DENTAL MATERIALS XXX (2018) XXX–XXX

Available online at www.sciencedirect.com

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Challenges in luting fibre posts: Adhesion to the post and to the dentine

Adriana Lemos Mori Ubaldini[a], *Ana Raquel Benetti*[b,*], *Francielle Sato*[c], *Renata Corrêa Pascotto*[a], *Antonio Medina Neto*[c], *Mauro Luciano Baesso*[c], *Anne Peutzfeldt*[d]

[a] *Department of Dentistry, State University of Maringá, Av. Mandacaru 1550, 87080-0009 Maringá, PR, Brazil*
[b] *Department of Odontology, Faculty of Health and Medical Sciences, University of Copenhagen, Nørre Allé 20, 2200 Copenhagen, Denmark*
[c] *Department of Physics, State University of Maringá, Av. Colombo 5790, 87020-900 Maringá, PR, Brazil*
[d] *Department of Preventive, Restorative and Pediatric Dentistry, School of Dental Medicine, University of Bern, Freiburgstrasse 7, 3010 Bern, Switzerland*

ARTICLE INFO

Article history:
Received 31 October 2017
Received in revised form
20 March 2018
Accepted 4 April 2018
Available online xxx

Keywords:
Raman spectroscopy
Dental cements
Resin cements
Posts and core technique
Dowel

ABSTRACT

Objective. To investigate the relationship between physicochemical interactions of resin luting cements with dentine and retention of fibre posts in root canals.
Methods. Retention of fibre posts (RelyX Fiber Post) was assessed by the pull-out method. The diffusion zone of the cements and their chemical interaction with dentine were estimated by micro-Raman spectroscopy. Resin luting cements employing etch-and-rinse (Rely X Ultimate and Variolink II), self-etch (Rely X Ultimate and Panavia F2.0), or self-adhesive (RelyX Unicem 2) modes were investigated. Data were analyzed by analysis of variance followed by Tukey HSD tests.
Results. The retention of the fibre posts decreased in the following order: RelyX Ultimate, etch-and-rinse mode > RelyX Unicem 2 ≥ RelyX Ultimate, self-etch mode ≥ Panavia F2.0 ≥ Variolink II ($p < 0.05$). One of the etch-and-rinse mode cements presented the deepest diffusion zone, while the other, along with the self-adhesive cement, produced the shallowest zone. Cements used in the self-etch mode showed intermediary diffusion into dentine ($p < 0.05$). All resin luting cements showed some degree of chemical interaction with dentine, the highest recorded for RelyX Ultimate used in the etch-and-rinse mode and the lowest for Panavia F2.0 ($p < 0.05$). The retention of fibre posts in the root canal could be attributed neither to the mode of interaction of the luting cements with dentine nor to their ability to diffuse into dentine.
Significance. Chemical interaction between the resin luting cement and the dentine paired with adequate post pretreatment contribute positively to the retention of fibre posts.

1. Introduction

The failure pattern of adhesively-luted fibre posts differs from that of metal posts: whereas fibre posts often fail due to

* *Corresponding author.*
E-mail address: arbe@sund.ku.dk (A.R. Benetti).
https://doi.org/10.1016/j.dental.2018.04.001
0109-5641/

debonding, metal posts often cause root fracture [1–3]. Thus, debonding of adhesively-luted posts has been reported to represent 37% of all failure modes [4,5]. In order to minimize such failures, efficient adhesion to two distinct substrates is required: (1) to the surface of the post and (2) to the dentine of the root canal.

Poor adhesion of luting cements to the surface of fibre posts is a well-known problem, and good adhesion to the post can be challenging to obtain [6–8]. Retention of adhesively-luted posts is influenced by the composition of the post [9]: higher debonding rates have been observed for glass fibre (49%) compared to carbon fibre (29%) and quartz (26%) fibre posts [4]. Additionally, gaps or defects often encountered in excessively thick cement layers around the posts contribute negatively to post retention [10,11]. The influence of the cement film thickness on retention of adhesively-luted posts becomes noticeable when these have not been pretreated [12]. Aiming to improve the overall retention of fibre posts, a number of surface pretreatments have been proposed, focusing mainly on increasing micromechanical and/or chemical interaction between the posts and the resin luting cements [6,8,13–15].

