BASIC RESEARCH – TECHNOLOGY

# Can Cone-beam Computed Tomography Change Endodontists' Level of Confidence in Diagnosis and Treatment Planning? A Before and After Study

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## ABSTRACT

**Introduction:** This study evaluated the influence of cone-beam computed tomography (CBCT) on endodondists' level of confidence in their diagnosis of endodontic cases and their treatment plans. **Methods:** Twenty clinical cases with periapical radiographs and small-volume CBCT scans were classified according to the American Association of Endodontists guidelines. Information was provided on patient clinical history, and both extraoral and intraoral examinations were simulated. Fifteen endodontists filled out 2 questionnaires. In the first (Q1), the clinical description and a periapical radiograph were presented, followed by the questions. Thirty days later, they answered a second questionnaire (Q2) containing the same clinical description and CBCT. Their confidence in diagnosis and treatment planning was analyzed before and after receiving the tomographic images. Responses were recorded on a 5-point Likert scale, and the Wilcoxon test was used to investigate before and after levels of confidence in diagnosis and treatment planning. **Results:** The CBCT images influenced confidence in diagnosis and treatment planning of endodontic cases classified as complex (Wilcoxon test; $P \leq .05$). There was a substantial change in the treatment planned in both moderate and complex cases after CBCT. Case complexity did not affect the participants' decision to request complementary information through CBCT. **Conclusions:** In complex cases, CBCT increased endodontists' confidence to diagnose and plan treatment, when compared with periapical radiographs. Endodontists tended to recommend intervention when periapical images were supplemented with CBCT. CBCT proved to be an imaging method that influences endodontists' preoperative evaluation and treatment choice. *(J Endod 2019;■:1–6.)*

## KEY WORDS

Cone-beam computed tomography; diagnosis; endodontics

## SIGNIFICANCE

Decisions on diagnosis and treatment proposals should be secure and confident. This study shows that CBCT increases the endodontist's confidence in making a diagnosis and providing treatment planning recommendations.

In endodontics, decisions are taken on the basis of professional experience, risk and benefit assessments, costs, prognosis, and treatment possibilities[1]. Radiographic interpretation can play an important role in this complex process.

In clinical endodontics, the periapical radiograph is usually the initial imaging modality to be considered. It is accessible and inexpensive and subjects the patient to a low radiation dose. However, a two-dimensional examination has limitations[2]. The lack of information on the third dimension can interfere with an accurate diagnosis[2,3]. Cone-beam computed tomography (CBCT) is a high-resolution three-dimensional technique that can overcome the geometric distortion and the overlap of anatomic structures associated with periapical radiographs[4].

Use of three-dimensional imaging in endodontics is described in the American Association of Endodontists (AAE) and the American Academy of Oral and Maxillofacial Radiology joint position

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statement and the SEDENTEXCT guidelines from the European Commission on Radiological Protection on the use of CBCT. They recommend that intraoral radiographs should be considered the imaging modality for initial evaluation. CBCT is recommended when the data provided by periapical radiography are inconclusive or incompatible with the clinical information. It is worth mentioning that a small field of view (FOV), small voxel sizes, low mA setting (depending on patient size), short exposure time, and a pulsed exposure mode of acquisition are recommended[5,6]. However, in these guidelines, there is no evidence on the efficacy of the diagnostic tests. The SEDENTEXCT project emphasizes the need for scientific evidence regarding changes in diagnoses and results of clinical planning using CBCT[6]. The cost-benefit of CBCT in terms of positive impacts for both patient health and society should be assessed. It is not clear how this imaging method influences diagnosis and treatment decisions[7].

Evaluation of diagnostic tests is based on their level of efficacy, ranging from technical measures of image quality to social impact, encompassing the entire contribution each test or examination makes to patient management. Level 1 and 2 studies demonstrate technical efficacy and effectiveness for diagnosis. Level 3 and 4 studies determine whether the information yielded changes professional diagnostic thinking and its effect on the patient management plan, respectively. Level 5 efficacy studies measure the information's effect on patient outcomes. Finally, level 6 analyses examine societal costs and benefits of diagnostic imaging technology[8]. Level 3 to 6 studies of use of CBCT in endodontics are scarce in the literature[9].

One systematic review evaluated the diagnostic efficacy of CBCT in endodontics. This review included 6 articles that evaluated the role of CBCT in professionals' decision-making on planning and treatment of different cases. The study concluded that it was not possible to establish the benefit of CBCT scans in terms of changes to diagnosis and treatment planning in endodontic cases and observed that research studies are mainly limited to assessments of technical and diagnostic precision (levels 1 and 2 of diagnostic efficacy)[10].

