A Preliminary Approach for Analysing Debris in the Complex Canal Network of Teeth

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Aims

In dentistry, root canal therapy is the internal cleaning of a complex channel network contained within the tooth. The aim is to disinfect the canal and remove any remaining bacteria to prevent further infection prior to root filling. Irrigant solutions play an important role in this procedure as they allow canal debridement. Sodium hypochlorite (NaOCL) is an irrigant that is clinically recommended due to its antimicrobial and demineralising actions¹,². Ethylene-Diamine-Tetra-Acetic acid (EDTA) is another commonly used irrigant that is also capable of demineralising tissue¹,².

Debridement of root canals and the anatomy of the isthmus (microcanals which link adjacent canals) have commonly been analysed using optical techniques such as stereomicroscopy and scanning electron microscopy (SEM)³-⁵. These approaches require mechanical cross-sectioning of the tooth to enable imaging. Analysing debris removal in hard to reach areas such as the isthmus therefore would be better performed using an internal non-invasive imaging approach. MicroCT provides such an alternative imaging however investigators are currently unable to distinguish between structural and debris dentine as both exhibit the same opacity to x-rays⁶.

The aim of this study was to create a computational method to quantify debris, distinguishing structural dentine and debris and subsequently use this approach to analyse differences between canal preparations performed using two different irrigants (NaOCL and EDTA).

Method

Twelve lower first permanent molar teeth were pre-scanned and divided into 2 groups based on size of isthmus. Teeth were further subdivided into 3 groups comprising treatment with: i) no irrigation (positive control), ii) 17% aqueous EDTA (Vista Dental, Racine, US) and iii) 6% aqueous NaOCL (Vista Dental, Racine, US). Each group contained an equal number of teeth from groups 1 and 2. The canals were prepared by an Endodontic clinical expert using standard instruments (Dentsply Maillefer, Addlestone, UK).

Analysis of the entire lengths of all teeth was performed prior to and after preparation using a Skyscan 1172MicroCT system (E2V).

Using segmentation, erosion and dilation processes, two image sets per tooth was obtained for canal space and debris in the canal space (Fig. 1). Debris per unit pixel was calculated through summation of pixels in each image set. By calculation on pre- and post-treatment scans, percentage increase/reduction in debris was determined.

Fig. 1.MicroCT images of A) canal space and B) debris in the same canal.
Results

A preliminary study initially quantified the debris in three teeth with large isthmuses. The use of no irrigant produced a 45% increase in debris whilst EDTA and NaOCL resulted in a 41 and 28% reduction in debris present. These results were in agreement with a qualitative analysis obtained by visual inspection of images.

Qualitatively NaOCL appeared to be the most effective irrigant however this was dependent upon canal morphology. Both protrusions and micro-canals create unreachable areas, prohibiting the complete removal of debris (fig. 2).

Figure 2. Images of root canal before (Top) and after (Bottom) preparation. Arrows indicate areas with accumulated debris.

Conclusion

The method presented to quantify debris in teeth provides promising results and is able to distinguish between structural and debris dentine whilst enabling quantification of the whole canal volume. Further work will apply this methodology to all samples and computational error will be determined using ball bearings with known volume.

Data indicates that no irrigation resulted in effective root cleaning however further studies are planned to investigate whether the use of additional ultrasonic cleaning techniques improve debridement.

References