Moreover, good mechanical properties of the luting cement and its ability to adhere to the root dentine are important contributing factors for the retention of posts. Resin luting cements fulfill both of these requirements and thus provide considerable advantages for the luting of fibre posts. Despite these desirable properties, both clinical [10] and *in vitro* studies [2,11,16–18] have reported the fragile link to lie at the interface between the resin luting cement and dentine. This observation may reflect the sensitivity of the adhesive luting technique towards application in the root canal, considering the difficulties associated with appropriate surface treatment of the dentine, control of the humidity, evaporation of solvents from the adhesives, insertion of the luting cement into the canal without air entrapment, and finally adequate polymerization of the cement. Some of these aspects are more troublesome for certain adhesive strategies of the luting cement than for others. Initially, 3-step etch-and-rinse adhesives were shown to provide reliable adhesion to root dentine [19,20]. More recently, however, a systematic review of *in vitro* literature demonstrated superior retention of fibre posts to dentine with the use of self-adhesive resin cement [21]. This positive finding for self-adhesive resin cements can be attributed, at least in part, to reduced technique-sensitivity gained through the elimination of the numerous steps involved in etching and application of primer and adhesive. Additionally, self-adhesive cements contain functional methacrylate phosphoric acid and/or carboxylic esters that chemically interact with hydroxyapatite [22,23]. Despite advances in understanding the underlying adhesion mechanisms between these functional methacrylates and hydroxyapatite [24–27], the contribution of chemical adhesion or micromechanical retention to the final bond strength to dentine is not fully understood. Analysis of the interface between dentine and resin luting cements usually focuses on the infiltration into dentine or on the degree of conversion of adhesives and cements [28–30], and even when combined with mechanical tests [20], these analyses offer limited information about the physicochemical interactions with the dental tissues.

Therefore, the purpose of this study was to investigate the relationship between physicochemical interactions of resin luting cements with dentine and the retention of fibre posts in root canals. The influence of two surface pretreatments for the posts was also assessed. The working hypotheses of this study were that the retention of fibre posts is influenced by (1) the mode of interaction with dentine of the resin luting cement and (2) the pretreatment of the fibre post.

2. Materials and methods

Five resin luting cements were included in this study. Regarding the mode of interaction with dentine, these cements were used in combination with etch-and-rinse or self-etch adhesives, or without any adhesive (self-adhesive cement). For one of the cements, a universal adhesive was used in the etch-and-rinse as well as in the self-etch mode. The investigated luting cements along with their respective adhesives and manufacturers are listed in Table 1. In order to avoid the influence of the mechanical properties on the outcome of the study, luting cements with similar flexural strength and modulus of elasticity were selected. These properties were determined as described below and before initiation of the retention test and the interface analysis. Film thickness of the luting cements was also assessed and used as an estimate of their viscosity.

2.1. *Flexural strength and modulus of elasticity*

Flexural strength and modulus of elasticity of the luting cements were obtained from three-point flexural strength tests based on the procedure described in ISO 4049 [31]. Five specimens were fabricated from each luting cement. The cements were either mixed manually or using an automix tip (see details in Table 1). Thereafter, the cement was inserted in a rectangular mold (25 mm × 2 mm × 2 mm) and light-cured at 950 mW/cm^2 (bluephase, Ivoclar Vivadent, Liechtenstein) at 5 overlapping sites on the top and on the bottom surfaces. The specimens were stored at 37 °C for 7 days prior to testing in a universal testing machine (Instron 5566, High Wycombe, UK) and then loaded at a cross-head speed of 0.75 mm/min until fracture. Flexural strength was registered and the modulus of elasticity of the luting cements was calculated from the linear part of the stress–strain curve.

2.2. *Film thickness*

Film thickness of the luting cements was assessed in a dark room based on the procedure described in ISO 4049 [31]. The thickness of two glass plates separated by two polyester strips was measured to an accuracy of 0.001 mm. This value (A) was registered before testing each luting cement. A constant volume (0.05 mL) of the cement was deposited in the center of the polyester strip covering the lower glass plate. The second polyester strip and the upper glass plate were centered and placed on top of the luting cement. A load of 150 N was applied centrally to the specimen for 180 s. The load was then removed and the specimen was irradiated (bluephase, Ivoclar Vivadent, Liechtenstein) through the center of the upper glass plate for 80 s. The thickness of the combined glass plates,

Please cite this article in press as: Ubaldini ALM, et al. Challenges in luting fibre posts: Adhesion to the post and to the dentine. Dent Mater (2018), https://doi.org/10.1016/j.dental.2018.04.001