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Marginal integrity of class V restorations: SEM versus dye penetration

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ARTICLE INFO

Article history:

Received 30 November 2006

Accepted 6 June 2007

Keywords:

SEM

Dye penetration

Marginal integrity

Class V

In vitro investigation

ABSTRACT

Objectives. To perform an in vitro investigation on the marginal integrity of different adhesives (Optibond FL, Scotchbond 1XT, Clearfil SE Bond, Adper Prompt L-Pop, S³ Bond, iBond exp., Adper Prompt L-Pop) in combination with Tetric Ceram as well as an experimental silorane-restorative (Hermes, Hermes Bond; 3M ESPE) using SEM and dye penetration (2% methylene blue) in a comparative manner.

Methods. Standardized class V-cavities (3 mm × 1.5 mm) were prepared in 70 extracted human teeth (n = 10). The adhesives were applied according to manufacturers' instructions. The cavities were restored with three increments. After finishing and polishing (Sof-Lex discs) and thermocycling (5000×, 5/55 °C), replicas were taken and the teeth immersed in the dye for 10 s (D10) and evaluated. After another penetration of 30 min (D30) a final evaluation of the percentage of dye-penetrated margins was conducted.

Results. The median percentages in marginal gaps (%) at the enamel margins for the three methods investigated (D10/D30/SEM) were—Optibond FL: 0/0/4, Scotchbond 1 XT: 5/16/11, Clearfil SE Bond: 0/0/0, S³ Bond: 0/0/1, iBond exp.: 20/42/12, Adper Prompt L-Pop: 5/23/8, Hermes/Hermes Bond: 5/45/24. Cementum margins—Optibond FL: 0/1/0, Scotchbond 1 XT: 0/21/23, Clearfil SE Bond: 0/0/4, S³ Bond: 0/0/0, iBond exp.: 0/0/0, Adper Prompt L-Pop: 10/32/23, Hermes/Hermes Bond: 0/0/13. After pooling the data of all groups, a Spearman's ρ test showed a good correlation between the methods D10 and D30 at the enamel margins and at the entire cavity margins (correlation coefficient 0.8 and 0.7).

Significance. SEM did not correlate with the results obtained from D10 (correlation coefficient <0.5). A fair correlation was found between SEM and D30 for the entire cavity margin but a good correlation for the enamel margins. No correlation between investigation methods was determined at the cementum margins. D30 showed a better correlation to SEM than D10 did. Therefore, 30 min of dye penetration time seems to be more suitable than 10 s.

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1. Introduction

SEM and dye penetration tests are both known to be valid tools for the determination of marginal gaps in in vitro studies. Some fundamental discussions took place during the last

months, if especially dye penetration – or even marginal leakage studies at all – are suitable to predict clinical performance, because of lack of data proving a correlation between in vitro studies on marginal integrity and true clinical performance. Especially dye penetration was in the matter of concern [1].

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doi:10.1016/j.dental.2007.06.002

Dye penetration is an established method for the determination of marginal leakage in vitro, mostly performed after cutting the teeth in a longitudinal direction. As a dye-marker, methylene blue is very common [2–10], but basic fuchsin [11–14] and silver nitrate are popular, too [15–17], while India ink is more rarely used [18]. However, it was documented, that different staining dyes may result in different interpretations of marginal leakages [19]. In addition, the storage time for the dye penetration varies from 10 s [20–23], over 2 h [15], 4 h [9,10], 6 h [7] to 24 h [2–6,12,13,16,24], 48 h [18], 72 h [11] up to 14 and 180 days [14]. An extended penetration time might become a problem in more hydrophilic, self-etching adhesives. Due to their hydrophilicity [25–27], they might absorb water and dye in a higher extend than conventional etch and rinse adhesives do. Therefore, the longer the penetration time is, the higher might be a risk of dye diffusion into the adhesive resulting in a stained adhesive layer. This can lead to false-negative results, due to the fact that stained adhesive layers might be interpreted as gaps. To minimize this potential risk was the original idea behind the reduction of the penetration time to 10 s [20–23,28]. This short-time period of dye penetration allows only a penetration due to capillary action and prevents a diffusion of the dye into the adhesive. Longer dye penetration periods would allow a particular look at nano-leakages and not only to surface-disintegrations, but this seems to be only suitable in comparison of adhesives with the same level of hydrophilicity.

