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IATROGENIC EFFECTS OF ORTHODONTIC PROCEDURES ON ENAMEL:A REVIEW

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ABSTRACT: Orthodontic treatment has the potential to cause some damage to dental enamel during cleaning with abrasives before bonding of brackets, the acid etching process itself, enamel fractures caused by forcibly removing brackets or debonding procedures, mechanical removal of composite remnants with rotary instruments or in the rebonding of failed brackets. In addition the enamel surface may be demineralised as the result of bacterial biofilm around orthodontic attachments and also may get worn or eroded due to contact more commonly with ceramic brackets. Structural damage may also be caused intentionally by clinicians when reducing enamel by interproximal enamel stripping. Clinicians should make every effort to minimize damage to tooth enamel.

KEYWORDS: **Tooth enamel, Debonding, Biofilm.**

INTRODUCTION

If orthodontic treatment is to be of benefit to the patient, the advantages of treatment should far outweigh any adverse sequelae which might be caused by the treatment. To prevent, minimize, and manage the possible adverse effects of orthodontic mechanics, the clinician should be aware of the problems that may occur during the treatment procedures.[1] It is well known that tooth enamel is the most mineralized tissue of the human body with the composition of 96 wt % inorganic material and 4 wt % organic material and water. Certain procedures performed as part of orthodontic treatment may cause physical damage to tooth enamel. Potential damage to enamel is associated with various orthodontic treatments.

Potential Damages during Bonding

With advances in adhesive technology and the introduction of new materials and bonding techniques have greatly influenced and revolutionized orthodontic practice. Contemporary adhesives can be divided into two systems: etch and rinse (E&R) and self-etch adhesives/primers (SEP)[2]. Etch and rinse involves phosphoric acid etching and primer/adhesive resin application as two separate phases, while the latter (SEP) combines etching and priming together in a single phase and the adhesive resin in another phase, or uses etch prime adhesive as an all-in-one procedure.

With all of the currently available adhesive systems, the degree of depth of penetration of the acid during etching depends on the type and concentration of the acid, the duration of etching, and chemical composition of the enamel surface[3]. Before any acid etching, the enamel surface should be cleaned. An initial prophylaxis with a bristle brush for 10 to 15 seconds per tooth may abrade away as much as 10 µm of enamel whereas about 5 µm may be lost when a rubber cup is used[4].

Traditionally, phosphoric acid is commonly used for orthodontic etching procedures at concentrations ranging from 30% to 50% for 15 to 60 seconds, followed by rinsing and drying of the surface[5,6]. One of the effects of etching with phosphoric acid is the dissolution of hydroxyl apatite of enamel causing demineralization of the most superficial layer of enamel[7]. Phosphoric acid causes a selective dissolution of either enamel prism cores or boundaries and creates microporosity of the enamel surface ranging in depth from 5 to 50 µm[5]. To control excessive enamel loss, maleic and polyacrylic acids have been used as alternatives for phosphoric acid, but resulted in a reduction of bond strength[8].

It was shown that when self-etching primers are used, the degree of penetration by the adhesive to the etched enamel is less than of the conventional acid etch technique. However, the greater the depth that the adhesive tags penetrate the enamel, the greater the risk of damage to the enamel during debonding[9].Studies evaluating composite-to-enamel bond strength obtained with self-etching adhesive systems reveal values of 20 to 30 MPa[10], which are in the same range as that reported for enamel etched with phosphoric acid[11]. Authors have reported an average of 7.4 µm enamel loss caused by orthodontic bonding and debonding after phosphoric acid etching using a computerized 3-dimensional scanner to measure enamel loss.

Enamel Damage during Debonding Procedures

The objectives of debonding are to remove the attachment and all the adhesive resin from the tooth and to restore the surface as closely as possible to is pretreatment condition. There are many factores which should be considered during debonding, the most important of which are the type of bracket and adhesive used, instruments used for bracket removal, and the armamentarium for resin removal[12]. Various studies have suggested bond strengths ranging from 2.8 to 10 MPa as being adequate for clinical situations[13,14]. The maximum bond strength should be less than the cohesive strength of enamel, which is approximately 14 MPa, to allow for the removal of the bracket without causing damage to the enamel[15].Studies have suggested that bond strengths lower than 12.75 MPa would be safe for the enamel[16].
Authors have attempted to measure the actual force applied by the pliers during debonding and found that this method transmits 30% less force to the enamel compared with a pure shear force.There are two schools of thought regarding the amount of adhesive remaining on the teeth surface after debonding. One favors the failure at bracket adhesive interface leaving the adhesive resin on the enamel surface[12,17] and the second at the enamel-adhesive resin interface leaving much less adhesive left on the enamel surface[18].

