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Adhesive performance of a caries infiltrant on sound and demineralised enamel

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ABSTRACT

Objective: Resin infiltration is considered as a treatment option for initial caries lesions. As cavitated early lesions might require additional restorative intervention, a caries infiltrant might be also used for enamel conditioning prior to composite insertion. This study aimed to analyse the shear bond strength of a flowable composite to sound and demineralised enamel pretreated with a caries infiltrant, a conventional adhesive or a combination of both.
Methods: Flattened bovine enamel specimens ($n = 120$) were either demineralised (14 d, acidic buffer, pH 5) or remained untreated. Sound and demineralised specimens (each $n = 20$) were then treated with: (1) 35% phosphoric acid, conventional adhesive, (2) 15% hydrochloric acid, caries infiltrant or (3) 15% hydrochloric acid, caries infiltrant, conventional adhesive. Shear bond strength of a flowable composite was tested after 24 h water storage (37 °C) and statistically analysed (ANOVA, $p \leq 0.05$). The mode of failure was assessed microscopically at 25× magnification.
Results: On demineralised enamel, the combination of caries infiltrant and conventional adhesive showed significantly higher shear bond strength values than the conventional adhesive alone, while both being not significantly different from group 2. No significant differences between the groups could be detected on sound specimens. A higher percentage of cohesive failures could be observed in demineralised samples of group 2 (40%) and 3 (65%), while all other specimens presented almost only adhesive failures.
Conclusion: The use of a caries infiltrant before application of a conventional adhesive did not impair bonding to sound and demineralised enamel and might be beneficial as a pretreatment in demineralised enamel.

1. Introduction

The infiltration of caries lesions with low viscosity light curing resins is considered as treatment option for non-cavitated lesions which are not expected to arrest or remineralise. In contrast to the conventional sealing concept where a resin layer is created on the surface, caries infiltrants aim to penetrate the porous lesion body completely.[1] Compared to dental adhesives or fissure sealants, caries infiltrants were optimised for rapid capillary penetration and exhibit a very low viscosity, low contact angles to enamel and high surface tensions.[2] Thus, laboratory experiments demonstrated a significantly deeper penetration in the lesion body than conventional adhesives.[2–5]

Due to the low viscosity of the infiltrant and as the infiltrant do not necessarily require a resin coating, the clinical

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application on tooth surfaces which are difficult to access, e.g. proximal surfaces, became possible.[6,7] Recently, it was shown that a caries infiltrant reduced proximal lesion progression to the same extent as a fissure sealant in situ.[8] As a positive side effect, white spot lesions of smooth surfaces might be masked by infiltrating the microporosities responsible for the whitish appearance of lesion.[1,9]

However, on the other hand, extensive active white spot lesions might exhibit superficial albeit cavitated defects[10] which require additional restorative treatment. Likewise, proximal enamel caries lesions might be underestimated by radiographic or visual examination. Up to 60% of proximal inner enamel lesions considered as not cavitated were shown to already exhibit a cavitation.[11–13]

Thus, initial but cavitated enamel lesions might require both infiltration of demineralised parts of the lesion as well as restoration of the cavitated areas. Under clinical considerations, the treatment of these lesions could be simplified if the infiltration of the demineralised parts could be done in the same step as the bonding of enamel for composite application.

Therefore, the aim of the present study was to analyse the shear bond strength of a flowable composite to sound or demineralised enamel which was pretreated with a caries infiltrant system, a conventional adhesive or a combination of both.

The null hypothesis was that the adhesive performance of the infiltrant (applied alone or in combination with the adhesive) on sound and demineralised enamel is not significantly different from the adhesive.

2. Methods

2.1. Specimen preparation

Specimens were prepared from 120 extracted bovine permanent incisors, which were stored in 0.5% chloramine solution (Sigma Aldrich, Buchs, Switzerland) for 7 days followed by storage in distilled water for 14 days after extraction. The teeth were cleaned and sectioned at the enamel–cementum junction using a water-cooled cutting wheel (Struers, Birmensdorf, Switzerland). The crowns were embedded in cylindrical moulds (picodent twinsil, picodent, Wipperfürth, Germany, 25 mm in diameter) filled with an auto-polymerizing acrylic resin (ScandiQuick, ScanDia, Hagen, Germany). The labial surfaces of the crowns were ground flat (SiC paper, 400 grit, Buehler, Lake Bluff, USA) under water cooling until a flat area of at least 5 mm × 5 mm was exposed.

Then, half of the specimens were immersed for 14 days in an acidic buffer containing 3 mM $CaCl_2 \times 2\,H_2O$, 3 mM KH_2PO_4, 50 mM lactic acid, 6 μM MHDP, KOH to adjust the initial pH to 5.0 and traces of thymol.[14] The solution was renewed each second day to keep the pH constant.

2.2. Bonding procedure and preparation for shear bond testing

Each 20 sound and 20 demineralised specimes were randomly assigned to three groups and treated as follows:

1. The enamel surface was etched for 60 s with 35% phosphoric acid (UltraEtch 35%, Ultradent Products, South Jordan, USA), and then rinsed distilled water for 60 s. After air drying of the surface, an unfilled adhesive (Heliobond, Ivoclar Vivadent, Schaan, Liechtenstein) was applied and gently rubbed in for 20 s with a microbrush, then thinned with mild air (1-2 s) and light cured for 20 s (3 M ESPE Elipar S10, 3 M ESPE, Seefeld, Germany).
2. The enamel surface was etched for 2 min with 15% hydrochloric acid (Icon Etch, DMG, Hamburg, Germany) and then rinsed with water spray for 30 s. Air drying of the surface was followed by application of ethanol (Icon Dry, DMG, Hamburg, Germany) for 30 s and additional air drying. Then, the low-viscosity resin infiltrant (Icon Infiltrant, DMG, Hamburg, Germany) was applied on the surface for 3 min by means of the sponge applicator provided with the resin infiltration system. After light-curing for 40 s, the infiltrant was applied for further 60 s and again light-cured for 40 s.
3. Enamel surfaces by hydrochloric acid etching and the resin infiltrant system as described for group 2. Then, the unfilled adhesive was applied for 20 s on the pretreated surface and light-cured for 20 s as described above.

The composition of the conventional adhesive and the caries infiltrant system based on the manufacturers' instructions are listed in Table 1.

An acrylic hollow cylinder with an inner diameter of 3 mm and a height of 4 mm was pressed on the enamel surface by means of a special bonding device described in detail previously.[15] A flowable composite (Tetric EvoFlow, Ivoclar Vivadent, Schaan, Liechtenstein, LOT: N01643) was applied in two layers of each 1.5 mm thickness and light-cured for 60 s (3 M ESPE Elipar S10, 3 M ESPE, Seefeld, Germany).

The specimens were carefully removed from the device and stored in distilled water at 37 °C for 24 h.

Table 1 – Composition of the conventional adhesive and the caries infiltrant system accordingly to the manufacturers' information.

Product	Composition	Lot number	Manufacturer
Heliobond	Bis-GMA, TEGDMA, initiators, stabilizers	L24292	Ivoclar Vivadent, Schaan, Liechtenstein
Icon	Icon etch: 15% hydrochloric acid, water, pyrogenic silica, tenside, pigments Icon Dry: ethanol Icon Infiltrant: triethylenglycoldimethacrylate-based resin	632178	DMG, Hamburg, Germany