International Poster Journal IPJ of Dentistry and Oral Medicine

Int Poster J Dent Oral Med 2000, Vol 2 No 4, Poster 53

Use of micro computed tomography to assess root canal geometry

Language: English

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Date/Event/Venue:
11.05.2000-13.05.2000
CONSEURO 2000
Bologna, Italy

Introduction

Detailed knowledge of the complex anatomy of root canal systems is essential for successful endodontics. The current study used high resolution scanning tomography (µCT) to assess changes in the canals' paths after preparation using 4 NiTi preparation systems.

Material and Methods

A commericallyavailabe µCT scanner (µCT-20, Scanco, Bassersdorf, CH, Fig. 1A) analyzed 40 extracted human maxillary molars. Specimens were radiographed (Digora, Soredex, SF) and mounted on a high-precision holder using an alignment tool (Fig. 1B). Specimens were scanned before and after 30 canals were prepared using GT, Files, NiTi K Files, Lightspeed and ProFile .04 instruments (Fig. 2).
Canal preparation was done according to a protocol developed in our clinic (ProFile .04, Schrader et al, Int End J, 1999) or following the manufacturers' guidelines. Copious irrigation was performed using NaOCl (2.5%) and EDTA (17%).

Fig 1a - Experimental setup: Tomography scanner left and Open VMS machine

Fig 1b - Alignment tool, mould and specimen holder

Fig 2 - Instruments tested in this study: GT-Files, NiTi K Files, Lightspeed and ProFile .04 Dentsply-Maillefer, Ballaigues, CH & Lightspeed Inc, San Antonio TX, USA (from left to right).

Precise repositioning aided by the holder and perfected by overlaying the outer tooth contours allowed repeated scanning of identical volumes of interest after preparation. Specimens were displayed using still images and Quick-Time movies (Apple, Cupertino, CA, USA).

Dentin volume and surface area for each canal before and after preparation were calculated using specially developed software. Differences between means were analyzed using multiple paired T-Tests and repeated measures ANOVA.

Results

Volume rendered images of roots and root canals revealed the detailed anatomy these structures (Fig. 3). Comparison of root canal images before and after instrumentation clearly showed a distinct conical shape after GT (Fig. 4A) preparation compared to more parallel and wider preparations rendered by ProFile .04 (Fig. 4B). The latter was similar after NiTi K-File and Lightspeed preparations. No gross preparation errors were detected visually.

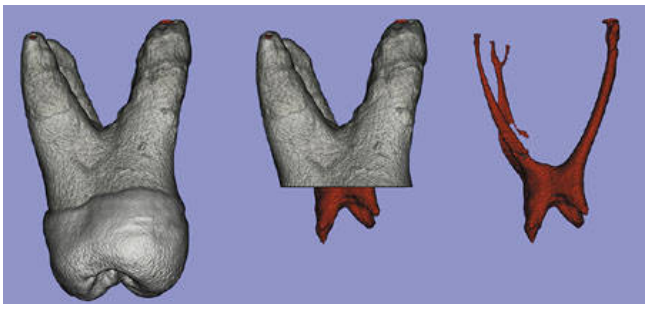

Fig 3 - Example for a specimen reproduced by volume rendering. Outer contour, pulpal horns and entire pulp are shown (from left to right).

Fig 4a - Typical examples for specimens prepared with GT-File (A) and ProFile .04 (B). Right panels unprepared, left after instrumentation. Top row clinical views, bottom row mesio-distal view.

Fig 4b - Typical examples for specimens prepared with GT-File (A) and ProFile .04 (B). Right panels unprepared, left after instrumentation. Top row clinical views, bottom row mesio-distal view.

Mean canal volumes and surface areas are shown in Fig. 5. Mean canal volumes and surface areas differed significantly ($p<0.001$) with respect to canal type. In contrast, no significant differences were found between the instrument types tested (ANOVA).

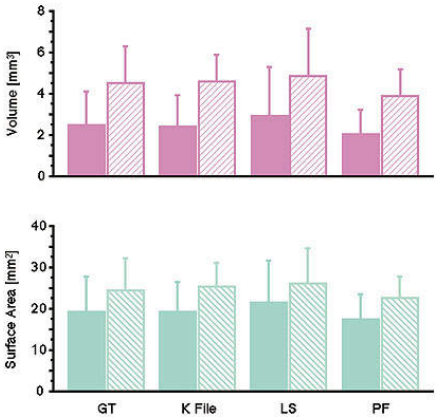

Fig 5 - Bar diagrams showing volume and surface area scores before and after canal instrumentation (n = 30). Significant difference ($p<0.001$) between pre-operative (filled bars) and post-operative scores (hatched bars).

Discussion and Conclusions

Micro CT has evolved as a promising tool in experimental endodontology. Qualitative analysis of root canal anatomy is readily possible. Figure 6 illustrates further applications, in particular qualitative analyses of the effects of root canal preparation.

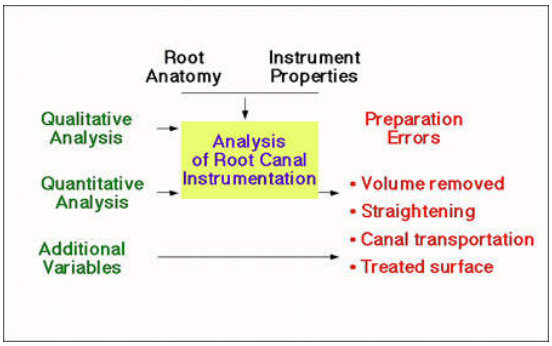

Fig 6 - Schematic drawing of root canal preparation analyses using µCT. Qualitative as well as quantitative analysis are possible.

