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Review Article

Relevance of Micro-leakage to Orthodontic Bonding - a Review

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Abstract

As it is seen, by passing the evolutionary process of banding of orthodontic attachments to the bonding ones, orthodontics have witnessed many developments, such as application of new adhesives, optimized base designs, new bracket materials, curing methods and more efficient primers. The studies often address the morphological, micro-leakage, and shear bond tests to evaluate bond efficacy. Among studies endeavored to develop the bond strength of brackets, some observed the reduction of micro-leakage of bracket-adhesive and enamel-adhesive interfaces. Owing to the importance of micro-leakage in orthodontics, this study aimed at reviewing the micro-leakage values directly relevant to the enamel decay and debonding of the brackets. To reach the best bond strength, the researchers tried to design different studies to evaluate the effect of variables and prevent any possible side effects in clinical situations. It is noticed that most studies have mainly focused on adhesives, enamel preparation and methods of curing which are discussed in this review. The literature was reviewed by searching databases, using micro-leakage and orthodontic bonding as the keywords . Having found the relevant studies, the researchers entered them into the database. After reviewing numerous studies conducted in this field, the type of adhesive or curing method was not found to have determinative role in the value of micro-leakage although more standardized studies are needed.

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Introduction

One of the challenges in orthodontics is the bond strength between the bracket base and the enamel surface. In restorative dentistry discoloration of the restoration margins, caries, dental sensitivity and apparent failure of the restorations are mentioned as the results of micro-leakage [1]. The reduction in marginal integrity in this junction would causes debonding of brackets during orthodontic treatment [2-4]. Moreover, bacterial accumulation causes white spot lesions during the orthodontic treatment under the influence of unfavorable bond [1-4]. Polymerase shrinkage of bonding materials, in addition to intermittent thermal cycle of mouth [5] due to hot and cold meals and mechanical loads, reinforces the marginal gaps.

Different thermal expansion coefficients between Enamel (α = 12 ppm/°C), adhesive (α = 20–55 ppm/°C) and bracket base (α = 16 ppm/°C) [6] will add a shear stress to the bond strength because of repeated expansion and contraction [7,8]. Fluid shift at the brackets-adhesive and enamel-adhesive interfaces and the lytic effect of water on the adhesive will form either large gaps or will cause debonding of brackets [5,7,9,10].

To reach the best bond strength, the researchers tried to design different studies to evaluate the effect of variables and prevent side effects in the clinical setting. Some of the studies focused on the effect of different adhesive materials, such as different self-etch primers [11-13], resin modified glass ionomers [14] and nanocomposites [15]. To reach the optimal bond , others applied different enamel preparations, such as application of bromelain and papaein gel [16], calcium silicate-sodium phosphate salts or resin infiltration [17] laser beam [18-21], air and bur abrasion [22] and different curing methods [23,24]. Some other researchers emphasized using new bracket materials [25], coating the bracket surface [26] and/or using optimized bracket base designs [27].

Having reviewed relevant studies performed, we noticed that after the banding of orthodontic attachments was replaced by the bonding ones, orthodontics underwent significant developments including the application of new adhesives, optimized base designs, new bracket materials, curing methods as well as more efficient primers. The studies often addressed the morphological, micro-leakage, and shear bond tests to evaluate the efficacy of the bond [7,28].

Among studies conducted to develop bond strength of brackets, some observed the reduction of micro-leakage of bracket-adhesive and enamel-adhesive interfaces [29,30]. As numerous studies have been carried out to investigate the effect of micro-leakage in bracket debonding and white spot lesions during orthodontic treatment and as there, at times, has not been consensus among their findings, the current study has reviewed the parameters of micro-leakage value which are directly relevant to the enamel decay and debonding of the brackets.

Materials and Methods

Medline and EMBASE electronic database searches were undertaken. Search terms included orthodontic brackets and micro-leakage.

