The geometry and quality of root-canal fillings in teeth: a phase-enhanced microtomography study on the *BAMline* imaging setup

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Human teeth are exposed to harsh working conditions in the mouth for many years. These harsh conditions promote wear and tear - not only due to a cyclic nature of pressure, thermal and hydration loads but also (occasionally primarily) due to damage caused by bacteria. Bacteria often actively destroy all types of tooth tissue, through the formation of caries. When extensive damage ensues and the root regions become affected/infected, the dental surgeon may perform root-canal treatment, so as to remove bacteria and debris from the tooth pulp chamber and inner canals. This is followed by canal sealing/obturation where a filler (e.g. Gutta Percha) is cemented into the empty and disinfected canal.

To date, this procedure remains problematic [1] for a variety of reasons: varying root geometry as well as access, preparation, filling and other treatment limitations. Consequently infection remains or may develop/re-appear in a large number of cases.

In the experiments reported here, single-rooted teeth were prepared according to accepted root-filling procedures as previously reported [2]. Representative samples were visualized under the partially coherent imaging conditions of the BAMline microCT setup, utilizing the propagation radiography method [3,4]. In a preliminary set of experiments, multiple phase-enhanced radiographs were collected in which edges, voids on the supra-micron length-scale and discontinuities can be seen (fig 1).

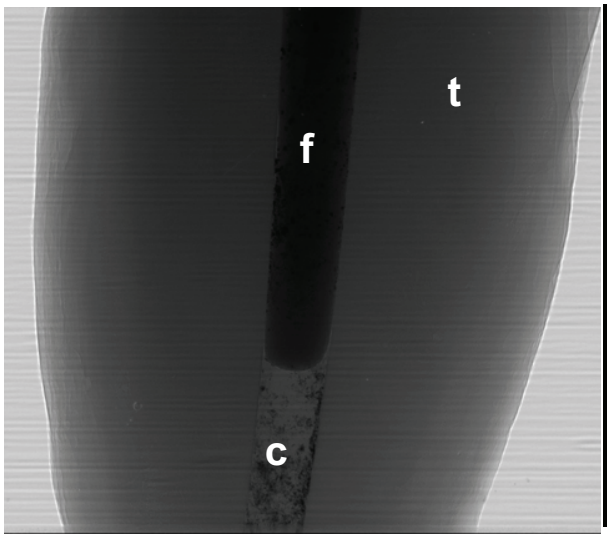

Figure 1: Typical radiograph of root-canal filled tooth; (t) - tooth (f) - filling (c) - cement

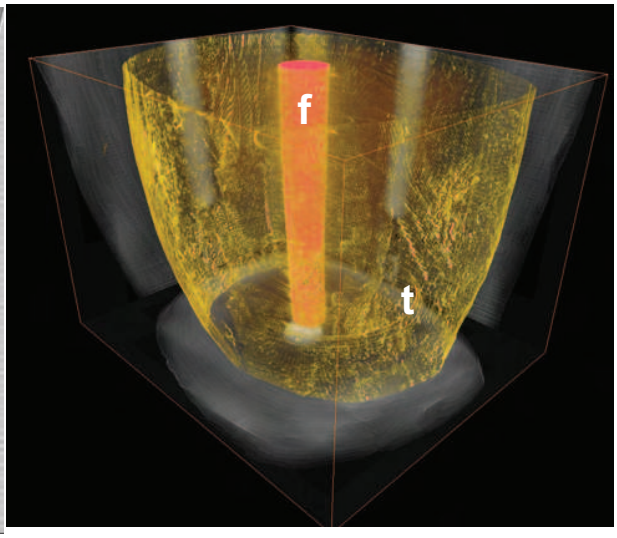

Figure 2: 3D rendering of a typical reconstruction. Red: root canal filling, yellow: outline of root and canal, black/gray: orthogonal side-projection views

The filling features revealed by the phase enhanced images are by no means simple to understand. When reconstructed into 3D tomograms, a large number of details of the canal, cement and tooth-microstructure emerge (fig 2). In such images, the complex structure cannot be represented by unique assignment of colors per region. Thus, only some of the important details are seen, attesting to a complex 3D picture.
When virtual slices are cut in the data, spatial relations between filler, cement and natural tissue are revealed (figs 3,4).
The non-destructive nature of this data and its unique level of detail suggest high potential for important findings in such measurements. Understanding the nature of interaction of the tooth and filling materials and the quality of fit along the canal require additional investigations, so as to be able to interpret the relation between the image and the real state of the materials in the wet tooth. Such information may shed important light on key contributions to the success or failure of this treatment.

Figure 3: Slice across root: low magnification view, revealing tooth root outline and filling of canal. Scale bar: 1 mm

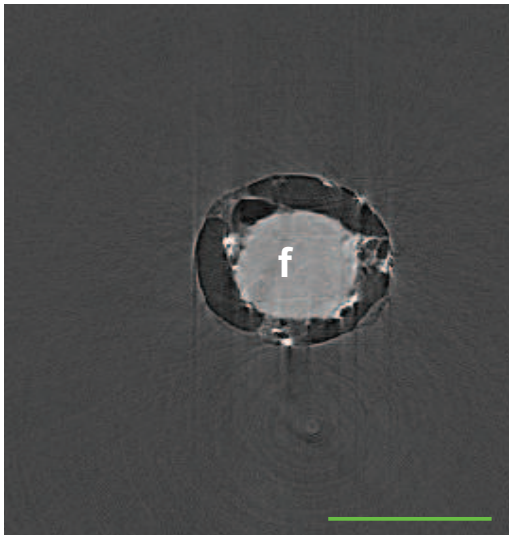

Figure 4: Slice across root: zone of root filling where clear gaps are seen between filling material and canal walls. Scale bar : 200 µm

References:

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