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Original article

In vitro evaluation of the effects of a fluoride-releasing composite on enamel demineralization around brackets

Matteo Zanarini[a], *Elisabetta Pazzi*[b], *Stefano Bonetti*[c], *Oddone Ruggeri*[d], *Giulio Alessandri Bonetti*[e,*], *Carlo Prati*[f]

[a] *DDS, Resident, Orthodontics Unit, Department of Oral Sciences, University of Bologna, Italy*
[b] *DDS, Resident, Orthodontics Unit, Department of Oral Sciences, University of Brescia, Italy*
[c] *DDS Assistant Professor, Orthodontics Unit, Department of Oral Sciences, University of Brescia, Italy*
[d] *Associate Professor of Metallurgy at the Faculty of Industrial Chemistry of the University of Bologna, Italy*
[e] *DDS, Assistant Professor, Orthodontics Unit, Department of Oral Sciences, University of Bologna, Italy*
[f] *MD, DDS, PhD, Full Professor, Endodontics Unit, Department of Oral Sciences, University of Bologna, Italy*

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ABSTRACT

Objectives: The aim of this in vitro study was to evaluate the effectiveness of a fluoride-releasing bonding agent in inhibiting enamel demineralization around orthodontic brackets after the exposure to a demineralizing solution.

Materials and methods: Twenty-six extracted upper molars were bonded with two different composites: Transbond XT (TXT) and Transbond Plus (TPlus), fluoride-releasing (both 3 M Unitek, Monrovia, CA, USA). The samples were exposed to an acid lactic solution for three days and then subjected to Metallographic Optical Microscope (MOM) and Scanning Electron Microscope/Energy Dispersive X-Ray (SEM/EDX) analyses. Enamel surface was examined in different areas: un-treated, etched and primer-painted, un-treated area with no acid exposure, central area with bracket bonded. The maximum demineralization depths and the fluoride content at 100, 200 and 300 μm depth were evaluated.

Results: MOM analysis showed statistically significant ($p < 0.001$) differences in demineralization depth for TPlus group compared to TXT group with lower values for the first one. EDX analysis confirmed the presence of fluoride in TPlus group.

Conclusions: The fluoride content of TPlus appeared able to weakly reduce the enamel demineralization.

1. Introduction

The early appearance of enamel demineralization (white spot lesions) [1–4] and the inadequate patient compliance in adjunctive fluoride therapy frequently characterizes orthodontic patients treated with fixed appliance.[5–8] Fluoride releasing bonding agents appeared effective in inhibiting enamel demineralization and showed a clinically acceptable bond strength.[6,7,9–12] Nevertheless clinical studies exhibited conflicting data about the efficacy of these materials in

* *Corresponding author*: Orthodontics Unit, Department of Oral Sciences, University of Bologna, Italy.
E-mail address: giulio.alessandri@unibo.it (G. Alessandri Bonetti).

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prevention/inhibition of white spot lesions compared to no-fluoridated sealants or adhesives[5,13–15] and further clinical studies are required to completely support the laboratory tests. Particularly, several studies in the literature evaluated the fluoride release of bonding materials[16–18] but there is no study evaluating quantitatively the fluoride enamel uptake from orthodontic composites. Enamel demineralization around orthodontic brackets has been evaluated by several techniques such as SEM (Scanning Electron Microscope), PLM (Polarized Light Microscope), QLF (Quantitative Light-induced Fluorescence), sonic digitizer and microhardness investigations.[9–11,19–22] In the following study the enamel morphological evaluation achieved with SEM (Scanning Electron Microscope) and MOM (Metallographic Optical Microscope) analyses has been accomplished by EDX (Energy Dispersive X-ray analysis) that allows an accurate semi-quantitative analysis of enamel chemical composition and fluoride uptake from fluoridated materials.[23,24] The aim of this study was to evaluate demineralization and fluoride content of enamel surrounding orthodontic brackets applied with a fluoride-releasing composite compared to a not fluoride-releasing one after exposure to a demineralizing solution.