Results

With a simple search and after deleting the common papers, 35 papers were encountered. The papers with English full text were adopted. After a gross review on the title and abstracts, the more relevant studies comprising 32 articles were included. The papers discussing the micro-leakage of orthodontic bands were also excluded from the study

Discussion

Although there is some evidence showing no correlation between micro-leakage and clinical parameters in restorative dentistry [31], several other studies insist on its adverse effects in orthodontics [5,7,9,10].

In order to investigate the micro-leakage accurately, the researchers have to use the related laboratory lab promptly. To accomplish this, each laboratory test in medical studies should fulfill some requirements- described for medical devices and compiled entitled "*Good Laboratory Practice*" by regulatory authorities such as the *Food & Drug Administration* (FDA) in Washington or the European authorities in Brussels in the 1970s and 1990s- respectively to be nominated internally valid [32]. The requirements are as follows: reproducible results, known parameters, acceptable and low variability of measured values and application of suitable devices for given purposes. On the other hand, the correlation of results with clinical findings addresses the external validity.

Considering this principle, we observed different methods used in evaluating micro-leakage beneath orthodontic brackets, as shown below.

The effect of adhesives on micro-leakage

The majority of studies conducted in this field were related to the application of different adhesives or modification of these materials. Although Buyuk *et al.* reported lower micro-leakage in low-shrinking composites, they found insufficient shear bond strength and adhesive remnant score [33] not clinically relevant. Kim *et al.* did not find significant differences between APC flash-free adhesive coated and PLUS adhesive coated system brackets [34]. Using a resin coat reduces the value of micro-leakage of orthodontic brackets [35].

Various studies were performed on the application of self-etch vs. acid-etch primers and its effect on the micro-leakage. Pakshir and Ajami, for example, did not find any statistically significant differences in micro-leakage using Transbond XT primer [36]. In a more comprehensive study [37] conducted on the effect of three self-adhesive resin cements, namely (Maxcem Elite, Relyx U 100 and Clearfil SA Cement), three two-step self-etch bonding system (Clearfil SE Bond, Clearfil Protecbond and Clearfil Liner Bond), three one-step self-etch bonding system (Transbond Plus SEP, Bond Force and Clearfil S3) and three total-etching bonding system (Transbond XT, GreenGlue and Kurasper F) on micro-leakage, it was not found to be directly related to the type of adhesive. To confirm the findings of these studies, Shahabi observed the same value for micro-leakage in spite of the lowest shear bond strength in self-etch primers (SEP) [38]. Uysal *et al*. adopted Transbond Plus Self-etching Primer vs Transbond XT. In contrast to previously addressed studies, they reported more micro-leakage in the application of self-etch primers [39].

Vicente *et al*. demonstrated that resin composites and flowable composites had poor performance after thermocycling [40]. Resin modified glass ionomers (RMGI) resulted in more micro-leakage especially at the enamel-adhesive interface [41]. The study performed on rebonding brackets found no differences in micro-leakage using various adhesive removal methods [42].

In comparison with direct and indirect bonding techniques, it was observed that applying different adhesives had no effects on micro-leakage [43]. This finding was verified by Ozturk *et al.* [44]. Canbek *et al*. compared human and bovine teeth for the evaluation of micro-leakage beneath the brackets. They reached the conclusion that unlike the thermocycled specimens, the value of micro-leakage in human teeth was less in the absence of thermocycling [7].

The effect of enamel preparation on micro-leakage

Some other studies applied different enamel preparations to investigate the differences in micro-leakage. Toodehzaeim *et al.*, for instance, found no differences between 1.5 and 2.5 watt Er:YAG laser and acid-etch preparation [19] although in a previous study, acid-etching appeared to have superior properties than laser preparation [45]. Furthermore, application of NaF 2% was reported to decrease micro-leakage on hypomineralised enamel [46].

