# Bioactivity of Sylc-bioactive glass on dentine remineralization

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## Introduction.

Calcium sodium phosphosilicate/bioactive glass facilitates hydroxyapatite deposition when exposed to body fluids and saliva (Burwell *et al.* Adv Dent Res 2009.21:35-39). The aim of this study was to perform a series of experiments to test the ability of air polishing powders in enhancing the remineralization and occlusion of the dentinal tubules before and after PBS storage.

## Materials & Methods.

Thirty-five dentin crown segments were obtained from human third molars recently extracted for surgical reasons and divided in three groups according to the following air-polishing powders: sodium bicarbonate; Alumina; Sylc-bioactive glass. Dentine crown slabs (1 ± 0.1 mm) were completely demineralised in 0.02M citric acid [pH 3.5] 72h or EDTA 0.5M for 7 days.

•Knoop Microhardness (KHN)(1), was performed with a load of 100 gr and dwell time of 20s.

•Raman Analysis(2) and FTIR(3) equipped with ATR were used to analyse the chemical structure of the dentine before and after the PBS storage. FTIR-ATR spectra were collected in the range of 800-1800 cm-1 at 4 cm-1 resolution using 64 scans. Each specimen was measured at 3 different places before and after treatment. While, Raman spectra were obtained A near-infrared diode laser spot size of ≤1µm operating at 785 nm was used to induce the Raman scattering effect. The spectral coverage of this model ranges from 200 to 3000 $cm^{-1}$.

• Morphology and Microstructure, the specimens were investigated using Scanning Electron Microscope/EDX(4) at 15 kV and AFM Nanoscope IV(5).

•Dentine permeability (Sauro et al., 2010 & 2011) was quantified using a fluid filtration system working at 20cm $H_2O$ before and after artificial saliva (AS) immersion. The hydraulic conductance obtained via micro-capillary tube was converted in to the dentine permeability (Lp): $Lp = Q/At$, where Lp is the dentin permeability (µl $cm^{-2}$ $min^{-1}$), Q is the fluid flow (µl), A is the area of the dentine ($cm^2$), and t is the time (min).

