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Bonding strategies for MIH-affected enamel and dentin

Norbert Krämer[a], Ngoc-Han Nana Bui Khac[a], Susanne Lücker[a,b], Vitus Stachniss[b], Roland Frankenberger[b,*]

[a] Department of Pediatric Dentistry, Dental School, University of Marburg and University Medical Center Giessen and Marburg, Campus Giessen, Schlangenzahl 14, D-35392 Giessen, Germany

[b] Department of Operative Dentistry and Endodontics, Dental School, University of Marburg and University Medical Center Giessen and Marburg, Campus Marburg, Georg-Voigt-Str. 3, D-35039 Marburg, Germany

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Objectives. Aim of the present study was to evaluate resin composite adhesion to dental hard tissues affected by molar incisor hypomineralisation (MIH).

Methods. 94 freshly extracted human molars and incisors (53 suffering MIH) were used. 68 teeth (35 with MIH) were used for μ-TBS tests in enamel and dentin, 26 (18 with MIH) for qualitative evaluation. Specimens were bonded with Clearfil SE Bond, Scotchbond Universal, and OptiBond FL. For MIH affected enamel, additional OptiBond FL groups with NaOCl and NaOCl + Icon were investigated. Beside fractographic analysis, also qualitative evaluations were performed using SEM at different magnifications as well as histological sectioning.

Results. Highest μ-TBS values were recorded with dentin specimens (ANOVA, mod. LSD, $p < 0.05$). Results were independent of adhesive and dentin substrate ($p > 0.05$). Pre-test failures did not occur in dentin specimens. Sound enamel specimens exhibited significantly higher μ-TBS values than MIH enamel ($p < 0.05$). The two-step self-etch adhesive (Clearfil SE Bond) and the two-step etch-and-rinse adhesive (Scotchbond Universal) showed the lowest values in affected enamel specimens ($p < 0.05$) with most pre-test failures ($p < 0.05$). OptiBond FL on affected enamel showed better results than Clearfil SE Bond ($p < 0.05$). An additional pre-treatment of affected enamel with NaOCl or NaOCl and Icon did not enhance enamel bonding ($p > 0.05$), however, it caused less pre-test failures ($p < 0.05$). Micromorphological analyses revealed that conventional phosphoric acid etching produces a much less pronounced etching pattern in affected enamel and a porous structure as weak link for the resin-enamel bond was identified.

Significance. Bonding to porous hypomineralized MIH enamel is the limiting factor in adhesion to MIH teeth. MIH-affected dentin may be bonded conventionally.

1. Introduction

Restoration of teeth suffering molar incisor hypomineralization (MIH) is problematic due to both micromorphological changes of tooth hard tissues and pain history of respective children [1]. Overall clinical therapy outcome is inferior,

* *Corresponding author.*
E-mail address: frankbg@med.uni-marburg.de (R. Frankenberger).

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MIH children reveal significantly higher DMFT values and treatment need than control groups [2]. Also restoration recommendations are very heterogenic [3], mentioning resin sealings [4,5], glass ionomers [6], resin composite restorations [7–9], amalgam [7,9], preformed metal crowns [7,9,10] or labside crowns [11] as viable pathways with overall limited data [3].

Regarding adhesion to MIH teeth, there is reported that enamel hardness is decreased [12,13], with unstructured surfaces and irregular apatite [12–15] leading to disruption of bonded margins or even retention loss [6,7]. Micro-shear data reveal reduced adhesion to MIH teeth with porosities in resin-enamel interfaces [16]. Furthermore MIH enamel surfaces cause irregular etching patterns [13,17], inhomogeneous crystalline parts [15,18], and high protein contens [19]. However, significant improvements of adhesion strategies to MIH teeth are missing. It was previously shown that apatite structures can be enhanced by casein phosphopeptide — amorphous calcium phosphate [18]. Also removal of surface protein using 5% sodium hypochlorite were discussed [20]. In severe cases, also dentin is affected by MIH [21]. Main findings in dentin were hypocalcemia, i.e. presence of interglobular dentin [22].

Therefore the null hypothesis of the present study was three-fold, 1. there is no difference in adhesion to enamel and dentin in sound and MIH-affected molars, 2. There is no difference between self-etch and etch-and-rinse adhesives, and 3. NaOCl or NaOCl plus Icon does not influence adhesion to MIH enamel.