The effect of contamination on micro-leakage

In a number of studies, the effect of contamination was addressed. Kustarci *et al*. found no differences in micro-leakage value between chlorhexidine gluconate, Clearfil Protect Bond and KTP laser [47]. Micro-leakage caused by enamel erosion increased in the presence of drinks. This might imply that these drinks could cause loss of adhesive materials [48]. Effect of saliva contamination in deteriorating the micro-leakage value was reported to be more evident in enamel adhesive interface [49]. Thus, debonding of brackets was more likely than decay on enamel surface.

The effect of light curing on micro-leakage

Having compared LED with Plasma arc units, Davari *et al.* observed that LED led to more micro-leakage value [23]. Ulker, however, found no differences in micro-leakage value of high and low- intensity curing units [50]. Micro-leakage beneath ceramic brackets was less with the protocol of curing with LEDs than with conventional curing unit [51].

Modules for evaluation of micro-leakage

Sample preparation

Almost all studies share a common method in preparation of samples for micro-leakage studies. After preparation of tooth surfaces and immersing them in a dye solution, the researcher began testing them. However, because of the ability of fluorescent dye to penetrate into the tubules, distorting results are inevitable [52,53]. In most studies conducted in this field, methylene blue is the optional choice [49,54]. The organic base of this molecule is combined with acid and its size is somehow smaller than the size of bacteria, helping the methylene blue to penetrate the tubules [6,54,55]. Unlike some other researchers, Ozturk *et al*. applied silver nitrate solution [44]. They could not detect penetration of dye because the particle could not penetrate into mini gaps.

Microscopic evaluation methods

The efficiency of microscopic evaluations can be determined through assessing the penetration depth, the quality and thickness of the hybrid layer [31]. After adhesive marked with a fluorescent dye, the researchers evaluated the specimen microscopically with a scanning electron microscope (SEM), a fluorescence microscope, the light microscope [34] or a confocal laser scanning microscope (CLSM).

On the other hand, most researchers [49-51,56,57] adopted stereomicroscope as an aid to evaluate the micro-leakage beneath orthodontic brackets. Arhun *et al*. reported more leakage at adhesive-bracket interface of metal brackets [56]. In addition, most researchers evaluated both the gingival and incisal margins [51]. Generally speaking, the stereomicroscope has the advantage of greater depth perception and allowing viewers to see objects in three dimensions but with low magnification.

The light microscope and SEM can qualitatively measure micro-leakage but they are dependent on a software program [58]. Some researchers adopted dye penetration light microscope evaluation. Kim *et al*, for instance, evaluated micro-leakage beneath ceramic brackets [34]. Although not statistically significant, they found higher median micro-leakage in the Flash-Free group. In addition, Canbek *et al.* evaluated the cervical and incisal bracket surfaces for excess bonding material using this technique [7]. They also analyzed dye penetration and adhesive-bracket and adhesive-enamel micro-leakage. However, Chapra *et al*, by adding surface-penetrating sealants, reached different results [29]. They found better marginal integrity both in unsealed and sealed groups. Buyuk [33] and Vicente [40] also applied this method. Vicente evaluated micro-leakage with the image analysis equipment to interpret the data. Navarro used SEM to evaluate the micro-leakage value [48] but Ozturk adopted micro CT [44]. To reduce the variability in the subjective evaluation of micro-leakage value, it is strictly recommended to increase the reproducibility of the results with the help of one examiner. The intra-operator variability (2-8%) is significantly less than inter-operative one (10-20%) [31].

Conclusions

Micro-leakage is one of the challenging topics in orthodontics. Scientific evidence has focused on the indispensable role of micro-leakage in bracket debonding and white spot lesions during orthodontic treatment. Generally, it seems that the type of adhesive or curing method does not have determinative role in the value of micro-leakage. Less micro-leakage is seen at the bracket-adhesive interface of the ceramic brackets. The most popular method to evaluate the micro-leakage is the analysis under a stereomicroscope.

Conflict of Interest: None declared.

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