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Micro-filled resin infiltration of fissure caries lesions *in vitro*

J. Lausch[a,*], H. Askar[b], S. Paris[b], H. Meyer-Lueckel[a]

[a] Department of Operative Dentistry, Periodontology and Preventive Dentistry, RWTH Aachen University, Germany
[b] Department of Operative and Preventive Dentistry, Charité – Universitätsmedizin Berlin, Germany

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ABSTRACT

Objectives: The aim of this in vitro study was to evaluate three treatment modalities [infiltrant resin (IR), micro-filled infiltrant resin (MFIR), infiltrant-sealant-combination (ISC)] regarding both their abilities to penetrate lesions differing in ICDAS-codes and to fill fissures and cavities.
Materials and methods: Extracted human molars (n = 90) showing fissure caries lesions with and without cavitations were etched with 15% hydrochloric acid (HCl) that was mixed with abrasives and a 15% HCl-solution (1:1). The etching gel was rubbed for 30 s within the fissure and, if eligible, within the cavity using a brush. After this pretreatment an infiltrant (Icon; DMG; IR) or an infiltrant mixed with microfillers (MFIR) was applied. ISC included the application of an infiltrant followed by a fissure sealant (Helioseal; Ivoclar Vivadent) From each tooth slices showing a non-cavitated (based on ICDAS-2) or cavitated lesion part (based on ICDAS-3/5) were prepared. Lesion (LA) and penetration areas (PA) as well as the completeness of fissure and cavity filling were analyzed using dual staining and confocal laser scanning microscopy.
Results: Percentage penetration (PP) was calculated as 100 × PA/LA. PP [median (25th/75th)] did not differ significantly between IR [95 (86/100)%], MFIR [93 (62/100)%] or ISC [89 (67/97)%] ($p > 0.05$; Kruskal-Wallis test). All three materials filled about 90% of the dimensions of fissures and cavities ($p > 0.05$; Kruskal-Wallis test).
Conclusion: It can be concluded that MFIR seems to be suitable to fill fissures and cavities like a fissure sealant and that it penetrates fissure caries lesions similarly deep as the conventional infiltrant after an experimental etching regime.
Clinical significance: The MFIR seems to combine advantages of the fissure sealing and the caries infiltration procedure.

1. Introduction

Due to the anatomy of pit and fissure surfaces that retain food debris, biofilms and bacteria the fissure system of human molars is known as the most vulnerable predilection site for dental caries [1]. Sealing fissures in order to prevent caries onset is well evaluated but several studies stated a lack of knowledge related to the effectiveness of sealants in preventing caries progression if non-cavitated and cavitated lesions are sealed for therapeutic reasons [2–5].

The sealing over caries lesions functions as a diffusion barrier that cuts off nutrient supplies from the oral cavity resulting in an arrestment of the caries process [6]. However, concerns about the retention of sealants over time or expected lesion progression below sealants might explain why the method of sealing to cover existing lesions is still very infrequently used [7–10].

In contrast to sealing over caries lesions the resin infiltration technique as a different approach creates the diffusion barrier for acids and dissolved minerals within the lesion body [11]. After the erosion of the surface layer that normally covers the lesion body the resin infiltration technique aims at penetrating a low viscosity resin, so called infiltrant, into the pores of the body of the lesion where it is subsequently light cured [12]. Several studies described the infiltration procedure for the treatment of proximal lesions but only two investigations for resin penetration into pit and fissure caries lesions can be found [13,14].

In contrast to proximal lesions the pit and fissure morphology as well as residual biofilm and calculus located within the fissure system might hamper the erosion of the surface layer. Consequently, lesions are not thoroughly conditioned for resin penetration [13]. Thus, an experimental pretreatment was evaluated using

* Corresponding author at: Department of Operative Dentistry, Periodontology and Preventive Dentistry, RWTH Aachen University, Germany, Pauwelsstraße 30, DE-52074 Aachen, Germany.
E-mail address: Jlausch@mailbox.org (J. Lausch).

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15% hydrochloric acid that was mixed with abrasives and applied by using a brush with hard bristles that differ in length [14]. It was assumed that the bristles remove the surface layer within the fissure system more completely than acid application alone resulting in a nearly complete penetration of the infiltrant into enamel pit and fissure caries lesions [14].

However, even if it was shown before that natural pit and fissure caries lesions can be infiltrated the infiltrant as a dental material cannot be recommended for occlusal purposes [15]. This seems to be attributed to three reasons: First, the infiltrant is not viscous enough to be handled like a flowable [15]. Second, air bubbles as a result of surface tension might impede a complete fill of the fissure [16]. Third, the infiltrant does not include any microfiller and therefore might not fulfill qualities (e.g. mechanical strength, radio opacity, polymerization shrinkage) that are recommended for resins for occlusal usage [15]. Due to these disadvantages of the infiltrant a different treatment that include an infiltrant combined with microfillers was introduced [15]. By applying this micro-filled infiltrant resin on caries lesions one part of the very liquid resin matrix penetrate into the lesion body driven by capillary forces while the filler remain embedded within the remaining matrix. However, this novel micro-filled infiltrant resin was only studied in artificial caries lesions so far [15].