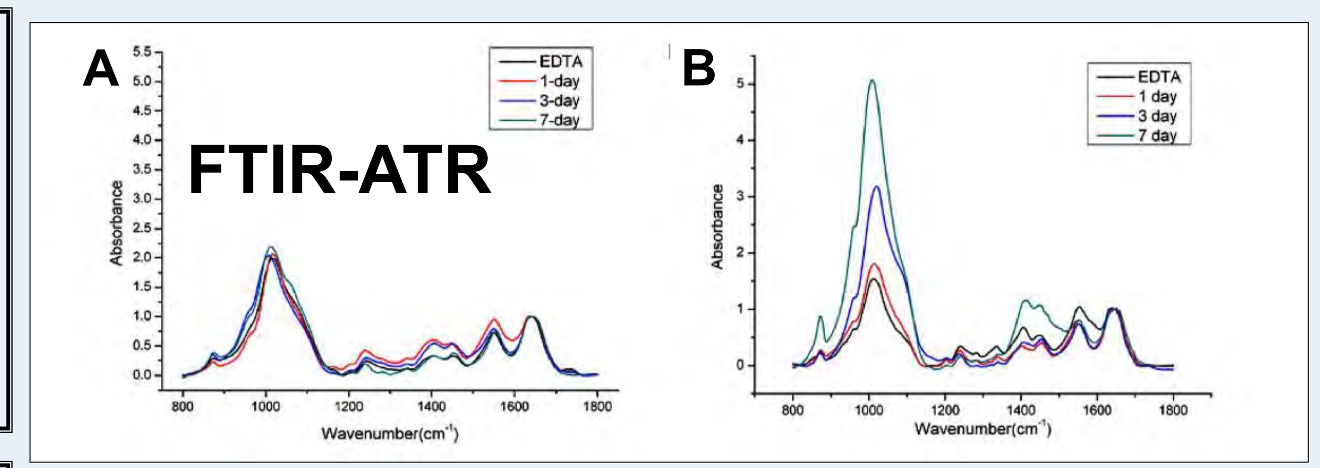
## Results

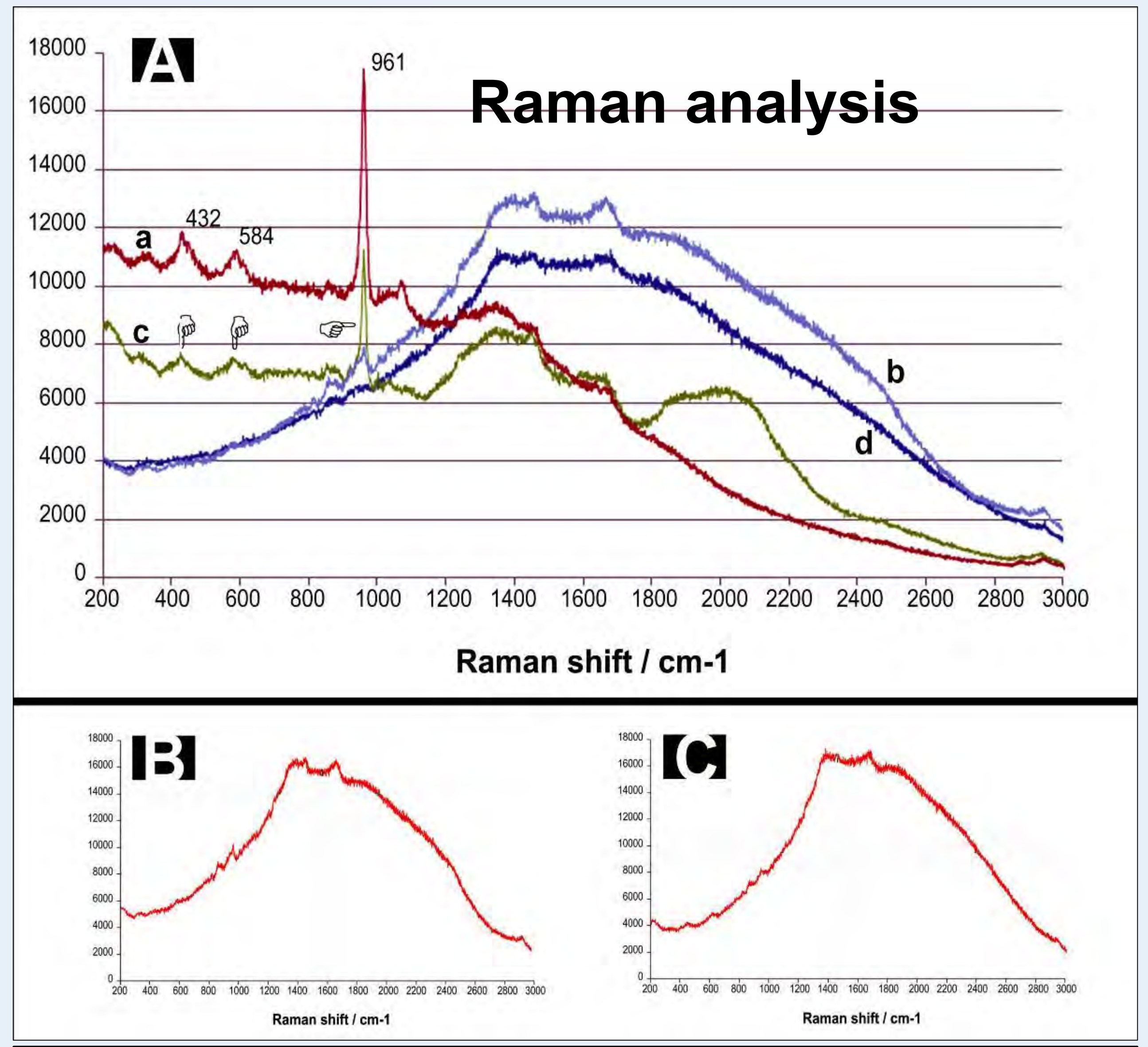
Sylc bioactive glass was the only substance able to reduce dentine permeability after immersion in PBS. Dentine remineralization was determined by clear hydroxyapatite precipitation using micro-Raman, FTIR-ATR. SEM-EDX showed high Ca and P/O ratios in the specimens treated with Sylc bioactive glass. The application of the other powders and subsequent immersion in PBS did not induce any increase in the concentration of the Ca and P/O. Knoop microhardness tests confirmed the results of remineralization by showing increase of the values.