The concentration of the staining dye is a matter of discussion, too: methylene blue is mostly used in a 0.5% concentration [2–5,9,10], but also in 2% [6,7] and even in 5% [8]. With basic fuchsine, both concentrations, 0.5% [11,13] and 2% [12] are used.

Furthermore, the results of the in-depth determination of dye penetration depends on the mode of collecting the data: different statistically significant results were found, when mean, median, maximum dye penetration, or the percentage of teeth in each group without any dye penetration were considered for the evaluation [29]. As a consequence, SEM can still be seen as the golden standard for the determination of marginal leakages in indirect [30] and directly placed adhesive restorations [31]. In class V, due to its smaller cavity sizes, an SEM-investigation on marginal integrity might be performed easier and is therefore used more commonly [32–39]. Often, SEM-investigations are completed by dye penetration studies, to obtain more information of the in-depth extend of marginal gaps [36,38–41].

Nevertheless, SEM needs significantly higher efforts in trained manpower and technical equipment. Therefore, researchers are still looking for valid alternatives to SEM [34,42].

The aim of the present study was to compare the results from an investigation on marginal integrity of class V restorations obtained from SEM and dye penetration with a 10 s and 30 min penetration time, where the evaluation procedure of the dye penetration test was performed as the determination of marginal gaps by means of a surface analysis in the same manner as with SEM. In addition, a conventional in-depth dye penetration investigation on the same teeth should add further information. To investigate this, a number of state of the

art self-etching adhesives as well as etch and rinse-controls were selected.

The null-hypothesis was that a dye penetration time of 10 s and 30 min will lead to the same results in marginal integrity as an SEM investigation.

Additionally, a second null-hypothesis was set up, that self-etching adhesives perform comparable to etch and rinse adhesives in mixed class V cavities in terms of marginal integrity in enamel and cementum margins.

The third null-hypothesis was that the performance of the new silorane restorative system was not different from that of the self-etching adhesives which were tested in combination with a hybrid resin composite.

2. Materials and methods

For this investigation on marginal adaptation of class V restorations, 70 freshly extracted teeth were stored in a 1% chloramine-B-hydrate-solution [43]. The indications for extraction have been periodontal and orthodontic reasons as well as dento-alveolar surgery of wisdom teeth. Minor caries lesions, which could be removed during the preparation without extending the standardized cavity design, were accepted. The teeth were randomly distributed into seven groups of 10 teeth each. Standardized class V cavities (3 mm × 1.5 mm, Fig. 1) were prepared with the Cerafil preparation set (4266, Komet Brasseler, Lemgo, Germany, utilizing 100 μm preparation and 30 μm finishing diamonds). The enamel margins were bevelled with a 15 μm finishing bur.

A total of six adhesives (Table 1), were used in combination with one resin composite (Tetric Ceram, Ivoclar Vivadent, Lot D58957, shade A3) to ensure comparability of the adhesive only. The etch and rinse adhesives Optibond FL (sds Kerr) and Scotchbond 1XT (3M ESPE) served as controls as well as the two-step self-etching adhesive Clearfil SE Bond. A two component self-etching adhesive (Adper Prompt L-Pop) and two ready-for-use all-in-one self-etching adhesives (S3 Bond,

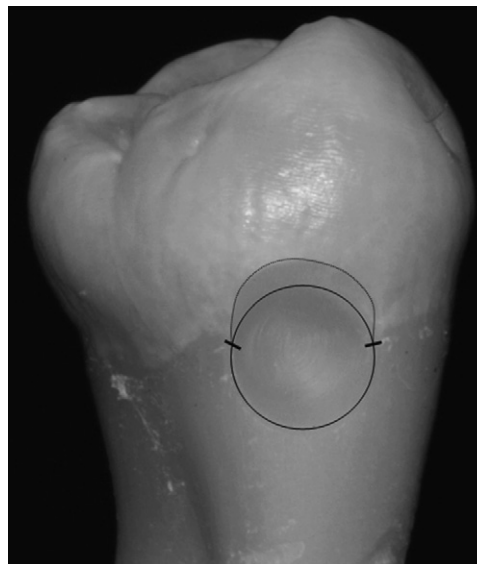


Fig. 1 – Cavity design of the standardized class V cavity.

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