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Hydroxyapatite-based Bioceramic Dental Inserts as Dentin Substitutes

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Tooth caries presents one of the most common diseases worldwide, and its treatment involves removal of the decayed tooth structure, and the cavity restoration using restorative dental materials. Resin based composites (RBCs) are the most commonly used restorative material in practice owing to their great aesthetic appearance allowing the clinicians to adapt the nuance of the restoration to the patient's tooth color. However, the RBCs harden by the polymerization of monomers that leads to the polymerization shrinkage of the restoration, leaving the micro-gaps at the teeth-restorations interface which allows the secondary caries formation.

In order to overcome this problem inorganic dental inserts based on feldspar, glass, porcelain etc. were introduced as cavity megafillers [1]. Nevertheless, these materials were very distinct from the human dentin tissue, leading to inadequate properties. Recently, the bioactive, biomimetic materials gained more attention for application in biomedicine. The goal of this study was to develop a dentin substitute based on hydroxyapatite, the main inorganic component of the bones and teeth, processed in the form of dense compacts with satisfactory mechanical properties, in order to mimic the removed dentin tissue. The dental inserts are intended to be placed in the central area of the removed dentin, while a thin layer of RBCs would be used as a top coat in the area of enamel for great aesthetic, wear and sealing purposes [2]. Therefore, a great bonding ability of the dental inserts with commercially available restorative materials needs to be achieved as well.

Hydroxyapatite nanosized powders doped with 5 mol. % magnesium and binary doped with 3 mol. % magnesium and 3 mol. % strontium ions were synthesized hydrothermally at 150 °C, pressed into compacts by applying cold isostatic pressing and sintered at 1200 °C for 2 h in order to obtain bioceramic dental inserts. Microstructure, average pore and grain size, phase composition and mechanical properties of the obtained dental inserts were determined. The bonding ability of the inserts with commercially available dental composites, adhesives and cements applied by *total-etch* and *self-etch* clinical protocols were tested by the shear bond strength test. The *total-etch* protocol implied acidic surface pre-treatment of the inserts with 37 % phosphoric acid. A Field Emission Scanning electron microscope (FE-SEM Tescan Mira 3 XMU) was engaged to determine the particles morphology, inserts' microstructure, as well as the intimate bonding of the dental inserts with the restorative materials, applied by the *self-etch* and *total-etch* protocols. A cross-section of a molar restored by the proposed protocol involving a hydroxyapatite-based dental insert was also examined by using the FE-SEM.

The results showed that dopants have a significant effect on the microstructure and phase composition of the hydroxyapatite-based dental inserts, distinct solubility and mechanical properties. Smaller average grain and pore size, as well as greater hardness by Vickers were obtained in the case

of magnesium doped hydroxyapatite. The bonding strength values of both dental insert types with the Filtek Z_250 dental composite applied by Single Bond Universal adhesive system by both *self-etch* and *total-etch* protocols were in the range of the bonding strength values previously reported for human dentin [3].

In conclusion, the obtained hydroxyapatite-based dental inserts present dentin substitutes that are chemically and structurally similar to the mineral component of the human dentin, with adequate mechanical properties, as well as great bonding ability to restorative materials commonly used in dental practice, which makes them promising materials for application in restorative dentistry.

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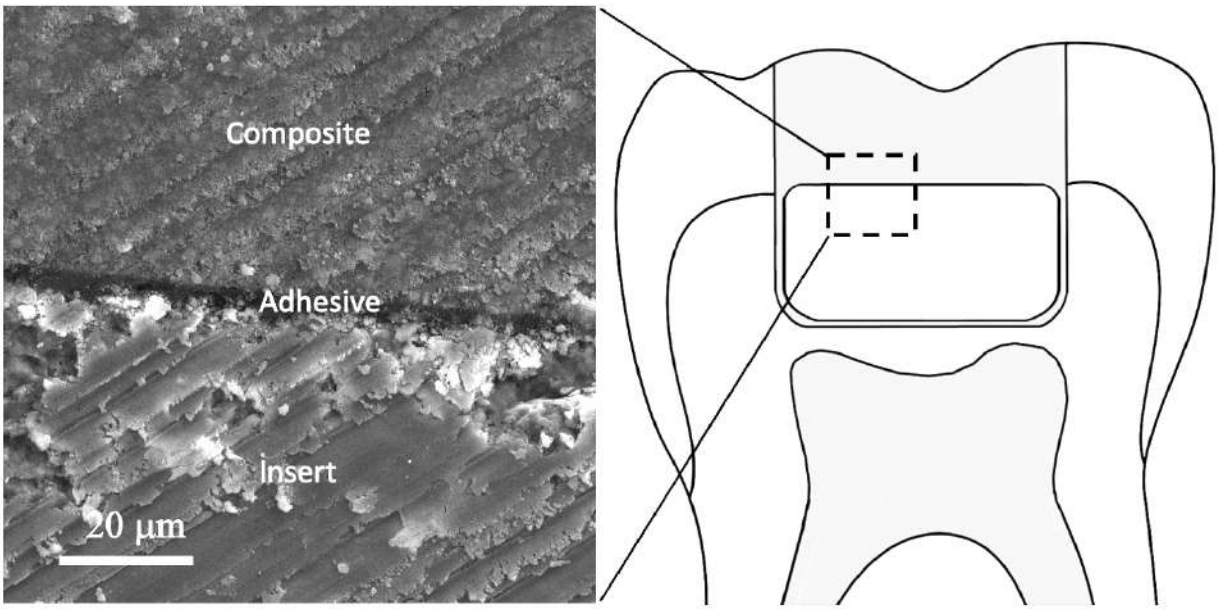

Figure 1. Schematic representation of cross-section of a molar restored by the newly proposed protocol involving hydroxyapatite-based dental insert, and FE-SEM micrograph of the composite-adhesive-insert interface. The dental insert based on hydroxyapatite doped with magnesium is bonded with Filtek Z_250 dental composite by Single Bond Universal adhesive applied by *total-etch* protocol.

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