

# Enamel Appearance after Orthodontic Attachment Removal

## *In vitro* SEM analysis

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*The aim of this in vitro study was to assess the enamel surface appearance and Adhesive Remnant Index (ARI) after braces removal. On teeth vestibular surfaces 90 braces were bonded as follows: metallic, ceramics respectively sapphire using as bonding material Opal Seal™ (Ultradent, SUA). Teeth were divided in 3 groups (N=30) and stored for 3 months in artificial saliva, tea and Coca-Cola®. For teeth stored in tea and Coca Cola®, ARI express lower values, indicating a risk for enamel injury as fracture occurs at adhesive-enamel interface. From practical point of view, this in vitro study enhance that braces detachment, finishing and polishing are risk manoeuvres for enamel surface. Materials used for collage must present specific properties in order to reduce enamel fracture.*

*Keywords: enamel, orthodontic adhesive, debonding, finishing*

Orthodontic treatment with fixed appliances aimed, at the end, to restore the enamel characteristic prior to treatment initiation or with limited damage. Bonding procedures and intake of some types of beverage can affect enamel appearance. In addition, braces detachment and finishing methods may determine enamel impairment. Debonding techniques using cohesive fracture at bracket-adhesive interface, when the composite remain on bracket base, are recommended by experts, in order to reduce enamel fracture risk during this procedure [1, 2]. Removing remnant adhesive generate an irreversible injury on enamel surface, with a loss of dental tissue varied from 27.5 till 55.6 µm, depending on filler characteristics, finishing technique, and the measurement algorithm [3]. Tungsten carbide and diamond burs used at high speed necessitate approximately 40 s per tooth to remove the composite - a high amount of time for finishing and polishing both arches [4, 5]. The aim of this in vitro study was to assess the Adhesive Remnant Index (ARI) and enamel surface characteristics after debonding, for 3 types of braces bonded with an orthodontic adhesive when teeth were immersed in different fluids.

### Experimental part

90 teeth extracted for orthodontic purpose were used for this in vitro study. The teeth were recently extracted, caries free, without stains, fissures, filling or hypoplasia observed at inspection, in standard condition. Patient informed consent for orthodontic extraction were obtained prior to treatment initiation. The teeth were cleaned with pumice, rubber cups and abrasive paste without fluoride (Klint™, Voco GmbH). Roots were embedded in resin, to seal the apex and for easy handling. Until used, teeth were kept in saline solution (NaCl 9%). On vestibular surfaces, 90 braces were bonded as follows: metallic (Opal Avex MX™, Ultradent, SUA), ceramics (Opal Avex CX™, Ultradent, SUA), respectively sapphire (Intrigue Clear™, Lancer Orthodontics, SUA). Materials used for collage were: 35% ortho phosphoric acid gel (Unitek Etching Gel- 3M Unitek, SUA) and Opal Seal™ (Ultradent, SUA) a light-cured bonding

adhesive composite for metal and ceramic appliances with medium viscosity. Enamel surfaces were prepared for bonding using total etch technique. Acid was applied on vestibular enamel for 15 s. Acid was washed with water and dried with air from unit air-water spray for 5-10 s. Primer was put on after white enamel appearance was obtained, dried for 2 s and light-cured for 5 s, using Light-Cured Unit LED Optilux 501 (Kerr Corp.). On braces base, composite adhesive was applied and the braces were positioned on vestibular surfaces, excessive material was removed with a probe and light cured for 15 s from mesial respectively distal, according to manufacturer recommendation. Bonding using total etch technique was used because is preferred by practitioners in clinical practice.

Two minutes after bonding, the teeth were divided in 3 groups (N=30) and immersed for 3 months (since orthodontic treatments are extended in time) in 3 different liquids: artificial saliva, tea and Coca Cola® (most widely consumed beverages by adolescents and children). Artificial saliva was chosen to simulate the oral cavity conditions. After 3 months, braces were detached with light forces by one orthodontist using the Angulated Bracket Remover Pliers (Ultradent, SUA).

After debonding, the amount of remaining composite resin was evaluated in a quantitative manner, using Adhesive Remnant Index (ARI) proposed by Årtun J., Bergland S. [6] as follow:

- 0-No adhesive on enamel surface;
- 1-less than 50% adhesive on enamel surface;
- 2 - more than 50% adhesive on enamel surface;
- 3 - all adhesive remain on tooth surface, with bracket impression.

Following braces removal, the remaining adhesive was take off from the tooth surfaces using diamond burs. Subsequently, enamel was polished using cups, disks, points, pumice, brushes and abrasive paste (Super Polish, Kerr).

Enamel surfaces after debonding and after finishing were examined by one examiner, in order to reduce inter-

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human variation, using scanning electron microscopy (Inspect F, FEI Company).

