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Probability of interface imperfections within SEM cross-sections of adhesively luted GFP

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ABSTRACT

Objectives. To calculate the probability of interface imperfections within SEM cross-sections of adhesively luted GFP depending on the level of analysis and the cement application method by means of LOM (light-optical microscopic evaluation method).
Material and methods. Four groups of artificial root canals received GFPs ($n = 5$) under following experimental conditions: I = RelyX™ Unicem, applied with application aid, II = RelyX™ Unicem, III = Panavia F 2.0 and IV = Variolink II. In groups II–IV only posts were loaded with cement (i.e. conventional post cementation). After GFP cementation, standardized photographs were taken perpendicularly to post surface under light-optical microscope from two opposite sides. The length of homogenous cement interface areas were measured using surface-analyzing software. The homogenous areas were related to length of apical, middle, cervical post section and to complete post length to generate the probabilities (%) of hitting imperfections when using SEM cross-section analysis.
Results. The probabilities (%) of hitting imperfections within SEM cross-sections for cervical, middle, and apical level of analysis were: I = 78, 64, 82; II = 89, 98, 99; III = 72, 91, 99; and IV = 85, 91, 97, respectively. For complete post length median values of probabilities (%) were: I = 75; II = 95; III = 87; and IV = 91.
Significance. The probabilities show, that SEM cross-section evaluation concerning detection of cement interface imperfections of adhesively luted GFPs depends on the cement application method and the level of analysis and seeming therefore not always unrestricted representative for the whole specimen.

1. Introduction

The retention of popular endodontic glass fiber reinforced composite posts GFPs [1,2] within the root canal depends on the adhesion between post surface and root dentin as a result of the used adhesive luting system and their type of cement application [3,4]. The clinical success of adhesively luted GFPs was shown by some in vivo studies [5–10], also in vitro studies examined the risk factors of GFP restorations, e.g. the influence of ferrule preparation and remaining sound dentin [11–13]. Modern systems for adhesive post placement involve special treatments of the post surface and the root dentin to achieve sufficient adhesion [14]. The application of the adhesive luting material is mostly realized without using a lentulo spiral drill, since an increased input of energy may cause faster cement setting. Therefore, adhesive luting cement application

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follows a standard procedure: the cement is applied into the canal by means of a probe or a microbrush and the post loaded with cement will be inserted into the root canal with parallel rotary motion. To avoid imperfections within the cement interface some of the post luting systems use special needle-like application aids [3], as for conventional cements the use of the so-called Jiffy-tube was reported [15].

Van Meerbeek et al. [16] reported that there are four commonly used microscopy techniques to image resin–dentin interfaces: scanning electron microscopy (SEM), confocal laser scanning microscopy (CLSM), transmission electron microscopy (TEM) and atomic force microscopy (AFM). The standard evaluation approach for cement interface imperfections is the use of SEM for cross or longitudinal sections of the cemented posts [17–20]. A few studies describe the TEM method to evaluate the interface of adhesively luted posts to dentin [21,22]. The CLSM was applied for interface evaluation by Bitter et al [23], and the AFM method was used in dentistry [24] for other applications than interface evaluation of cemented dental posts. One of the main disadvantages of all these commonly used microscopy techniques is, that only a small area of the real interface can be evaluated. Hence this area is not always representative for the whole specimen.

Alternatively, the cement interface homogeneity may be controlled in whole by means of a new light – optical microscopic evaluation method described before [3].

The null hypothesis tested was that the evaluation of several SEM cross-sections in terms of detection of cement interface imperfections of adhesively luted GFPs is representative for the whole specimen for each level of analysis and cement application method.

2. Material and method

In four groups, 5 GFPs (RelyX Fiber Post, 3M ESPE, Seefeld, Germany) each were inserted in artificial root canals under standardized conditions. The artificial root canals were simulated by using transparent PMMA blocks. For the preparation of 5 post spaces (length = 13 mm) in each PMMA block the corresponding cavity drill of the GFP (RelyX Fiber Post universal cavity drill, size 2; 3M ESPE) was used. Following experimental placement approaches of the GFP were examined: group I = RelyX™ Unicem and cement application with an application aid (elongation tip, 3M ESPE), group II = RelyX™ Unicem (3M ESPE), group III = Panavia F 2.0 (Kuraray Dental, Düsseldorf, Germany), and group IV = Variolink II (Ivoclar Vivadent, Schaan, Liechtenstein) applied conventionally, respectively.

The conventionally adhesive post placement procedure of the groups II–IV contains 2 major steps: first, the adhesive luting material is placed into the root canal access by means of a dental probe and than the post loaded with luting material was inserted rotary into the root canal. For further details of post cementation procedures please refer to Watzke et al. [3].

2.1. *Group I*

GFP and the artificial root canal were pretreated as per manufacturer's recommendations. GFP were degreased with propanol (70%) and dried with air. A silane coupling agent (ESPE sil, 3M ESPE) was applied on the post surface and dried for 5 min. The artificial root canal was pre-treated by rinsing the canal with NaOCl and H_2O and dried with paper points.

The cementation procedure starts with clicking the flexible root canal shaped application aid (elongation tip, 3M ESPE) on the Unicem Aplicap. After activating the aplicap for 2–4 s the resin cement was machine mixed for 15 s with the capmix machine. Then the application aid was inserted down to the bottom of the root canal and the self-adhesive resin cement (RelyX™ Unicem, 3M ESPE) was applied by slowly pulling the application aid out of the canal (5–10 s). Thus, the tip of the application aid was always embedded within the cementation material during the cement application. The post, loaded with the rest of the resin, was pressureless inserted into the artificial root canal. The self-adhesive resin cement was light activated for 2 s. Excess material was removed by using cotton pellets. Then the GFP was kept in position by means of the polymerization lamp and the cement was finally polymerized for 20 s.

2.2. *Group II*

In group II we used the same pretreatment of the GFP, the artificial root canal and the cementation procedure as described for group I, except the use of the application aid. The cement was solely applied at the root canal access using the Unicem Aplicap.

2.3. *Group III*

In Group III the pretreatment of the GFP and the artificial root canal was identical to group I. The cementation process started with applying the primer (Panavia F 2.0 ED primer, Kuraray, Düsseldorf, Germany) using a microbrush. The primer was dried gently with air and excessive primer was removed with paper points. Then the mixed resin cement (Panavia F 2.0, Kuraray, Düsseldorf, Germany) was applied into the root canal by means of a microbrush. The GFP was also loaded with resin cement and inserted pressureless into the root canal. The excess resin material was removed using cotton pellets. Then the GFP was kept in position by means of the polymerization lamp and the cement was finally polymerized for 20 s.

2.4. *Group IV*

In group IV the pretreatment of the GFP was similar to the description of groups I–III. The pretreatment of the artificial root canal implied some more steps. After rinsing the canal with NaOCl and drying with paper points the root canal walls were etched with H_3PO_4 (37%) for 10–15 s. Afterwards rinsing and drying was performed as described above.

The cementation process began with the application of the primer (Syntac, Ivoclar Vivadent, Schaan, principality of Liechtenstein) by means of a microbrush. The primer was dried gently with air for 15 s and excessive primer was removed with paper points. Then the adhesive (Syntac, Ivoclar Vivadent) was applied and dried in the same way as the primer. The mixed dual curing composite cement (Variolink II, Ivoclar Vivadent; base and catalyst 1:1 for 10 s) was applied into the