## Discussion

The results of this study showed that the remineralization of dentine and the formation of crystalline apatite inside the dentinal tubules may be a reliable approach for the reduction of the dentine permeability. Bioglass showed high bioactivity in forming hydroxyapatite on demineralised dentine tissue when analysed by micro-Raman microscopy. SEM EDX analysis also showed high Ca and P/O ratios in the specimens treated with the Bioglass and immersed in RSS. The micro-hardness values showed viscoelastic characteristics in demineralised dentine which disappeared when the specimens were treated with Bioglass and immersed in PBS.

Moreover, Sylc bioactive glass may offer the possibility of a less invasive approach (Banerjee *et al.* Clin Oral Investig. 2010) when used in air-cutting devices and may induce a therapeutic remineralisation of dentine within the resin-dentine leading to an increase in restoration longevity.




### Captions of the chemical analysis

RAMAN ANALYSIS shows the spectra of sound dentine (a) and the absence of minerals in demineralised dentine before (b) and after PBS storage (d). The demineralised dentine treated with Bioglass and immersed in PBS for 72h shows the peaks of apatite (c). Raman spectra of the dentine treated with bicarbonate (B) and alumina (C) immersed in PBS. It is possible to observe the presence of no peak for the HCA but only a high intensity region spanning from 1,200 to 3,000 $cm^{-1}$ representing the organic components; the intensity of this region is slightly lower than that observed in the totally demineralized dentine

FTIR-ATR: the demineralised dentine immersed in PBS show no minerals (A). The dentine treated with Bioglass shows increasing of minerals content overtime(B).

| Active principles | Max Lp% (Etched dentine) | Immediate application | PBS 72h |
|---|---|---|---|
| Bioactive glass (100%) $SiO_2$, $Na_2O$, CaO $P_2O_5$ (SYLC, OSSPRAY ltd, London, UK) | 100 | 99.6±5.2 B1 (δ -0.4) [90±1.3] a1 | 20.9±5.9 A2 (δ -79.1) [57±3.4] b2 |
| Sodium bicarbonate $NaHCO_3$ (Cavitron® Prophy Powder; DENTSPLY corp., London, UK) | 100 | 98.3±3.5 B1 (δ -1.7) [89.2±1.1] a1 | 97.3±3.5 B1 (δ -2.7) [86.1±0.9] a1 |
| Alumina $Al_2O_3$ (DENTSPLY corp., London, UK) | 100 | 98.9±4.1 B1 (δ -1.1) [90.1±1.2] a1 | 93.4±5.1 B1 (δ -6.6) [88.6±1.1] a1 |

