

## Root canal geometry assessment through micro computed tomography

F. Paqué<sup>1</sup>, A.Laib<sup>2</sup> and O.A. Peters<sup>1</sup>

<sup>1</sup>Dep. of Prev. Dentistry, Cariology and Peridontology, University of Zurich, Switzerland

<sup>2</sup>SCANCO Medical AG, Brüttisellen, Switzerland

<sup>3</sup>Department of Endodontics, University of the Pacific, San Francisco, USA

### Customer need

The customer needed a tool for comparison between different root canal preparation techniques. For this micro computed tomography ( $\mu$ CT) was used to produce 3D reconstructions of the root canals in extracted human maxillary molars. The  $\mu$ CT data was used to determine canal volume, surface area and morphometric parameters.

### Materials and methods

A total of 30 root canals selected from 40 three-rooted maxillary molars were prepared with four different preparation techniques. A microCT 40 system from SCANCO Medical was used to scan the teeth twice, before and after the preparation. Volumes of interest were selected extending from the furcation region to the apex of the roots. The original grayscale images were then processed with a slight Gaussian low-pass filtration for noise reduction and a fixed segmentation threshold to separate root dentine from the root

canals. These procedures produced binary images of the root canals. The high contrast of dentine to the root canals filled with thymol or air yielded excellent segmentation of the specimens. The best superimposition of the outer root contour was automatically detected with the SCANCO registration software with a precision better than 1 voxel.

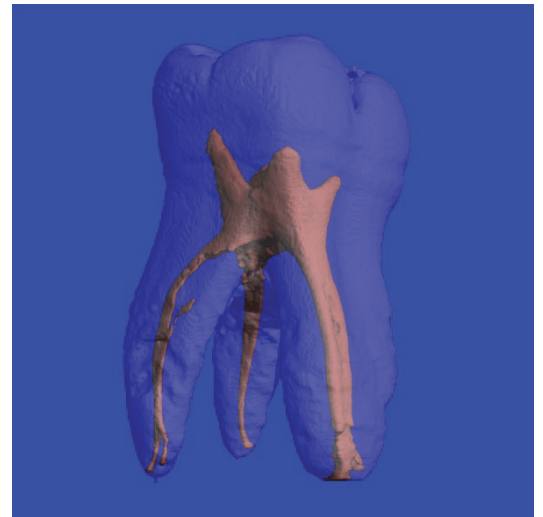


Figure 1. Volume rendered image of external and internal morphology of scanned maxillary molar.

### Customer need

Quantitative values describing the geometry of root canals.

### Materials and methods

SCANCO Medical  $\mu$ CT 40 scanner was used to produce the images and SCANCO evaluation software for the analysis.

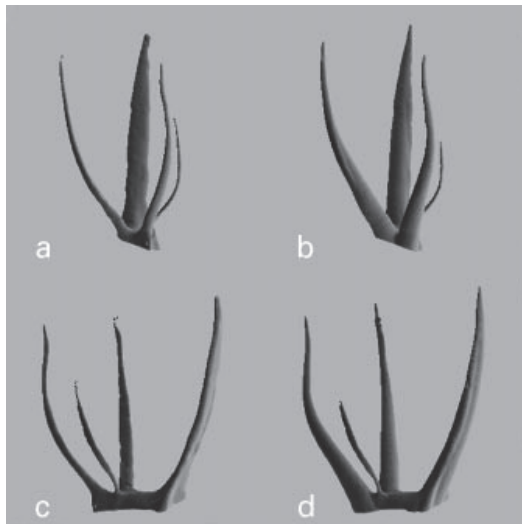
### Results

Quantitative values describing the geometry could be obtained and compared through analysis of the  $\mu$ CT images such as volume and surface area, structure model indices, thickness, conicity, curvature and average canal transportation.

Matched root canals were evaluated as follows: volumes and surface areas of the root canals were determined from triangulated data using the 'Marching Cubes' algorithm. Increases in volume and surface area were calculated by subtracting the scores for the treated canals from those recorded for the untreated counterparts. Triangulated data were also used to determine Structure Model Indices (SMI) and 'thicknesses' of the canals.

The conicity of the canals was calculated by relating thicknesses to the lengths of the canals. Exact superimposition had to be accomplished, before and after canal preparation, to obtain reproducible results for centres of gravity (CoG). CoGs of the

canals, calculated for each slice, were connected along the z-axis by a fitted line. This fitted line was analysed mathematically to determine canal curvature as the second derivative. Average canal transportations were calculated by comparing CoGs before and after treatment for the apical, middle and coronal thirds of the canals. Finally, matched images of the surface area of the canals, before and after preparation, were examined to evaluate the amount of surface area instrumented. The amount of instrumented surface could be calculated by subtracting the number of static surface voxels from the total number of surface voxels.



*Figure 2. Typical examples of possible effects of preparation on root canal anatomy illustrated by  $\mu$ CT images. Mesio-buccal canal system classified as class 3. a, b) clinical projection before and after instrumentation. c, d) mesio-distal projection before and after instrumentation.*

## Results of the analysis

Volume rendering revealed detailed images of outer root contours, as well as root canal systems (Fig. 1). Gross canal anatomy was studied using volume rendered images of isolated root canals.

The effect of root canal preparation gave rise to substantial changes in gross canal anatomy, depending on the type of instrument used. Quantitative analysis revealed that instrumentation resulted in mean increases in canal volume. Surface areas were increased after instrumentation in the vast majority of the cases; these gains were statistically highly significant. There were no statistically significant differences between the four experimental groups with respect to changes in volume and surface areas. By contrast,

significant differences were noted when grouping was made with respect to canal type. Similar results were obtained for differences in SMI and thickness. A significantly more distinct conicity was found by using one of the techniques than canals prepared with the three other techniques. Furthermore, canal curvatures were found to change in varying degrees after canal instrumentation. Overall, canal preparation led to a loss of canal curvature.

No specific pattern was found with respect to the direction of canal transportation versus instrument type and canal area. Whilst there was a similar distribution between canals transported outwards and inwards in the coronal and middle part of the canals, the vast majority of the specimens showed an outwards transportation in the apical third.

## Conclusion

The study evaluated root canal geometry using high-resolution tomography or  $\mu$ CT. This technique has evolved into an exciting tool for experimental endodontology. The 3D visualization alone does not use the full potential of  $\mu$ CT techniques, which can also be used for quantitative evaluation of objects of interest.

## References

For more information, please see original paper: International Endodontic Journal, **34**, 221–230, 2001 and newer publications such as Paqué et al, J Endodontics, **35**, 1056-1059, 2009

### SCANCO equipment

SCANCO Medical  $\mu$ CT 40 scanner

### SCANCO software

Measurement program incl. Scout View

Evaluation program (IPL)

- ✓ Segmentation
- ✓ Filtering
- ✓ 3D Registration
- ✓ Volume and surface area
- ✓ Structure Model Indices
- ✓ Thickness
- ✓ Conicity
- ✓ Curvature
- ✓ Average canal transportation

Visualization program