

A Method for μ CT Based Assessment of Root Canal Instrumentation in Endodontics Research

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The field of **endodontics** is devoted to the study and treatment of tissues inside (endo) the tooth (dontia). When a nerve within a tooth becomes necrotic and/or infected, so-called root canal therapy might be considered. In this case, a dental practitioner cleans and widens the inner root canal system by chemical irrigation and mechanical instrumentation with respect to the original canal morphology (see Figure 1). The success of this dental therapy largely depends on the safety and effectiveness - thorough cleaning and proper shaping - of the techniques employed for mechanical instrumentation (e.g. NiTi rotary files).

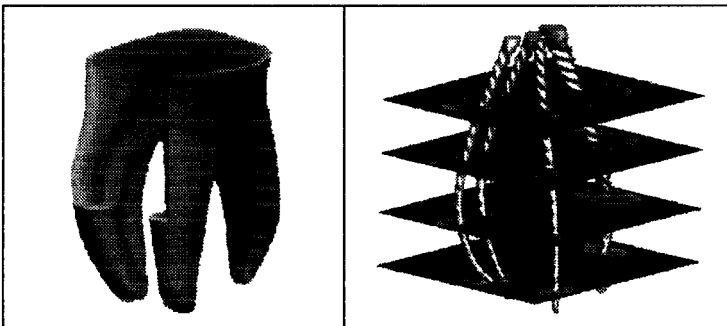


Fig. 1. *Left:* volume visualization of a μ CT scanned extracted maxillary molar before instrumentation, partially showing its interior root canal system. *Right:* visualization by axial slices of the same tooth, now with the endodontic instruments (ProFile, Dentsply Maillefer, Ballaigues, Switzerland) in place (for illustrative purpose only).

Here we present a non-destructive approach, based on micro-focus CT (μ CT) imaging [1], to study file-based preparation of root canals. A 3D methodology for quantitative evaluation of preparation effects is applied. The method was tested on ten in vitro phantoms (extracted mandibular molars). Each phantom was submitted to the five actions: 1) Acquisition of a 'pre' image volume. 2) Mechanical instrumentation of two mesial root canals by a LightSpeed file (Tulsa Dental Products, Tulsa, OK) in one canal, and by a GT Rotary file (Dentsply Maillefer, Ballaigues, Switzerland) in the other canal. 3) Acquisition of, a 'post' image volume after repositioning the phantom in the μ CT device, using parameter values equal to 'pre'. 4) Post to pre registration: as only a small percentage of a phantom was affected by the instrumentation, a rigid geometric transformation could be assumed almost everywhere between the pre and post image volumes. The approach of [2], which is

unaffected by local image deformations, was applicable (see Figure 2).
5) Quantification of instrumentation influences.

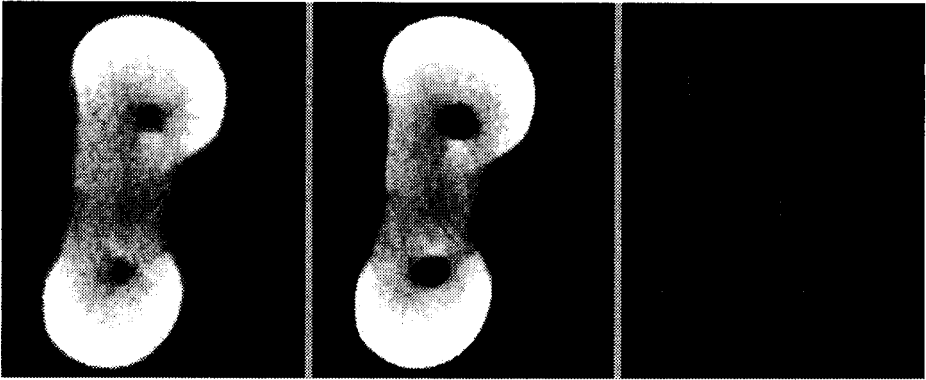


Fig. 2. *Left:* one slice from a pre image volume. *Middle:* corresponding slice from the post volume after image volume registration and resampling. Notice the effect of the endodontic instruments on both root canals. *Right:* overlay of the contours calculated on pre and post slice. Outer contours are aligned. Changes to the inner (canal) contours need to be quantified.

Instrumentation characteristics that were previously defined on 2D (destructive) cross-sections only, such as canal transportation and centering ability (Figure 3, right), were transferred to 2D reslices through post and pre image volumes. At five different levels (1.0, 3.0, 5.0, 7.0, and 9.0mm from the apex) of the pre canal axis these volumes are resliced perpendicular to the local tangent line.

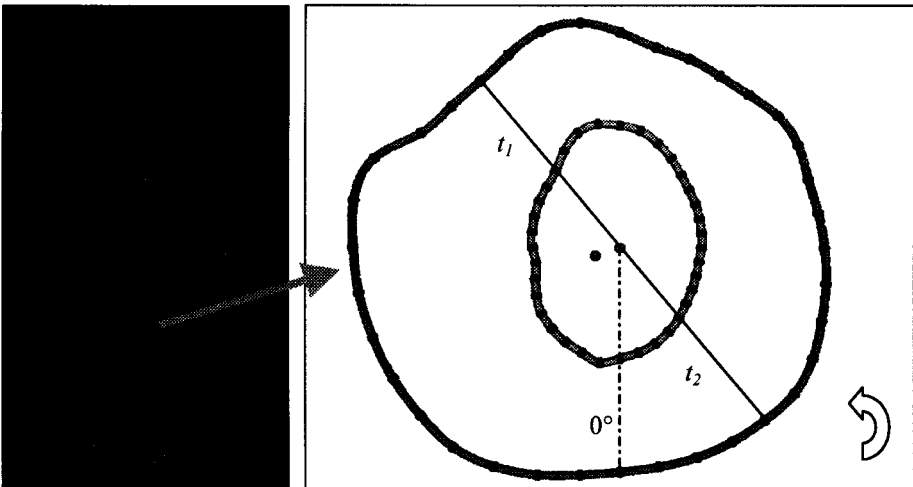


Fig. 3. Pre and post contours on a reslice plane (*left*), are represented in polar coordinates centered around the pre origin (*right*). 0° is taken at the buccal side of the root and each contour is sampled by a 10° increment counterclockwise. For each of the 18 directions thus obtained, **transportation** is defined by the distances t_1 and t_2 , net transportation by $nt = |t_1 - t_2|$ and d is the distance between the opposite post boundary points, nt/d is the centering ratio. The **centering ability** of the instrument at this reslice is then defined as $\max(nt/d)$ over all directions.

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