Investigation of dentine tubule occlusion using correlative three dimensional techniques

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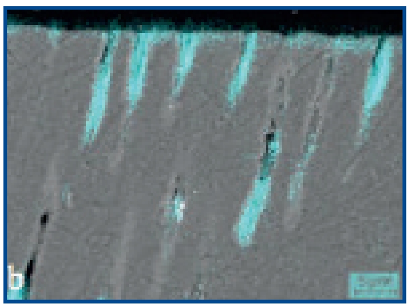
Aim

To develop systematic procedures *in vitro* to assess, with more detail, how an experimental stannous fluoride dentifrice formulation (Sensodyne® Rapid Relief) acts on dentine tubules in the treatment of dentine hypersensitivity.

Methods

Specimens of human coronal dentine were analysed via a multi-scale approach, following a hydraulic conductance study. The whole dentine discs were imaged, with 3D datasets from X-ray Micro Tomography (XMT). Then, Focused Ion Beam (FIB) Scanning Electron Microscopy (SEM) milling techniques were used to prepare cubes of known orientation and origin from the original dentine disc. These smaller specimens were then reimaged using higher resolution XMT, before Transmission Electron Microscopy (TEM), Dynamic Secondary Ion Mass Spectroscopy (DSIMS) and nano SIMS analysis for high resolution chemical and structural analysis.



BSEM image with corresponding DSIMS analysis of stannous distribution (cyan) overlaid

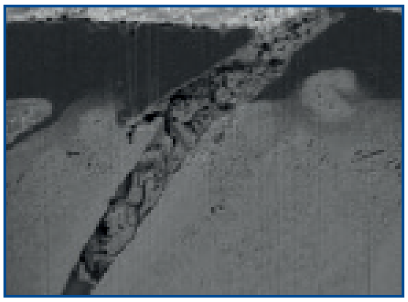
Results

This study succeeded in characterising human dentine at multiple scales.

The combination of non-destructive x-ray imaging at the micron and nano scale, plus site-specific FIB preparation procedures and high resolution TEM analysis complimented by DSIMS studies, has been applied successfully to characterise the same region of dentine from centimetres to the atomic scale.

The combination of Backscattered SEM and DSIMS images has shown clear correlation of tubule features with the presence of stannous.

Combining physical structure information from SEM and TEM with chemical information from DSIMS imaging and EDS data provides a useful method to demonstrate the mode of action of stannous fluoride.



Higher magnification SEM image showing occlusive nature of the post-treated dentine surface

Novel data fusion image combining 3D imaging data overlaid with DSIMS stannous data (blue) from the same

Conclusions

This study demonstrates the potential for a 3D *in situ* model to evaluate dentine tubule occlusion, both qualitatively and quantitatively, from the atomic to the macroscopic scale.

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