2. Materials and methods

2.1. Samples preparation

Human permanent upper molars extracted for periodontal reasons were collected and stored in 4 °C water for no longer than 30 days. Teeth with cracks visible under 4X magnification, hypoplasia, white spots, caries, or reconstruction were not included. Based on the analysis of the scientific literature[2,6,10,25,26] the estimated percentage of less demineralization obtained by comparing various fluoridated products and controls was at least of 50% with $\alpha = 0{,}01$ and power = 84% for a double sided test. As a consequence a minimum of 6 for each group was needed.

Twenty-six teeth were collected and randomly assigned to 2 groups of 13 elements each. All the teeth were axially cross-sectioned with a carbide tungsten bur (Komet, Gebr Brasseler, Lemgo, Germany H245 ISO 233006) thus eliminating the root approximately 2.5 mm below the dentin-enamel junction. On the buccal surface of each sample an adhesive tape template with a calibrated opening of 6X3 mm (with an excess of 3 mm in a single side of the bracket) was placed in order to delimit an etched and primer-painted enamel surface contiguous to the tested composites. All the samples were etched for 30 seconds (s) with 35% phosphoric acid gel (Scotchbond 3 M Unitek, Monrovia, CA, USA), rinsed for 30 s and air-dried for 10 s before the application of the primer (Transbond XT, light cure adhesive primer, 3 M Unitek, Monrovia, CA, USA), according to the producer's prescriptions. Brackets (0.022-inch pre-adjusted edgewise premolar bracket, 3 M Unitek, Monrovia, CA, USA) were bonded to the mid-buccal aspect of each tooth. Thirteen teeth were bonded with Transbond XT (3 M Unitek, Monrovia, CA, USA) (TXT group) and thirteen with Transbond Plus (3 M Unitek, Monrovia, CA, USA) (TPlus group). A thin and uniform layer of composite was applied on the brackets and the excess was removed by a scaler.

Time	Bath
8.00 → 8.30	distilled water
8.30→12.30	lactic acid
12.30→13.00	distilled water
13.00→16.30	lactic acid
16.30→17.00	distilled water
17.00→8.00	lactic acid

Fig. 1 – Demineralization procedure.

The composite was polymerized for 20 seconds with a visible curing light (Demetron A2, Demetron –SDS ©2007 Kerr Corporation KerrHawe SA Bioggio, Switzerland) at the constant intensity of 350-400 mW/cm^2. A layer of varnish (colored nail polish Max Factor, Procter and Gamble, Surrey, UK) was applied in the opposite side of the primer painted surface of each sample, in order to delimitate an untreated area.

2.2. Demineralization and perfusion procedure

Specimens of the two groups were alternatively immersed into different baths for 3 days and stored in an incubator model ICT 70 (Falc Instruments SRL, Bergamo, Italy) at 37 °C according to the sequence shown in Figure 1. Teeth were stored in a bath containing 75 ml of a demineralizing solution with 30 min preservation in a 75 ml distilled water bath (pH 7.0) to prevent any ionic contamination. The demineralizing solution contained a 0.1 M lactic acid adjusted to pH 4.4. After the storage procedure, samples were washed with distilled water in order to completely remove any cariogenic solution residual, rinsed and finally dried. All specimens were embedded in methylmetacrylate (Technovit ®2060, Italy) in plastic cylinders and finally cut with a microtome (Micromet M, Remet, Bologna, Italy).

2.3. Samples preparation for MOM analysis

Specimens were flattened by passing through paper of abrasive particle size decreasing from 220 to 2000 Grit and polished on discs of tissue (Polilap n°10, Italy), with a suspension of alumina powder N2-3 from 3 to 0.1 μm to obtain a mirror surface of the sample. This preparation made possible the complete removal of abrasion from the samples surfaces allowing a better observation on metallographic optical microscope (Reichert MeF_3, Germany). All samples were subjected to morphological evaluations of the enamel in the following areas (Figure 2):

- un-treated area (positions 1-2)
- etched and primer-painted area (position 3)