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Do in vitro and in situ erosive challenges alter the bonding performance of universal adhesives?

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Abstract

Objective

To evaluate microtensile bond strengths (μTBS), nanoleakage (NL), and degree of conversion (DC) of two universal adhesives, using etch-and-rinse (ER) or self-etch (SE) strategies on eroded dentin submitted to in vitro and in situ erosive challenges.

Methods

Dentin blocks were prepared from 120 human molars and categorized based on dentin condition (sound, in vitro eroded, and in situ eroded), adhesive system (Scotchbond Universal [SBU] and Zip bond Universal [ZIP]), and adhesive strategy (ER and SE). In the in situ erosive challenge, 20 volunteers' acrylic resin palatal devices with dentin blocks, immersing them in cola soft drink for 90s, six times daily for 15 days. The same erosive protocol was used in vitro, followed by rinsing and remineralization. Sound dentin blocks served as controls. Afterward, all dentin blocks were restored with composite resin and sectioned into resin-dentin bonded sticks for μTBS, NL, and DC assessments. Data were analyzed using three-way ANOVA and Tukey's test (α=0.05).

Results

Sound dentin exhibited the highest μTBS and DC values and the lowest NL values, while in situ eroded dentin showed the lowest μTBS and DC values and the highest NL values (p<0.0000001). While some differences in the μTBS values were observed between universal adhesives when evaluated on sound dentin (p=0.0001), no significant differences between adhesives were observed when tested on in vitro and in situ eroded dentin. Regarding NL and DC, no significant differences were found between SBU and ZIP, as well as among adhesive strategies (p>0.05).

Conclusion

Erosion in dentin, especially under in situ conditions, presents significant challenges to the adhesion of restorative materials. The choice of an effective adhesive system is crucial, as dentin eroded in situ showed lower adhesion strength and greater nanoleakage. These results highlight the need for specific clinical strategies to improve the durability and effectiveness of restorations.

Introduction

Dental erosion is defined as a chronic, and irreversible dissolution of dental hard tissues caused by acids of a non-bacterial origin [1]. This phenomenon has been identified as a globally emerging oral health problem, affecting approximately 30% of the world's population [2]. This process appears to progress at a much faster rate than caries as a surface lesion, and even though most often affects the tooth enamel, its continual progression may lead to dentin exposure, resulting in clinical signs such as hypersensitivity [3,4].

Restorative procedures are the primary choice of treatment for mitigating the progression of the erosion process. They not only alleviate the symptoms of dentin hypersensitivity but also restore both esthetics and function [5]. In terms of restorative procedures, adhesive systems are generally categorized as etch-and-rinse (ER) and self-etch (SE) systems [6]. A recent advancement in this field is the development of "universal adhesives" (UAs) [7]. This new generation of adhesives offers enhanced versatility as they can be effectively employed in both ER and SE strategies [8]. Moreover, they exhibit a chemical interaction with the dental hard tissue facilitated by the functional monomer 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP) [9]. Several in vitro studies have demonstrated the efficacy of these materials in the immediate and the longevity of restorations in sound and eroded dentin [7,10], [11], [12].

However, a significantly higher pattern of degradation was observed when UAs were applied in in vitro eroded dentin in comparison with sound dentin [13], [14], [15]. Actually, the bonding of eroded dentin surfaces is a challenge, once a network of exposed collagen fibers, by a continuous and progressive mineral loss due to the eroded process, impairs the monomer infiltration during the adhesive procedure [13], [14], [15]. Additionally, collagen fibrils that are not impregnated by resinous monomers become susceptible to hydrolytic degradation, resulting in the formation of water-rich areas at the hybrid layer, which promotes the occurrence of interfacial defects [13], [14], [15]. Furthermore, bonding procedures can be impaired due to an increased rate of accelerated erosive demineralization in the presence of host-derived enzymes, like as pepsins, matrix metalloproteinases (MMPs), and cathepsins [16] from dentin and saliva [17], ultimately limiting the durability of the bonding interface.

