# Evaluation of New Cone-beam Computed Tomographic Criteria for Radiographic Healing Evaluation after Apical Surgery: Assessment of Repeatability and Reproducibility

*Thomas von Arx, Prof Dr med dent,* Simone F.M. Janner, Dr med dent,* Stefan Hänni, Dr med dent,†‡ and Michael M. Bornstein, Prof Dr med dent**

## Abstract

**Introduction:** Conventional 2-dimensional radiography uses defined criteria for outcome assessment of apical surgery. However, these radiographic healing criteria are not applicable for 3-dimensional radiography. The present study evaluated the repeatability and reproducibility of new cone-beam computed tomographic (CBCT)-based healing criteria for the judgment of periapical healing 1 year after apical surgery. **Methods:** CBCT scans taken 1 year after apical surgery (61 roots of 54 teeth in 54 patients, mean age = 54.4 years) were evaluated by 3 blinded and calibrated observers using 4 different indices. Reformatted buccolingual CBCT sections through the longitudinal axis of the treated roots were analyzed. Radiographic healing was assessed at the resection plane (R index), within the apical area (A index), of the cortical plate (C index), and regarding a combined apical-cortical area (B index). All readings were performed twice to calculate the intraobserver agreement (repeatability). Second-time readings were used for analyzing the interobserver agreement (reproducibility). Various statistical tests (Cohen, kappa, Fisher, and Spearman) were performed to measure the intra- and interobserver concurrence, the variability of score ratios, and the correlation of indices. **Results:** For all indices, the rates of identical first- and second-time scores were always higher than 80% (intraobserver Cohen $\kappa$ values ranging from 0.793 to 0.963). The B index (94.0%) showed the highest intraobserver agreement. Regarding interobserver agreement, the highest rate was found for the B index (72.1%). The Fleiss' $\kappa$ values for R and B indices exhibited substantial agreement (0.626 and 0.717, respectively), whereas the values for A and C indices showed moderate agreement (0.561 and 0.573, respectively). The Spearman correlation coefficients for R, A, C, and B indices all exhibited a moderate to very strong correlation with the highest correlation found between C and B indices ($r_s$ = 0.8069). **Conclusions:** All indices showed an excellent intraobserver agreement (repeatability). With regard to interobserver agreement (reproducibility), the B index (healing of apical and cortical defects combined) and the R index (healing on the resection plane) showed substantial congruence and thus are to be recommended in future studies when using buccolingual CBCT sections for radiographic outcome assessment of apical surgery. *(J Endod 2016;42:236–242)*

## Key Words

Apical surgery, cone-beam computed tomography, healing indices, radiographic healing outcome, repeatability, reproducibility

The evolution of modern apical surgery is based on the enhancement of visualization (surgical microscope, endoscope), the introduction of microsurgical techniques and microinstruments, and the use of biocompatible and cement-inducing root-end filling materials (1–4).

The introduction of cone-beam computed tomographic (CBCT) imaging has been another milestone in modern endodontics (5). Although CBCT imaging has gained a wide reputation for diagnostics and treatment planning, CBCT scanning does not yet have the same impact on the assessment of endodontic treatment outcome (6). The latter is mainly because of economic aspects and concerns about radiation dose (7). In apical surgery, CBCT imaging has been shown to be an important tool for case assessment and treatment planning (8, 9). However, the actual benefit of CBCT imaging for treatment outcome and its cost-effectiveness (cost-benefit analysis) have not yet been elaborated in conjunction with conventional or surgical endodontics.

Recently, some clinical articles have documented the use of CBCT imaging for postoperative evaluation in apical surgery (10–12). These studies either compared periapical radiography (PA) and CBCT imaging in the outcome assessment of "radiographic healing" based on the absence or presence of radiolucencies in follow-up radiographs or measured the size of persistent lesions using CBCT imaging. Although some authors have suggested a new CBCT periapical index for the evaluation of endodontic lesions before treatment (13, 14), that index is not applicable and useful for CBCT assessment of the outcome of apical surgery.

Traditionally, the PA criteria for healing assessment of apical surgery are based on the work by Rud et al (15) and Molven et al (16). However, a recent study has shown that these 2-dimensional criteria may not be valid for the evaluation of 3-dimensional

From the Departments of *Oral Surgery and Stomatology and †Preventive, Pediatric, and Restorative Dentistry, School of Dental Medicine, University of Bern and ‡Private Practice Limited to Endodontics, Bern, Switzerland.

Address requests for reprints to Dr Thomas von Arx, Department of Oral Surgery and Stomatology, School of Dental Medicine, University of Bern, Freiburgstrasse 7, CH-3010 Bern, Switzerland. E-mail address: thomas.vonarx@zmk.unibe.ch

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**TABLE 1.** Definition of R, A, and C Indices According to Chen et al (17)

| Index | Definition | Score 0 | Score 1 | Score 2 |
|---|---|---|---|---|
| R | Resection plane (cut root face) | No bone deposition (no formation of PDL space) | Partial bone deposition (partial formation of PDL space) | Complete bone deposition (complete formation of PDL space of normal width) |
| A | Apical area (former bone defect) | No apparent bone formation | Partial bone formation | Complete bone formation |
| C | Cortical plate (access bone window) | Not re-established | Re-established, but concave | Re-established and flat |

PDL, periodontal ligament.

