plus, Dentsply DeTrey, Konstaz, Germany), while specimens of sub-group B were filled with a methacrylate resin sealer (Epiphany, Pentron Clinical Technologies, CT). In sub-group B, the Epiphany primer was applied on the root canal walls using a paper point prior to placement of the sealer. Following this, the sealer was light-cured for 40 s. The root canals were sealed with a temporary filling material and specimens were stored at 37°C and 100% humidity for 24 h.

Preparations of root slices for push-out bond strength testing

Each root was embedded in epoxy resin in a custom-made split-ring copper mould. After setting of the epoxy resin, 12 slices (1 mm thick) were obtained from each root (four per each root third) using a water-cooled precision saw (Ernst-Leitz, Wetzlar, Germany). The first slice of each root third was selected for the push-out test. Each specimen was marked on its coronal surface with an indelible marker and the exact thickness of each slice was measured using a digital caliper to 0.04 mm accuracy (Mitutoyo, Tokyo, Japan).

Each section was coded and measured for the apical and coronal diameters of the obturated area using an Olympus Camedia C-5060 digital camera (Tokyo, Japan) attached to a stereomicroscope (Global G6, St Louis, MO). Each root section was then subjected to a compressive load via a universal testing machine (LIoyd LRX-plus; LIoyd Instruments Ltd, Fareham, UK) at a crosshead speed of 1 mm/min using a 0.8-mm diameter stainless steel cylindrical plunger. The plunger tip was positioned so that it only contacted the filling material. The push-out force was applied in an apico-coronal direction until bond failure occurred, which was manifested by extrusion of the epoxy resin obturation material and a sudden drop along the load deflection. The force was recorded by using Nexygen data analysis software (Lloyd Instruments Ltd). The maximum failure load was recorded in Newtons and was used to calculate the push-out bond strength in megapascals (MPa) according to the following formula [9,10]. Push-out bond strength (MPa) = N/A ; where N = Maximum load (N), A = Adhesion area of root canal filling (mm^2).

The adhesion (bonding) surface area of each section was calculated as: $(\pi r_1 + \pi r_2) \times L$, where $L = \sqrt{(r_1 - r_2)^2 + h^2}$; where π is the constant 3.14, r_1 and r_2 are the smaller and larger radii, respectively, and h is the thickness of the section in millimetres. The data was analysed by using two-way analysis of variance and multiple comparison test. The significance level set at 0.05.

Results

The mean values of bond strengths recorded for test groups are presented in Table I. Statistical analysis revealed a significant difference in bond strength between Group I and the solvent treated groups for both the sealers ($p < 0.05$). The bond strength of the epoxy resin sealer (sub-group a) was significantly

Table I. Push out bond strength values (MPa; mean ± standard deviation) of the sealers following treatment with different solvents.

	A- AH Plus	B - Epiphany
Group I - saline	4.07 ± 0.04^a	4.12 ± 0.19^a
Group II - xylene	0.95 ± 0.29^b	1.20 ± 0.39^b
Group III - Endosolv E	3.10 ± 0.40^c	2.15 ± 0.69^b

Mean values that share a superscript letter were not significantly different at the 5% level within the same time point (2-way ANOVA).

different between groups II and III ($p < 0.05$). However, there was no significant difference between groups II and III for the methacrylate resin sealer (sub-group b) ($p > 0.05$).

Discussion

One of the objectives of root canal obturation is to create a fluid-tight seal and also to seal any microorganisms that could not be entirely removed during cleaning and shaping procedures. In addition, sealers should demonstrate adhesive properties to dentin, which may lead to greater strength of the restored tooth and its clinical longevity [11,12].

Solvents are routinely used to facilitate the removal of gutta percha and sealers from the root canal system. Chloroform is a commonly used gutta percha solvent because it dissolves gutta percha rapidly [13]. However, chloroform tends to dissolve the gutta percha rapidly, leaving residues on the walls of the pulp chamber. Xylene, on the other hand, dissolves the gutta percha more slowly, thus allowing for better removal of softened gutta percha [14]. Owing to the growing concerns about chloroform, clinicians and researchers have developed a renewed interest in finding alternate solutions.

In the present study gutta percha solvents, namely xylene and Endosolv E, have been tested. Xylene is a benzene derivative and is commonly used to remove gutta percha and root canal sealers since it is a milder solvent with a slow evaporation rate [15]. Endosolv E is a newer solvent composed of tetrachloroethylene and is used for removal of gutta percha and zinc oxide eugenol-based sealers.

The results of this study indicated that gutta percha solvents have a negative effect on bond strengths to the root canal, hence the null hypothesis is rejected in this study. This may be due to the reason that the solvents may change the chemical composition of the dentin surface, thereby altering bond strength [6]. Moreover, these solvents are usually oil-based, which makes its complete removal difficult from root canals. This waxy film may interfere with the development of resin–dentin bonds. However, comparing the solvents, this study showed that bond strength of the epoxy resin sealer (sub-group A) was significantly different between groups II and III ($p < 0.05$) but not for the methacrylate resin sealer (sub-group B) ($p > 0.05$). Also, the bond strength produced by Endosolv E was significantly higher ($p < 0.05$) than that of xylene for the epoxy resin sealer. There is evidence to show that epoxy resin sealers like AH plus bond chemically to the collagen of dentin [16]. It may be hypothesized that trichloroethylene may not bring about a chemical alteration of the dentin in contrast to xylene. This warrants further research.

It may be argued that solvents are usually used in endodontics to remove root filling material and such a methodology was not applied in this case. In this work, initial root filling was not done in order to eliminate a possible confounding factor, i.e. remnants of root filling material. Since the objective was to study the impact of solvents on the bond strength of sealers, only the solvent treatment was employed. For the same reason, the root canals were filled only with sealer and no core material was used [16,17].

Bond strength testing is commonly used for determining the effectiveness of adhesion between endodontic materials and tooth structure. In the present study, the push-out test method was used to test the dentin bond strength of different root canal sealers. The advantage of this method is that it allows root canal sealers to be evaluated even when bond strength is low [9,16]. The push out test method used in the present study is of clinical value as the sealer can be placed in direct contact with the intra-canal dentin walls and it can accommodate to canal shape and penetrates into the dentinal tubules, promoting mechanical retention similar to clinical conditions [9,10,16,17].

The impact of these solvents on the bond strength of root canal sealers and its relation to clinical outcomes may be questioned. There are no long-term clinical studies to demonstrate the effect of dentin bond strength of root filling material on clinical outcome. However, Neelakantan et al. [16] were the first to demonstrate *in vitro* that there is a very high negative correlation between push out bond strength and leakage, which means that any chemical treatment which results in high bond strength to dentin also resulted in low leakage and vice-versa. Furthermore, adhesion of root filling material is desirable in a clinical situation like drilling a post space.

It has been reported in previous studies that some chemical agents cause alterations in the chemical structure of human dentin and change the Ca:P ratio of the dentin surface and, thereby, effect the adhesion of dental materials to hard tissues [18–20]. Calcium and phosphorous levels of human dentin have been shown to change after treatment with chloroform [6] and chloroform also had a negative effect on bond strength of C&B Metabond (Parkell, Farmingdale, NY) to root canal dentin [5]. Future studies should focus on the chemical characterization of these solvents on dentin.

Conclusion

Gutta percha solvents reduce the bond strength of resin sealers to root canal dentin. This effect depends on the solvent and the sealer used.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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