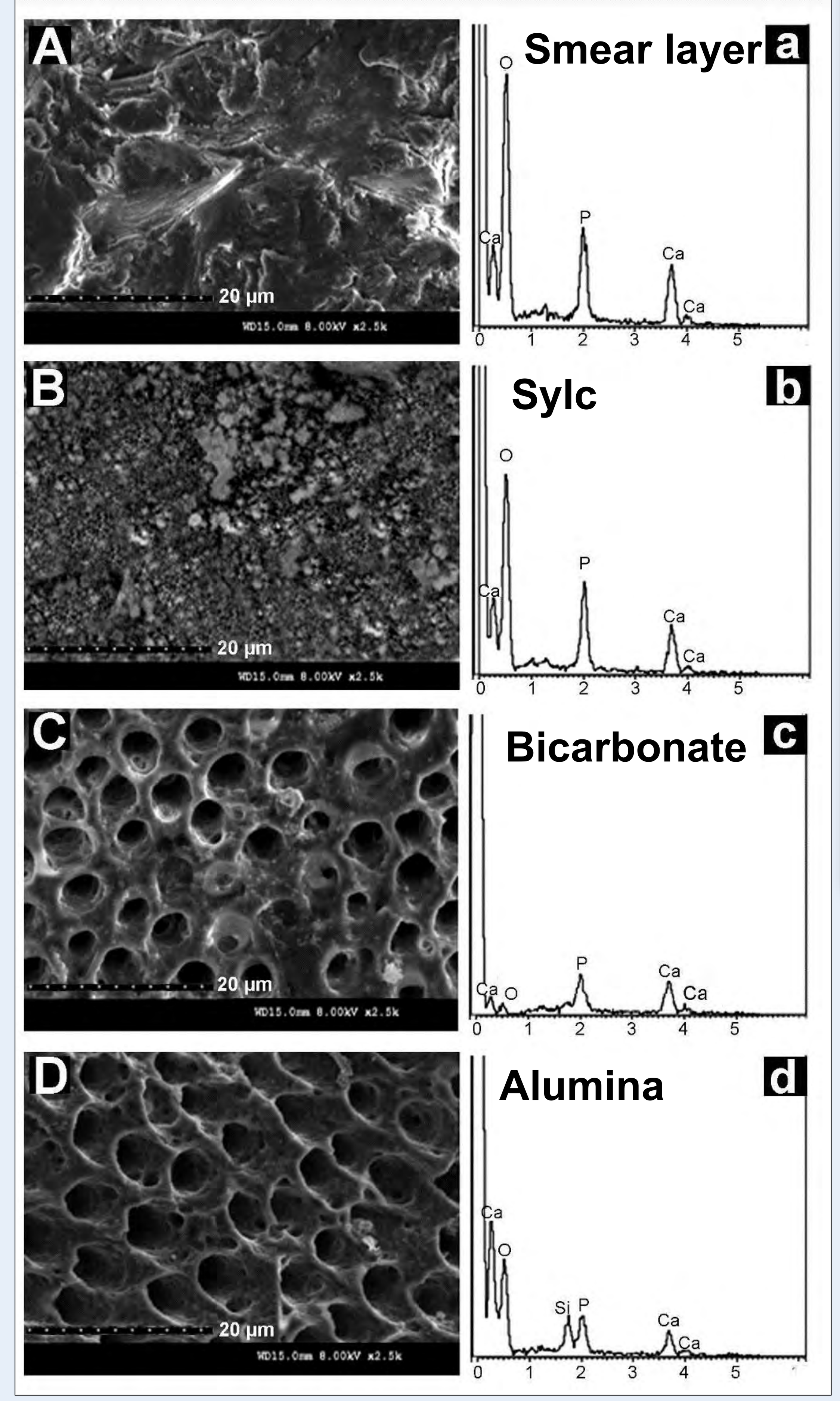
Table 1

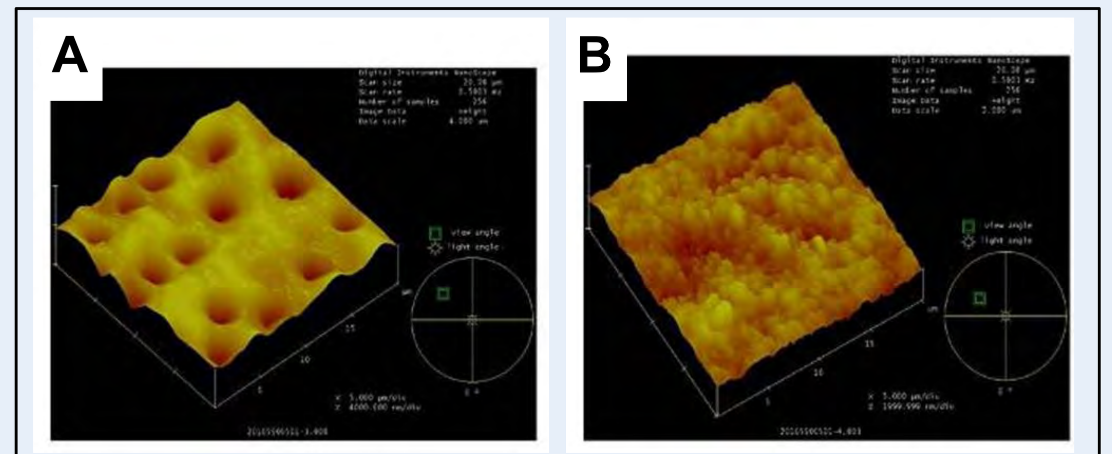
The values of dentine permeability (expressed as (%)) are reported as means. Lp after 35% PA treatment was considered the maximum permeability (Lp = 100%).

Delta values in parentheses indicate the percentage of dentine permeability reduction –Lp% between treatments and Max permeability.

Numbers in brackets represent the microhardness of the dentine surface [KHN].

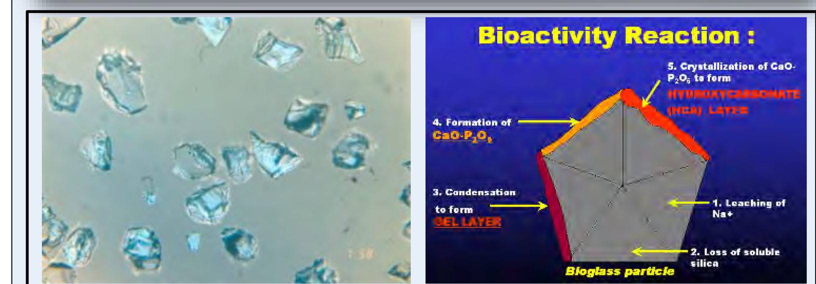
Same uppercase letter indicates no differences in columns with different product treatments maintained in the same media. Same number indicates no differences in rows for time of RSS immersion (p>0.05).




SEM and AFM image Captions

The totally demineralised dentine shows a surface characterised by exposed dentinal tubules (A). The application of Bioglass and the subsequent immersion in PBS for induce the precipitation of HCA which completely covers the dentine surface and the dentinal tubules (B).




## References

Burwell AK, Litkowski LJ, Greenspan DC. Calcium sodium phosphosilicate (NovaMin): remineralization potential. Adv Dent Res 2009.21:35-39

