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Effect of selective carious tissue removal on biomechanical behavior of class II bulk-fill dental composite restorations

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ABSTRACT

Objectives. This study aimed to develop a method to induce carious lesions in the pulpal floor dentin of a class II cavity preparation, and to determine the effects of this carious lesion on the biomechanical behavior of the dental composite restoration.
Methods. The pulpal floor dentin of class I cavities in sound third molars were demineralised with acetic acid for 35 days followed by a 7-day exposure to pooled human saliva biofilm and demineralization was verified by micro-CT. Subsequently, the proximal walls were removed forming a class II cavity and the caries lesion was left intact or was completely removed prior to restoration with a bulk-fill dental composite (n = 10). Cuspal deflection was assessed by strain-gauge and micro-CT imaging. The presence of enamel cracks was assessed by transillumination before and after restoration, and again after 1,200,000 cycles of mechanical fatigue in a chewing simulator. Finally, resistance to fracture by axial compressive loading and failure mode was determined. Data were analyzed by 2-way repeated measures ANOVA, Fisher's exact test, and *t*-test ($\alpha = 0.05$).

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Results. The presence of carious lesions had no significant effect upon cuspal deflection, formation of enamel cracks, and fracture strength of the dental composite restorations. The restorative procedure increased the number of enamel cracks, which was not affected by mechanical cycling.

Significance. Maintaining carious lesions does not affect the biomechanical behavior of class II restorations performed with bulk-fill dental composite.

1. Introduction

Dental caries must be treated by managing patient risk factors to prevent the development of new lesions and, if caries lesions are not prevented, to arrest and repair early lesions [1,2]. When caries lesions become cavitated, restorative procedures are necessary to facilitate plaque control, protect the dentin-pulp complex, and restore the form, function, and esthetics of teeth [3,4]. Non-selective carious dentin removal has long been advocated prior to insertion of restorative materials to avoid any possible deleterious effects of the remaining carious tissue on the longevity of the restoration [5]. This concept stems from evidence obtained from restorations that were performed using non-adhesive materials, such as amalgam, where the presence of sound and thick, hard dental tissue in the internal cavity walls was required to support the restoration. However, current practice utilizes adhesive procedures to reinforce the remaining dental structures; thus, the removal of all carious dentin may not be necessary to assure the longevity of the dental composite restorations [6]. Additionally, the presence of extensive lesions involving the inner third of dentin, the maintenance of deeper soft dentin reduces the risk of pulp exposure [7–9], avoiding increased complexity and treatment cost [10,11].

Selective carious lesion removal techniques discard outer portions of the contaminated, softer dentin, which presents significant degradation of the network of collagen fibrils, and maintain the inner demineralized dentin, which presents structural characteristics that allows it to remineralize [7,9,12–15]. After some waiting period to permit the formation of reparative and tertiary dentin, the cavity can be reopened to remove the remaining inner carious dentin (the so-called step-wise carious tissue removal). However, the reopening procedure may result in pulpal exposure or damage to the surrounding tissue [8,14,16–18]. In contrast, maintaining the caries lesion under the dental composite restoration increases the likelihood of preserving pulpal sensibility [15,18]. Nonetheless, clinicians have expressed concern that the presence of less-mineralized, softer dentin under the dental composite restoration could reduce its clinical longevity [19].

A recent systematic review of controlled clinical trials showed that selective carious tissue removal did not affect the failure rate of restorations when compared to non-selective carious tissue removal [8]. However, most of studies included in this review presented follow-up times no longer than 2 years, which may be insufficient to assess the effectiveness of restorative procedures [20]. Further, selective carious tissue removal was mainly performed in deciduous teeth. A study with a longer follow-up time of 10-years demonstrated similar longevity between dental composite restorations placed over demineralized dentin and amalgam restorations after selective carious tissue removal [12]. Therefore, the possible effects of selective carious tissue removal on the biomechanical behavior of dental composite restorations has not yet been fully established.

Clinical trials with long follow-up times following restorative procedures are difficult and expensive. Moreover, it is difficult to standardize cavity dimensions in these trials, therefore, large sample sizes are required. Contrary to clinical studies, in-vitro methodologies permit detailed analyses of restoration biomechanical behavior, for example, micro-computed tomography can assess cusp deformation due to dental composite polymerization via image analyses of tooth tissues and restorative materials volumes in the same specimen [23–25]. Some prior in-vitro studies evaluating the effect of selective carious tissues removal (natural or induced by acid challenge) on fracture strength of composite restorations found conflicting results [19,21]. Schwendicke et al. [21] evaluated the possible effect of selective carious tissue removal on cusp deformation under loading and reported that the carious tissues removal protocol did not affect this outcome. However, it is has also been reported that dental composite shrinkage stress during the restorative procedure may lead to enamel crack formation under cuspal deformation [22]. Therefore, it is reasonable to hypothesize that these undesirable consequences can be affected by the carious tissue removal protocol.

Various protocols have been reported for in-vitro carious lesions induction to include, acid challenges (e.g., acetic acid), and specific (e.g., Streptococcus mutans) and non-specific biofilms [21,26–28]. An interesting approach was used by Umwali et al. [29] cultivating a biofilm with *Lactobacillus rhamnosus* on previously demineralized dentin specimens. However, to the best of our knowledge, no prior study induced carious lesions on the pulpal floor of dental cavities by associating acid challenge and a microcosm biofilm model. Therefore, the present study aimed to: (1) develop a method to induce carious lesions on the dentin pulpal floor using an acid challenge followed by exposure to pooled human saliva biofilm; (2) determine the effect of maintaining softened dentin under the dental composite restoration on the biomechanical behavior of the restoration. We tested the null hypothesis that there is no difference between non-selective or selective carious tissue removal on enamel crack forma-