The use of ceramic brackets for orthodontic treatment is increasing as greater numbers of adult patients, who are concerned about appearance, are being treated. Increased bond strength with ceramic brackets resulted in bond failure at the enamel surface, rather than at the bracket adhesive interface, resulting in more enamel fractures[19,20].Two particular properties of ceramics—hardness and brittleness—have necessitated the use of special debonding instruments to prevent both the enamel and bracket fracture. There are various alternative methods of debonding ceramic brackets have been proposed such as ultrasonic, electrothermal, and laser techniques[4].

To enhance the retention of adhesive to the metal base of orthodontic brackets,various chemical and mechanical retentive designs have been suggested. Other innovative approaches included using laser structured bases [21], using metal plasma-coated bracket bases [22],fusing metallic or ceramic particles to the bases [23], and sandblasting bracket base mesh surfaces [24].

Interdental Stripping: Intentional Damage

Interdental stripping, synonyms such as interproximal enamel reduction, enamel reproximation, or slenderization, is a common clinical procedure in orthodontic therapy. Among various techniques available today, the most commonly used ones are handheld or motor-driven abrasive strips, and tungsten carbide or diamond burs[25].Since many orthodontists now are increasingly focusing on nonextraction therapy, the popularity of enamel reduction has increased.It has been claimed that 0.3 to 0.4 mm of enamel can be safely removed without rendering the enamel prone to dissolution[26].

Enamel Wear

Abrasion of enamel surfaces can occur when teeth make contact with either metal or ceramic brackets during orthodontic treatment. This situation may be encountered on upper canine tips, as the cusp tip hits the lower canine brackets during retraction. It may also be seen on the incisal edges of upper anterior teeth where ceramic brackets are placed on lower incisors of a patient who has an increased overbite. The clinician should take precautions that no enamel damage is occurring due to bracket placement. One method to prevent the above situation is to delay the placement of brackets that are likely to make contact with opposing teeth, and thus assist in the prevention of enamel wear.

Susceptibility to Caries and White Spot Formation

Demineralization is a common side effect associated with fixed appliance orthodontic treatment. The development of white spot lesions (WSL) is almost inevitable when oral hygiene is poor . The components of the appliance and the bonding materials promote plaque accumulation and bacterial colonization, especially *Streptococcus mutans* and *Lactobacillus*[27],with subsequent acid production leading to decalcification. This might produce an alteration in the appearance of the enamel surface[28,29]. The incidence rate of enamel decalcification ranges from 2% to 96% and it is mainly the result of change in the pH of the oral environment favoring diffusion of calcium and phosphate ions out of enamel[30].

Chemical agents such as chlorhexidine or benzydamine used in the form of mouth rinses or oral sprays have shown to be useful adjuncts in plaque and inflammation control[31].Varnish forms of the other antibacterial solutions such as benzydamine, triclosan and xylitol could be helpful in orthodontic patients for suppressing levels of oral mutans or the other microbes for long periods, when used before the placement of fixed orthodontic appliances.

Enamel Damage During Adhesive Removal and Rebonding Failed Brackets

Although the primary orthodontic goal lies in returning the enamel surface to its original state following removal of orthodontic attachments, the adhesive removal procedures after debonding may remove up to 55.6 µm of surface enamel[32]. The failure at the bracket-adhesive interface decreases the probability of enamel damage, but has the disadvantage of requiring the mechanical removal of the residual adhesive after debonding.

Various methods for adhesive resin removal following debonding has resulted in the introduction of a wide array of instruments and procedures. These include manual removal with the use of a hand scalers or a band removing pliers [33],tungsten carbide burs (TCBs) with low or high speed hand pieces [34], Sof-Lex disks [35] and special composite finishing systems with zirconia paste or slurry pumice as well as ultrasonic applications[36]. Also novel approaches involving carbon dioxide laser application and air powder abrasive systems have been promising [37,38]. TCBs used at low speed with appropriate air cooling may be the method of choice with an acceptable enamel surface and provides good rebond strength [39].

CONCLUSION

Enamel damage can be considered as an inevitable sequela to orthodontic treatment, with various procedures producing varied effects. The aim of every orthodontic practitioner should be to minimize damages to enamel, helping improve the longevity of teeth as well as dentition as a whole. This can be done by keeping abreast with the recent technologies and using them in a proper manner. This brings in the necessity to have a fundamental knowledge of preventive dentistry principles and the clinical skill to apply those in the proper manner.

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