Sauro S, Watson TF, Thompson I. Dntine desensitization induced by prophylactic and air-polishing procedures: an in vitro dentine permeability and confocal microscopy study. J Dent. 2010. ;38:411-22.

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### Materials & Methods – manufactures details

1:Leitz Microhardness Tester; Ernst Leitz Wetzlar GmbH, Germany; 2: Leica DM/LM optical microscope with a 20x objective and CCD detector attached to a modular research spectrograph (Renishaw InVia, Renishaw plc, Gloucheshire, UK). A near-infrared diode laser spot size of ≤1µm operating at 785 nm was used to induce the Raman scattering effect. 3: Nicolet 5700 FTIR spectrophotometer (Thermo Fisher Scientific Inc., Waltham, MA, USA) equipped with a diamond crystal attenuated total reflection (ATR) accessory; 4: SEM/EDX (FEI QUANTA-200, Eindhoven, Netherlands) ; 5: Nanoscope IV(Veeco Inc, NY, USA); 6: GC corp. UK: 7: Leica SP2 CLSM, Heidelberg, Germany equipped with a 63×, 1.4 NA oil immersion lens (514 nm argon/helium ion laser) reflection or fluorescence (600 nm) filters. A z-step of 1 µm was used to optically section the specimens to a depth of up to 20 mm below the surface.