Therefore, the objective of the present study was to determine the influence of CBCT on treatment planning and to evaluate its effect on endodontists' level of confidence in their diagnoses and treatment plans for clinical cases with different levels of complexity.

## MATERIALS AND METHODS

This single-center, "before-and-after" study obtained Research Ethics Committee approval with CAAE Protocol number 80080817.6.0000.5347.

### Study Participants

Eligible participants were endodontists and postgraduate students in the last year of the residency course. The sample size was calculated assuming the expected population standard deviation to be 4.5, and using the t-distribution, the study would require a sample size of 12 to estimate a mean with 95% confidence and a precision of 3[11]. Twenty participants were invited, and 15 concluded both phases of the study. All participants signed informed consent form before participating in the study.

### Selection of Cases

Imaging records were selected from the archives of a private dental radiology clinic. Data containing periapical and small-volume CBCT scans with endodontic pathosis were evaluated. Twenty cases were selected for this study. Cases were classified as moderate ($n = 10$) or complex ($n = 10$) by 2 specialists in Oral and Maxillofacial Radiology (A.M.W. and H.T.V.) and 1 specialist in Endodontics (F.M.) using the evaluation form proposed by the AAE[12]. No cases of minimal difficulty were selected because using CBCT is not indicated in such scenarios.

Periapical radiographs were obtained by using the paralleling technique in a KaVo FOCUS (KaVo Dental, Biberach, Germany) device, operated at 66 kVp, 8 mA. The image receptor was the VistaScan system (Vista Scan Perio; Durr Dental, Bietigheim Bissingen, Germany). The CBCTs were performed in the Vatech Pax-Duo3D Pano/CBCT System (Vatech, Seoul, Republic of Korea) with 5 × 5 cm FOV and 0.08-mm voxel (CBCT), operating at 89 kV, 8 mA, and 12-second scanning time.

The cases were accompanied by fictitious clinical histories, including data such as patient age and sex and clinical signs and symptoms such as depth of probing, gingival bleeding, swelling, sensitivity, pain (identifying type and duration), pulp sensitivity test findings, and the patient's systemic condition. This information was intended to simulate details from patient history taking.

### Design and Evaluation of Questionnaires

Two questionnaires were designed on Google Docs, web 2.0 (Google Inc, Mountain View, CA) (Fig. 1 and Table 1). First, a questionnaire with the periapical image (Q1) was made available to the observers. After 30 days, the second phase questionnaire (Q2) was provided, containing the same clinical description as Q1 and also the multiplanar tomographic reconstruction, followed by similar questions to those in Q1. In both questionnaires, cases and examiners were identified by codes. Participants were recommended to use the same desktop or laptop computer (with a screen size of at least 13 inches) and reduced lighting during both evaluation periods.

### Statistical Analysis

Statistical calculations were performed using SPSS version 18.0 (SPSS, Chicago, IL). The significance level was set at 5%. The answers to the questionnaires containing the periapical radiography (Q1) and the CBCT (Q2) were compared. A total of 240 responses were considered for data analysis, with an equal proportion for moderate and complex cases. Responses were recorded on a 5-point Likert scale, and the Wilcoxon test was applied to analyze the observers' confidence in diagnosis and treatment planning. The $\chi^2$ test was performed to determine whether, at the end of Q1, the respondent believed that supplementary examination with CBCT was needed.

## RESULTS

Table 2 shows the results for the question "What is your level of confidence in the case diagnosis?" In the moderate complexity cases, it was observed that 70 responses maintained the same score in Q1 and Q2, whereas 44 had higher scores on the Likert scale when CBCT examination was used for diagnosis. In 27.5% of responses, the observers felt more confident in performing the diagnosis using CBCT. There was no statistical difference in diagnostic confidence in cases classified as moderate (Wilcoxon test; $P = .413$). For the cases classified as complex, the same values were found as for the moderate cases (70 responses), but there was a significant difference for positive scores (31.3%) (Wilcoxon test; $P = .010$).

After evaluating the clinical history and periapical radiography, the observer was asked whether he/she would request CBCT. In 45.2% of the moderate and 55.3% of the complex cases, observers stated they would request complementary CBCT. Case complexity did not affect the participant' decision to request the additional information provided by CBCT ($\chi^2$ test; $P = .409$).

