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Diagnosis and Decision Making in Endodontics with the Use of Cone Beam Computed Tomography

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Abstract

In the current thesis the use of cone beam computed tomography (CBCT) in endodontics has been evaluated within the framework of ex vivo and in vivo studies.

The first objective of the thesis was to examine whether CBCT scans can be used for the detection of vertical root fractures in endodontically treated teeth. The results of two ex vivo and one in vivo studies support the use of CBCT scans for the detection of vertical root fractures in endodontically treated teeth. They also suggest that the reproducibility and accuracy in vertical root fracture detection depend on the CBCT system used.

The second objective was to follow the volumetric changes of periapical radiolucencies in endodontically treated teeth one year after orthograde retreatment with the use of CBCT scans. The volume of periapical radiolucencies reduced in 57% teeth, remained unchanged in 23% and increased in 20%.

The third objective was to compare the precision of root canal length measurement on CBCT scans and periapical radiographs and to examine the influence of tooth type on these measurements. Root canal length measurements of posterior maxillary teeth were more accurate on CBCT images than periapical radiographs.

The present thesis does not suggest that CBCT scans should replace the periapical radiographs for every endodontic patient. It rather emphasizes the need for careful patient selection together with the most suitable CBCT system and settings. Furthermore, it points out the importance of making the best use of available pre-existing CBCT scans before a patient is treated.

Summary

In the current thesis the use of cone beam computed tomography (CBCT) endodontics has been evaluated within the framework of in vitro and in vivo studies. The possible enhancements in the diagnosis and the decision-making in endodontics have been analyzed and the factors affecting the formation of a treatment plan have been demonstrated.

Chapter 2 is dedicated to the detection of vertical root fractures of endodontically treated teeth on CBCT scans. Section 2.1 contains an in vitro study where the accuracy of CBCT scans is compared to that of periapical radiographs in detecting vertical root fractures. The influence of root canal filling material on the fracture visibility was also examined. The vertical root fractures in the teeth used were artificially created and the teeth were placed in dry mandibles for the scanning. The CBCT scanner used was the I-CAT (120 KvP, 5 mA, 10 x16 cm field of View (FoV), 0.25mm voxel size; Imaging Sciences, Hatfield, PA). The overall accuracy of the I-CAT CBCT scanner (86%) was higher than that of periapical radiographs (66%). The presence of root canal filling material had a negative influence on the specificity of CBCT scans ($p=0.032$) and on the sensitivity of periapical radiographs ($p=0.006$). In Section 2.2 the second in vitro study conducted as part of this thesis is presented. It examined the accuracy of five different CBCT scanners in detecting vertical root fractures. Additionally the influence of root canal filling material and the selection of the slice orientation were analyzed. The vertical root fractures in the

teeth used were artificially created and the teeth were placed in dry mandibles for the scanning. The CBCT scanners used were the following: NewTom 3 G (110KvP, 2.4mA, 10x10cm FoV, 0.2 mm voxel; QR SLR, Verona, Italy), Next Generation I-CAT (120 KvP, 5 mA, 10 x16 cm FoV, 0.25mm voxel; Imaging Sciences International, Hatfield, PA), Galileos 3D (85KvP, 7mA, 15x15cm FoV, 0.3mm voxel; Sirona Germany, Bensheim, Germany), Scanora 3D (85KvP, 10mA, 7.5x10cm FoV, 0.2mm voxel; Soredex, Tuusula, Finland), and 3D AccuiTomo-xyz (80KvP, 3.3mA, 3x4cm FoV, 0.25 voxel; J. Morita, Kyoto, Japan). There was a significant difference among the accuracy of the CBCT scanners (p=0.0001). The presence of root canal filling material negatively influenced the specificity (p=0.003) in all scanners. The use of axial slices for the assessment of the scans resulted in significantly more accurate detection of vertical fractures (p=0.0001), than the use of coronal or sagittal slices. In Section 2.3 the validity of two CBCT scanners on detecting vertical root fractures is examined in vivo. Thirty nine individuals with 39 endodontically treated teeth suspected of vertical root fracture were scanned before endodontic surgery. No fractures were visible on periapical radiographs. The scanners used were the NewTom 3G (110 kv, 3.90-5.6 mA, 0.2mm voxel; QR SLR, Verona, Italy) and 3D Accuitomo 170 (90 kv, 5mA, isotropic voxel size 0.08mm; J. Morita, Kyoto, Japan). The findings of orthograde retreatment, endodontic microsurgery, or extraction were used to verify the presence or absence of a vertical fracture. The results of this study suggest that the reproducibility and accuracy of VRF detection depend on the CBCT system used, and support the use of 3D Accuitomo 170 for the detection of VRFs in endodontically treated teeth over the use of NewTom 3G. The accuracy of 3D Accuitomo 170 (93%) is significantly higher than that of NewTom 3G (68%).

Chapter 3 contains a clinical study that examines the change in volume of periapical radiolucencies of endodontically treated teeth one year after endodontic orthograde retreatment. Forty-five endodontically treated teeth with persistent apical periodontitis requiring endodontic orthograde retreatment, from 37 individuals referred to the Postgraduate Endodontology Clinic at the Academic Centre for Dentistry Amsterdam (ACTA) from 2009 to 2011. The research protocol was approved by the VU University Medical Center Amsterdam (VUmc) ethics committee (2007/265) and the participants signed a letter of consent. For every individual there was a CBCT scan made before retreatment and a second scan a year later. The recall rate was 78% for the teeth and 73% for the patients. Two observers measured independently the volume of radiolucencies on CBCT images using the AMIRA software (5.3.4, Visage Imaging GmbH). The volumetric change in periapical radiolucencies one year after retreatment was statistically significant (z= - 3.112, p<0.005). The volume of periapical radiolucencies reduced in 20 teeth (57%) remained unchanged in 8 (23%) and increased in 7 (20%).
Chapter 4 examines the precision of root canal length measurement on CBCT scans and the influence of tooth type (anterior, posterior) on these measurements. In total 40 root canals of 33 teeth (molars, premolars, canines, incisors) out of five dentate maxillas of human cadavers were included. Root canal length measurement was performed by a consensus panel. The CBCT scanner used was the 3D Accuitomo 170 (90KV, 5mA, 360° rotation, standard resolution, 4x4cm field of view, voxel size 0,125mm; Morita, Kyoto, Japan) and digital periapical radiographs. All teeth were extracted and the measurements made on digital images (AxioCam, Carl Zeiss), linked to stereozoom microscope (Stemi SV6, Carl Zeiss), were used to define the actual root canal length. For root canals of anterior teeth there was no significant difference between the periapical

radiographs and the CBCT scans. For root canals of posterior teeth, CBCT images gave results significantly closer to the gold standard in comparison to periapical radiographs (t-value -1.96, critical value is 1.74 significance level of 0.05). Root canal length measurements of posterior maxillary teeth were more accurate on CBCT images than periapical radiographs.