2. Materials and methods

94 freshly extracted human molars (N = 86) and incisors (N = 8; in total 53 suffering MIH) were stored (0.5% chloramine T) for up to four weeks after extraction. Teeth were extracted due to medical reasons with written informed consent of the parents and approval by a local ethics committee (Ref. No. 143/09). Bonding to dentin was performed on buccally and orally flat ground surfaces. Tooth hard tissues were exposed with different techniques for enamel and dentin. Analogous to Jalevik's histological characterization [21] teeth were randomly assigned to test groups. MIH specimens were additionally evaluated in order to guarantee that exclusively MIH-affected structures were included in the measurements. The inclusion criteria were: Sound enamel: caries-free permanent incisors without any superficial defects. Sound dentin: caries-free sound third molars with >90% root development. MIH enamel: caries-free teeth with >1 cm^2 affected area, up to moderate appearance [23], no surface defects like cracks. MIH dentin: caries-free specimens with moderate to severe defects and partially lost enamel coating. 68 teeth (35 with MIH) were used for μ-TBS, 26/18 for qualitative evaluation.

Enamel was buccally flattened with a grinding machine (Beta Grinder-Polisher) (Buehler, Lake Bluff, USA) under water irrigation. Dentin was exposed by removing occlusal enamel with a slow-speed diamond saw (Isomet 1000 Precision Sectioning Saw, Buehler, Lake Bluff, USA) and diamond disk (Isomet Wafering Blade 152 × 0,5 × 12,7 mm Series 15LC No. 11-4276) (Buehler, Lake Bluff, USA) to mid-coronal dentin levels. Enamel and dentin surfaces were polished with 180-grit silicon carbide paper to create bonding surfaces covered with smear layers, and immediately bonded. Both etch-and-rinse and self-etch adhesives were examined in this study. The composition and manufacturers' instructions of these adhesives are included in Table 1. Control groups were bonded on sound teeth, test groups were bonded to MIH teeth (Tables 2 and 3). Further OptiBond FL groups were a. rubbed with a 5% NaOCl-soaked foam pellet for protein removal or b. NaOCl + Icon (DMG, Hamburg, Germany). Adhesives and resin composite were polymerized with a Bluephase light-curing unit (Ivoclar Vivadent, Schaan, Principality of Liechtenstein) at a distance of 2 mm away from the materials to be polymerized. The intensity of the light was checked periodically with a radiometer (Demetron Research Corp, Danbury, CT, USA) to ensure that 600 mW/cm^2 was always exceeded during the experiments. The adhesive was polymerized for 20 s prior to application of the resin composite (Z250 shade A2, 3 M Espe, Seefeld, Germany) which was applied in five three increments of 1 mm thickness. Each layer was light-cured for 40 s. From the resulting dentin disks, three central beams (width 2 mm) were cut from each specimen. The beams were finally ground with 600-grit silicon carbide paper to achieve the final shape with a thickness of 4 mm (2 mm dentin, 2 mm resin composite). For microtensile bond strength test (μTBS), the central regions of five beams per group were used. After cutting the beam longitudinally, three perpendicular cuts were made resulting in four sticks per beam (n = 20), each with a cross-sectional area of 700 × 700 μm (0.5 mm^2). The sticks were mounted in a TC 550 device (Syndicad, Munich, Germany) with a cyanoacrylate glue (Zapit, Dental Ventures of America, Corona, CA, USA) and tested with a 50-N load cell traveling at a crosshead speed of 1 mm/min. μTBS was determined by computing the quotient of maximum load and the individually measured adhesion area (software TC-550 V.2.1.0.4558, Certiga Engineering Solutions/Syndicad Dental Research, Munich, Germany). When one or more of the sticks failed during to the sectioning process, the individual specimen was assigned a null bond strength value of 0 MPa [24] (Tables 4 and 5).

Failure patterns were evaluated under a light microscope (AZ100, Nikon, Tokyo, Japan) at 40× magnification classifying the parameters adhesive fracture (AF), cohesive tooth fracture (CFT), cohesive composite fracture (CFC), mixed adhesive/tooth (mAT), mixed adhesive/composite (mAC), mixed tooth/composite (mTC). Selected specimens were investigated using SEM (Amray 1610 Turbo, Liebscher, Wetzlar, Germany) by means of epoxy replicas (Alpha Die MF, Schütz, Rosbach, Germany) sputtered with gold (Sputter Coater SC 502, Polaron, Fisons Instruments, New Haven, UK). When original specimens were evaluated, they were rinsed with NaOCl for 20 min and then washed in 20% HCl. Critical point drying was achieved by 20 min each in 60/70/80/90% ethanol and finally 60 min in 100% ethanol. Drying was carried out with 1,1,1,3,3,3-hexamethyldisilazane (Merk Schuchardt, Hohenbrunn, Germany).

For histological sectioning, the mesial surface of each tooth was placed face down in contact with a mounting plate at the base of an embedding cylinder, such that the cut root face was vertical and the distal surface of the tooth was upper most. A right-angled triangle of blue foil with a base to height length of 1: 2 ($\beta = 63.5°$) was mounted in relation to the cut root

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