## Results and discussions

An important amount of adhesive material on enamel surface was observed for metal braces, regardless the storage liquid (fig. 1, 2).

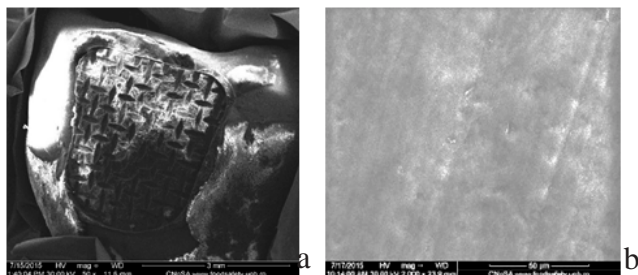


Fig.1. SEM image for tooth store in artificial saliva, ARI score=3: a) metal bracket base, magnification x3mm; all material remain on dental surface. Fracture at debonding occurred at bracket composite interface, minimising the risk for enamel fracture; b) finished and polished enamel after metal bracket removal, magnification x50µm. Limited fissures in enamel surface; eliminate the excessive amount of adhesive imposed an accurate technique in order to reduced enamel loss

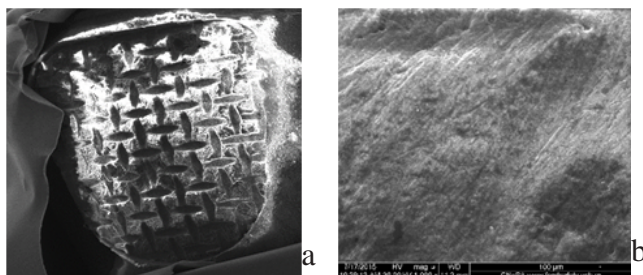


Fig. 2. SEM image for tooth store in Coca Cola®, ARI score=3: a) metal bracket base, magnification x3mm; all material remain on dental surface; b) finished and polished enamel after metal bracket removal, magnification x100µm. Reduced risk for enamel crack, but caution must be taken to limit iatrogenic enamel loss during finishing

Ceramic braces exhibited better adhesive behaviour for teeth stored in tea, versus teeth stored in Coca Cola® (fig. 3, 4).

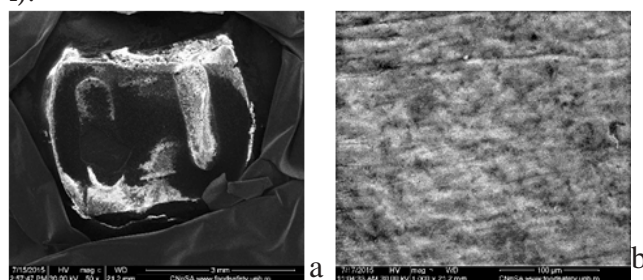


Fig. 3. SEM image for tooth store in tea, ARI score=2; a) ceramic bracket base, magnification x3mm; more than a half of material remain on enamel surface; b) finished and polished enamel after ceramic bracket removal, magnification x100µm; enamel with no appearance of cracks

When detached sapphire braces, adhesive fracture occurs at tooth-composite material interface (fig. 5).

The composite materials used in restorative dentistry should present aesthetic and adhesive properties to certify their durability over time. In orthodontics, adhesives must ensure the attachment position on tooth surface for a limited period of time. This goal requires for orthodontic adhesives to present sufficient mechanical strength but to

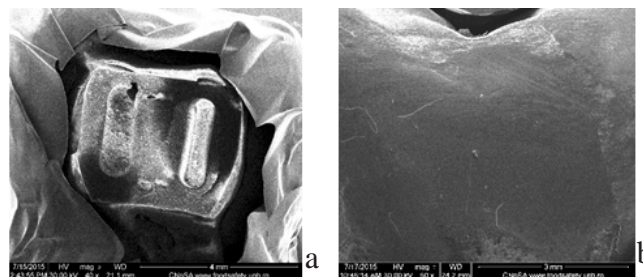


Fig. 4. SEM image for tooth store in Coca Cola®, ARI score=1; a) ceramic bracket base, magnification x4mm; less than half of material remain on vestibular enamel. Caution must be taken to reduce the risk for enamel fracture; b) finished and polished enamel after ceramic bracket removal, magnification x3mm; enamel fissures with longitudinal path

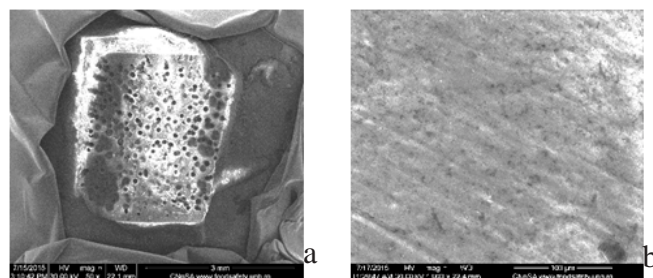


Fig. 5. SEM image for tooth store in tea, ARI score=1; a) sapphire bracket base, magnification x 3mm; less than half of material remain vestibular enamel; b) magnification x100µm, image for finished and polished enamel after sapphire bracket removal reveal limited longitudinal fissures

be able to be removed with a limited risk for enamel. The adhesive system Opal Bond™ MV (Ultradent, SUA) was chosen in this in vitro study because of its excellent physical properties, frequent clinical use and significant shear strength.