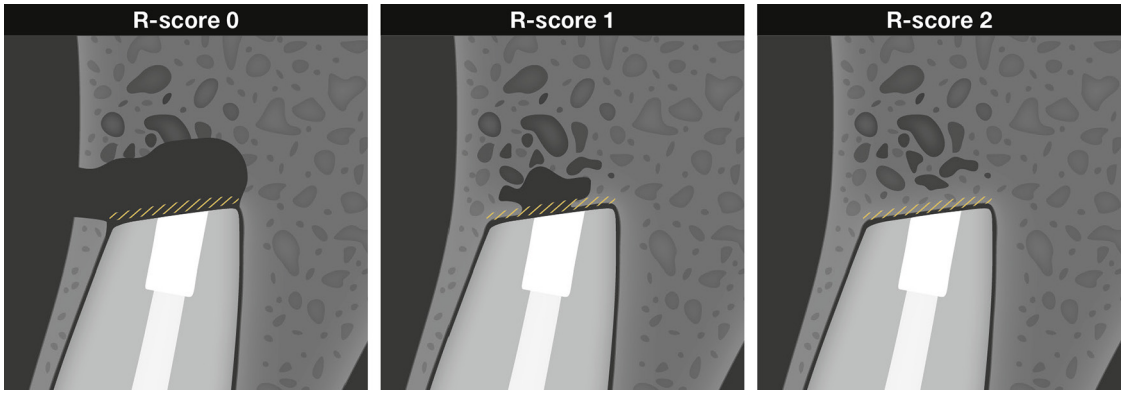


**Figure 1.** A schematic illustration of the R index (bone deposition along the resection plane).

images (12). A new experimental dog study has suggested scoring criteria for CBCT evaluation of teeth treated with apical surgery (17).

The objective of the present study was to evaluate these new CBCT-based criteria in a prospective clinical study for the radiographic outcome assessment 1 year after apical surgery.

## Materials and Methods

The present study was approved by the Ethics Committee of the State of Bern, Switzerland (approval number KEK-BE 098/11) (18). Patients were enrolled provided that they agreed on having presurgical and 1-year follow-up PA and CBCT radiographs in conjunction with apical surgery. Patient information, recruitment, and treatment were performed according to the Declaration of Helsinki 2013.

All surgeries were performed using local anesthesia in an operating room by the same surgeon (19). All surgical steps were performed using a surgical microscope. A rigid endoscope (Hopkins Tele Otoscope; Karl Storz GmbH, Tuttlingen, Germany) was used for intraoperative diagnostics during root-end management (resection, cavity preparation, and filling). All treated roots were filled with MTA (ProRoot Dentsply Tulsa Dental, Tulsa, OK).

Patients were recalled 1 year after surgery for healing assessment including a clinical examination, PA, and CBCT imaging. For the present analysis, only 1 tooth was randomly included (Quickcalcs; GraphPad Software Inc, La Jolla, CA) in patients who had apical surgery of multiple teeth.

The CBCT images were obtained with 3D Accuitomo 170 (J Morita Manufacturing Corp, Kyoto, Japan). The normal field of view was $4 \times 4$ cm or $6 \times 6$ cm for preoperative and $4 \times 4$ cm for postoperative CBCT imaging. The parameters of the recordings were 3.0 mA and 80 kV with an exposure time of 17.5 seconds. CBCT images were evaluated on a Dell 380 workstation (Dell SA, Geneva, Switzerland) and a 19-inch

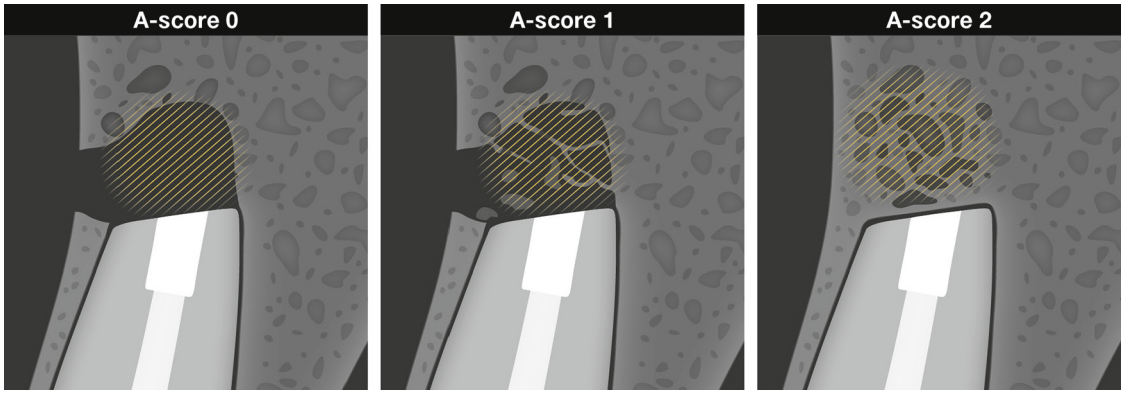


**Figure 2.** A schematic illustration of the A index (bone formation within the apical area).