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Marginal integrity and secondary caries of selectively excavated teeth *in vitro*

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ABSTRACT

Objectives: Selective caries removal involves sealing of carious dentine beneath restorations, which might decrease their marginal integrity and increase the susceptibility for secondary caries and microleakage. The present study compared these marginal characteristics of restorations in selectively and completely excavated teeth.

Methods: In 32 premolars, shallow and deep artificial lesions were created on pulpo-axial walls of mesial-distal-occlusal cavities, with mesial and distal margins located in enamel and dentine, respectively. Demineralised dentine was either removed or left before adhesively restoring the teeth ($n = 8$), which were then submitted to thermo-mechanical cycling. The integrity of gingivo-cervical margins was assessed using scanning electron microscopy. In half of each margin, caries was induced adjacent to restorations using a continuous-culture biofilm model, and resulting lesions were evaluated using transversal microradiography. The other half of each margin was used to assess microleakage.

Results: Integrity or microleakage of margins located in enamel did not differ significantly between groups, and bacterial biofilms did not induce distinct caries lesions in enamel. Dentinal margins in teeth with deep compared with shallow lesions showed a significantly higher proportion of marginal imperfections, gaps and microleakage ($p \leq 0.05$, Mann–Whitney/χ^2-test). In contrast, neither marginal integrity nor microleakage differed significantly between completely and selectively excavated teeth ($p > 0.05$). Dentinal mineral loss adjacent to restorations did not differ significantly between groups ($p > 0.80$).

Conclusions: The marginal characteristics of restorations were affected by the depth of sealed or excavated lesions, but not by the performed caries excavation. This study did not find selective excavation detrimental for restoration integrity *in vitro*.

Clinical significance: Selective excavation of deep lesions was shown to reduce pulpal risks, whilst leaving caries beneath restorations is feared to compromise the marginal characteristics of the subsequently placed restoration. Based on the present *in vitro* study, such assumptions cannot be supported.

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1. Introduction

Treatment of dentinal caries lesions usually involves complete removal of affected and infected dentine before restoring the cavity. For deep, pulpo-proximal lesions, this treatment was found associated with a high risk of pulpal exposure and post-operative complications.[1] In contrast, selective (incomplete, partial) excavation of deep lesions significantly reduces these risks,[2] allowing to retain teeth for longer at lower costs, since follow-up treatments, for example endodontic interventions, are avoided or postponed.[3] Nevertheless, leaving caries beneath a restoration is often feared to increase other, non-pulpal risks[4,5]: the reduced bond strengths of adhesives to caries-affected and infected dentine[6] and the mechanical effects of soft carious dentine on the overlying restoration might compromise the long-term marginal integrity of restorations placed on caries lesions. A possibly accelerated marginal deterioration with formation of gaps could lead to both a higher susceptibility for caries adjacent to restorations and an increased microleakage.[7,8] The latter might eventually even compromise the arrest of the sealed lesion.

Therefore, the present study analysed marginal integrity, caries susceptibility and microleakage of selectively *versus* completely excavated teeth. Since it is unclear whether deep and highly demineralised lesions might have greater effects on the marginal properties than shallow, moderately demineralised lesions,[9,10] we additionally analysed the effects of different lesion depths. We hypothesised that

- marginal integrity, susceptibility for caries adjacent to restorations and microleakage do not significantly differ between selectively and completely excavated teeth, and
- lesion depths and mineral loss of sealed or excavated lesions do not significantly influence these parameters.

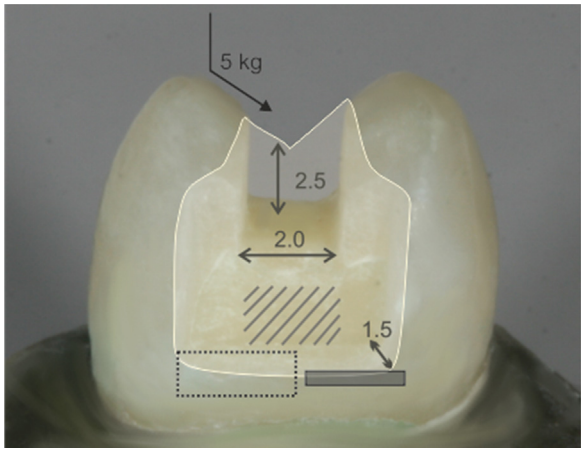

Fig. 1 – Specimens preparation. Standardised cavities were prepared as outlined using copy-milling. Since teeth were chosen according to their buccal-oral and mesial-distal dimensions, the remaining cuspal-supporting hard tissue was standardised as well. Cervical margins were located 1.0 mm above (mesial) or below (distal) the cemento-enamel-junction. Artificial lesions (3 × 2 mm) were created at pulpo-axial walls (hatched grey area). After placement of a composite restoration (transparent), teeth were submitted to mechanical cycling using a ceramic ball loaded 1.5 mm below the cuspal aspect on the inner incline of the palatal cusp with a force of 5 kg (black arrow). After thermal cycling, teeth were covered with nail-varnish, with only one half of each gingivo-cervical margin being unprotected (grey window). After immersion in 0.2% fuchsine dye, the window was covered and the other half of the margin re-exposed (dotted window). Teeth were then submitted to a bacterial-induced demineralization to create caries lesions adjacent to the restorations.

2. Materials and methods

2.1. Study design

To reliably control lesion parameters, we artificially induced lesions in pulpo-proximal walls of 32 natural teeth using different demineralisation protocols. Afterwards, caries was either removed or left untouched, and the teeth were restored. After thermo-mechanical loading to simulate long-term ageing, marginal integrity was assessed. Then, the susceptibility for caries adjacent to the restorations was tested by submitting one half of each gingivo-cervical margin to a cariogenic biofilm and subsequent microradiographic analysis of induced lesions. For the other half, microleakage was controlled using dye penetration analysis.

2.2. Specimens preparation

Thirty-two human, upper second premolars obtained with informed consent under an ethics-approved protocol (D444/10) were selected from a pool of 100 premolars according to their dimensions (mesial-distal 6.4–7.4 mm and buccal-oral 8.3–9.3 mm). Teeth were cleaned, controlled for any cracks or abnormalities and subsequently embedded in chromed brass tubes (ø15 mm; Richter, Kiel, Germany) 1 mm below the cementum-enamel-junction using acrylic resin (Technovit 4071, Heraeus Kulzer, Hanau, Germany) and a gauge. Standardised cavities were prepared using water-cooled copy-milling (Celay, Mikrona, Spreitenbach, Switzerland). Minor adjustments compensating for differences in length of teeth were performed with rotating instruments. Cavity surfaces were then controlled for cracks or abnormalities using a stereomicroscope (Stemi Zoom, Zeiss, Oberkochen, Germany). Teeth were subsequently covered with nail varnish (High Gloss, Rossmann, Burgwedel, Germany), with a window (3 × 2 mm) left unprotected on both the mesial and distal pulpal-axial wall, respectively (Fig. 1).

Teeth were randomly allocated to two groups, with 16 teeth being submitted to demineralisation using an acetic acid solution[11] containing 50 mM acetic acid, 3 mM $CaCl_2 \cdot 2\ H_2O$, 3 mM KH_2PO_4 and 6 μM methylhydroxy-diphosphonate (pH 4.95, 37 °C) for 3 weeks, creating shallow lesions with moderate mineral loss. The other 16 teeth were exposed to EDTA solution (0.5 M, buffered to pH 7.0 using citric acid) for 96 h at 37 °C, thus creating deep and extensively demineralised lesions. Lesions resulting from this protocol had been