Preparation of apical stops using Lighspeed, ProFile .04 or K Files as done in the current study resulted in canal forms distinctively different from those shaped with GT Files. However, under the conditions of this study, the use of hand or rotary NiTi instruments resulted in similar changes in canal volume and surface area. Further analyses are required to evaluate any possible subtle changes in the canals' paths after preparation. This can be also be done using the novel non-destructive approach currently presented.

For this purpose, a variety of variables have been described: namely, a Structure-Model-Index (SMI), "Thickness" and Curvature (Peters et al, JDent Res, in press).

However, µCT does have some disadvantages. For example, due to the process of segmentation any details of surfaces will appear sharper than they are. Therefore, metrical assessments of 3D reconstructed images should be carefully interpreted. Nevertheless, root canals present steep attenuation gradients which make segmentation rather robust.

Within the limitations of the technique used, there were few differences between the four instrumentation techniques evaluated.

In contrast, a strong impact of variations of canal anatomy was demonstrated. Further studies with 3D-and other techniques are required to fully understand all bio-mechanical aspects of root canal preparation.

This Poster was submitted on 25.10.00 by Dr. Ove Andreas Peters.

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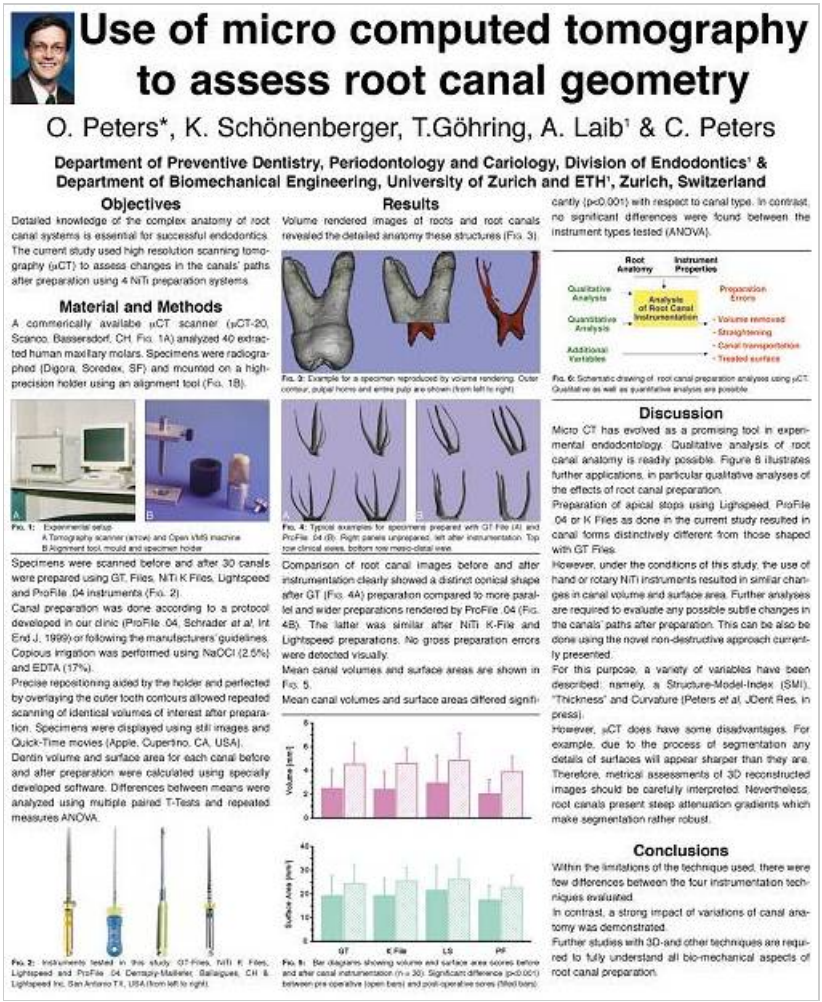

Use of micro computed tomography to assess root canal geometry

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Objectives

Detailed knowledge of the complex anatomy of root canal systems is essential for successful endodontics. The current study used high resolution scanning tomography (µCT) to assess changes in the canals' paths after preparation using 4 NiTi preparation systems.

Material and Methods

A commercially available µCT scanner (µCT-20, Scanco, Bassersdorf, CH, Fig. 1A) analyzed 40 extracted human maxillary molars. Specimens were radiographed (Digora, Soredex, SF) and mounted on a high-precision holder using an alignment tool (Fig. 1B).

Fig. 1: Experimental setup
A Tomography scanner (arrow) and Open VMS machine
B Alignment tool, mould and specimen holder

Specimens were scanned before and after 30 canals were prepared using GT Files, NiTi K Files, Lightspeed and ProFile .04 instruments (Fig. 2).

Canal preparation was done according to a protocol developed in our clinic (ProFile .04, Schrader *et al*, Int End J, 1999) or following the manufacturers' guidelines. Copious irrigation was performed using NaOCl (2.5%) and EDTA (17%).

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Fig. 2: Instruments tested in this study. GT-Files, NiTi K Files, Lightspeed and ProFile .04. Dentsply-Maillefer, Ballaigues, CH & Lightspeed Inc, San Antonio TX, USA (from left to right).

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Mean canal volumes and surface areas are shown in Fig. 5.

Mean canal volumes and surface areas differed significantly ($p<0.001$) with respect to canal type. In contrast, no significant differences were found between the instrument types tested (ANOVA).

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Fig. 6: Schematic drawing of root canal preparation analyses using µCT. Qualitative as well as quantitative analysis are possible.

Discussion

Micro CT has evolved as a promising tool in experimental endodontology. Qualitative analysis of root canal anatomy is readily possible. Figure 6 illustrates further applications, in particular qualitative analyses of the effects of root canal preparation.

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