Nevertheless, most of the studies that evaluate the performance of UAs in eroded dentin was performed in in vitro model [5,18], [19], [20]. It is well-known that in vitro models are carried out in a controlled manner and that they cannot fully reproduce the complex oral environment and all its biological variations that influence the process of dental erosion [21], overestimating the true effects of erosive solutions on the adhesive interface. Therefore, in situ models seem to be ideal since they resemble the challenging clinical conditions that dentin surfaces present when subjected to an erosive oral environment [22]. Additionally, in situ models are performed within the oral cavities of human volunteers, mimicking the natural conditions of dentin erosion and providing a more realistic representation of the oral environment, including the influence of saliva, oral microbiota, and occlusal forces [23,24].

Regarding this matter, only two studies have assessed the impact of in situ erosion simulation on tooth bonding. However, both examined bond strength to enamel using the previous generation of adhesive systems. Neither of these studies compared bond strength between specimens eroded in vitro and those eroded in situ [25,26]. Therefore, to the extent of the author's knowledge, no previous studies evaluate the adhesive properties of in vitro and in situ eroded dentin using UAs, the main objective of the present study.

Thus, the present study aimed to evaluate microtensile bond strengths (μTBS), nanoleakage (NL), and degree of conversion (DC) of two UAs, using either etch-and-rinse (ER) or self-etch (SE) strategies, on eroded dentin subjected to in vitro and in situ erosive challenges, compared to sound dentin. The null hypotheses are as follows: (1) The μTBS, NL, and DC values of UAs applied using either a self-etch or an etch-and-rinse adhesive strategy will not differ when applied to eroded dentin in both in vitro and in situ erosive models compared to sound dentin; (2) The μTBS, NL, and DC values of UAs applied using either a self-etch or an etch-and-rinse adhesive strategy will not differ between the in vitro and in situ erosive models; and (3) Different UAs, when applied using both adhesive strategies, will not yield different μTBS, NL, and DC values for sound dentin in both in vitro and in situ erosive models. It is worth mentioning that two commercial UAs were included to assess whether the hypotheses of the present study are applicable to more than one UA.

Section snippets

Tooth selection and preparation

The present study (in vitro and in situ) has the approval of the Commission of Ethics in Research of the CEUMA University (São Luiz, MA, Brazil), under protocol #4.464.345, following the guidelines established by the Declaration of Helsinki [27]. After that, 120 caries-free, sound human molars [28] were sterilized using a steam autoclave [29] and stored in distilled water changed weekly until use. Middle dentin specimens were obtained by removing the roots 3 mm below cement–enamel junction ...

Microtensile bond strength test (μTBS)

All resin-dentin bonded sticks showed approximately 10–12 mm in length. The mean cross-sectional area ranged from 0.72 to 0.88 mm^2 and no difference among groups was detected (p=0.72). The percentage of specimens with premature failure and the frequency of each fracture pattern mode are shown in Table 2. The most frequent mode of failure in the present study was adhesive or adhesive/mixed failures, occurring in 96 % of all specimens, followed by premature failure (1.7 %) and cohesive failures ...

Discussion

According to the results of the present study, a significant decrease in the adhesive performance was observed for both UAs in in vitro and in situ eroded dentin when compared to sound dentin, regardless of adhesive strategy, leading to the rejection of the first null hypothesis. It is recognized that eroded dentin differs structurally and chemically from healthy dentin due to its mineral/organic composition [39,40], especially in the reduced amount of Ca on the surface of eroded dentin [41,42 ...

Conclusion

Both erosive cycles (in vitro and in situ) significantly reduce the bonding performance of universal adhesives when compared to sound dentin. Unfortunately, the bonding properties of universal adhesives in in situ eroded model was lower than in vitro eroded model, that indicates that eroded dentin in the laboratory may not fully replicate all the complexities that occur when eroded dentin is formed in situ. ...

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CRediT authorship contribution statement

Pedro Henrique de Aguiar Moreira: Writing – review & editing, Writing – original draft, Methodology, Investigation, **Michel Wendlinger:** Writing – original draft, Methodology, Formal analysis, **Rammon de Faria Nonato:** Methodology, Investigation, **Abrahim Lincoln Calixto:** Supervision, Methodology, Investigation, **María Cristina Bínz-Ordoñez:** Writing – review & editing, Methodology, Investigation, **Fabiana Suelen Figueredo de Siqueira:** Writing – review & editing, Supervision, Conceptualization. ...

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. ...

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