Thus, the aim of the present in vitro study was to evaluate a commercial infiltrant resin (IR), the micro-filled infiltrant resin (MFIR) and an infiltrant-sealant-combination (ISC) regarding their abilities to penetrate natural occlusal lesions differing in ICDAS-codes as well as to fill fissures and cavities. We hypothesized, that the fissure sealant would fill fissures and cavities significantly more complete than the MFIR and that the penetration of the infiltrant into fissure caries lesions would be significantly deeper compared with the MFIR.

2. Materials and methods

Extracted human molars (n = 90) were graded by two calibrated examiners (J.L., H.M.-L.) according to the international Caries Detection and Assessment System (ICDAS). Fissures showing lesions with and without cavitations (based on ICDAS 3/5 and ICDAS-2) were selected. In case of disagreement a consensus rank was agreed. All teeth were carefully cleaned using a rotating brush and polishing paste (Proxyt; Ivoclar Vivadent, Schaan, Lichtenstein) to remove the biofilm. The study protocol conformed to the principles outlined in the German Ethics Committee's statement for the use of human body material in medical research [17]. Teeth were stored in 0.1% thymol solution until usage.

2.1. Treatment

Teeth were etched [15% hydrochloric acid gel (Icon etch; DMG, Hamburg, Germany; HCl) that was diluted with 15% HCl-solution (1:1 ratio) to lower viscosity and mixed with abrasives (2% pumice)] for 30 s. The etchant was rubbed within the fissure or cavity using a brush with stiff bristles as described in a previous study [14]. Teeth were rinsed (30 s) and stored in 0.1% ethanolic tetramethylrhodamine isothiocyanate (RITC; Sigma Aldrich, Steinheim, Germany) to label all accessible pores with red fluorophore (24 h). Subsequently, the teeth were dried with oil-free compressed air (10 s). All selected molars were randomly allocated to nine groups and either the commercial infiltrant resin (Icon infiltrant; DMG; IR) or micro-filled infiltrant resin (MFIR) including 45% methacrylate based pre-polymerized filler and 55% infiltrant resin (Icon infiltrant; DMG) was applied for 180 s and light cured (60 s) (530 mw/cm^2; Astralis 5; Ivoclar Vivadent) [15]. The infiltrant-sealant-combination (ISC) included the application of the infiltrant (Icon infiltrant; DMG) for 180 s. Infiltrant surplus was removed (compressed air) and the remaining infiltrant within the lesion was light cured (60 s). Subsequently, the application of a fissure sealant (Helioseal; Ivoclar Vivadent) and light curing (60 s) followed.

Roots of the teeth were removed (Band Saw 300cl; Exakt Apparatebau, Norderstedt, Germany) and the crowns were embedded in methacrylate resin (Technovit; Heraeus Kulzer, Wehrheim, Germany). To create slices of approximately 1.2 mm thickness teeth were cut across perpendicularly to the lesion surface. From each tooth a slice that showed a cavitated part of the fissure (ICDAS-3/5) and a second slice from a different area of the fissure system without a cavitation (ICDAS-2) were prepared (Band

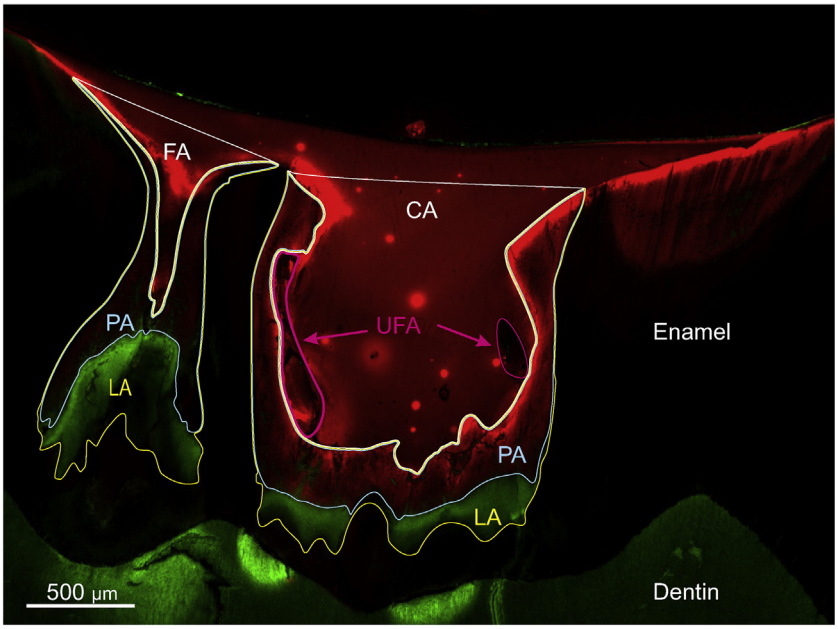

Fig. 1. Infiltrant penetration (red) into non-cavitated (left) and cavitated (right) lesions (green). Lesion area (LA). Penetration area (PA). The respective fissure or cavity area (FA, CA) as well as the completeness of the filling of these areas with resin were analyzed. Unfilled parts of a fissure or cavity (UFA).