To avoid enamel cracks and traumatic fractures, especially for vestibular collage techniques, materials used as orthodontic adhesives are recommended to have properties which ensure at debonding ARI scores 2 and 3 [6]. Reducing the time for polishing and finishing enamel surface, which must regain its previous appearance after attachment removal, entailed for orthodontic adhesives ARI scores 0 and 1 [7, 8].

The in vitro evaluation lead to differences comparatively with clinical situations; discrepancies occur at the interface tooth/ adhesive- ideal isolation conditions are difficult to be achieved in clinical situations [7]. There are many factors that can cause tearing for mechanical connection at tooth bracket interface: mouth ecosystem, pH variations, chewing cycles, alcohol, temperature variations and food consistency. The variety and diversity of these factors make extremely difficult to assess the mechanical and chemical characteristics of orthodontic bonding agents [8]. In the present study, the type of bracket (metal, sapphire or ceramic) influenced the fracture level when orthodontic attachments are removed and the amount of remnants adhesive. Enamel surface is inevitably affected, more or less, with the emergence of dental hard tissue fissures [7, 9]. The greater amount of adhesive remaining on the enamel surface prevents traumatic micro fracture, but extends the time required for tooth surface cleaning, finishing and polishing [10].

A technical detail that can be considered to be influential for enamel appearance could be the etching interval. Studies have revealed more adhesive remaining on the teeth and the loss enamel decreases, when enamel was etched for a shorter time. According to literature, total etch technique settle on fewer irreversible changes of the

enamel. The most popular orthodontic adhesives are composite materials, which are attached to the enamel surface using micromechanical retention created generally with 35-40% phosphoric acid applied for about 30 s to clean enamel surface for partially dissolve the minerals. Braces placement after this algorithm causes thick resin layers with relatively deep penetration in enamel; the changes in enamel structure can be observed up to 50 mm [11, 12].

Teeth storage fluid establish a different mechanical behaviour for the adhesive system assessed in this study. In literature, SEM evaluation of the effect of carbonated beverages on tooth enamel with orthodontic attachments, revealed areas where the adhesive was lost. This observation allows us to consider that sodas may compromise the mechanical strength of the material, and facilitates at the end of the treatment braces detachment engendering fracture at the interface enamel composite material. In our study, this element was in line with the statement above; teeth stored in Coca Cola® had ARI scores 1 or 2, element that for ceramic braces increases the menace of enamel fractures or fissures [13-15].

Adhesive debris removal from the enamel surface is a real risk manoeuvre that can compromise the enamel surface. The elements determining this issue are: the composite persistent in micro retentive areas generate by etching, enamel hardness less than the materials used for finishing and polishing (tungsten carbide, quartz) [16-18].

The debonding procedures, debris removal and polishing of the adhesive can also remove a fraction of tissue, generating changes in the enamel morphology with the formation of potholes and cracks [19, 20].

Diamond high speed burs accelerates the removal of a significant amount of composite material and polishing discs have the capacity to ensure adequate polishing, especially if their surface has been treated with aluminium oxide (Sof-Lex). Using successive discs grain (high, medium, fine and superfine) ensures recovery of the enamel surface properties, but is a time-consuming manoeuvre [21, 22].

In our study we observed a good appearance after finishing for teeth stored in tea and cola comparable to those stored in artificial saliva. This observation is consistent with literature - storage liquid influence mechanical behaviour of orthodontic adhesive and the amount of remnant adhesive [23, 24]. At the end of the treatment with fixed appliances, regardless the ARI index and the finishing technique, the final look of enamel must be comparable to adjacent surfaces of the natural enamel, dry or wet [25- 27].

## Conclusions

Although the limits determined by specific conditions of an in vitro study, the following conclusions can be drawn:

The orthodontic collage must respect an algorithm in order to achieve the mechanical and biological requirements of orthodontic treatment;

Orthodontic adhesive behaviour was related in our study with the storage liquid;

De bonding, finishing and polishing are risk manoeuvres for enamel surface;

It is advisable to respect the algorithm for bonding and de bonding, in order to limit enamel surface damage.

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