Figure 2 shows the results for treatment planning. Use of CBCT changed the treatment plan in 54% and 56% of responses for

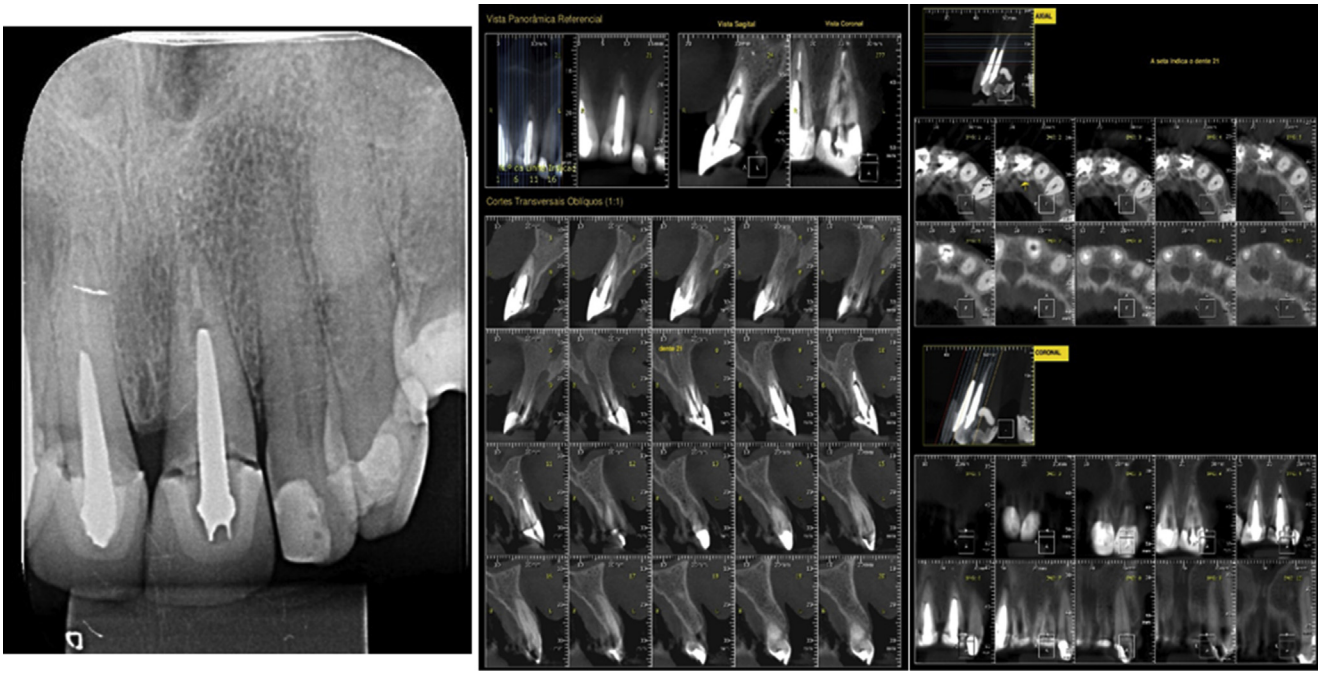


**FIGURE 1 –** Example of the cases chosen for the study. Periapical radiograph was used for questionnaire 1 (Q1), and CBCT multiplanar reconstruction was used for Q2. A clinical history followed both images, eg, "A 50-year-old male patient requested a dental appointment to evaluate his left maxillary incisor. The patient had no history of systemic disease. There was no gingivitis, and periodontal probing depth was 3 mm at all sites. The tooth had a fixed prosthesis with a post. The patient reported tenderness on percussion. Root canal treatment had been performed four years previously. The patient had suffered a sports-related dental trauma. During clinical examination, vertical and horizontal percussion sensitivity tests were positive. The patient did not have edema or pain on apical palpation. The tooth is not mobile and there is no sinus tract present".

moderate and complex cases, respectively. More specifically, CBCT evaluation prompted a large proportion of respondents to change the treatment recommended from "following-up the case" to "non-surgical clinical approach" (87.3% for moderate cases and 92% for complex cases). When the treatment option in Q1 was "non-surgical clinical approach," 71% and 73% of responses to moderate and complex cases, respectively, remained the same in Q2. If the treatment plan changed from Q1 to Q2, the observer intended to adopt a more invasive treatment option. The "clinical surgical approach" was chosen in only 1 response in Q1 for a moderate case, and this decision remained the same in Q2. "Dental extraction" was chosen in 3 responses for moderate cases and 14 responses for complex cases in Q1. Changes were observed after the CBCT examination, especially in complex cases, where 5 of 14 responses migrated to "non-surgical clinical approach." There were substantial changes in treatment planning from Q1 to Q2 in both moderate and complex cases.

For the question "What is your level of confidence in the treatment plan?" (Table 3), there was a predominance of unchanged responses for both moderate and complex cases (78 and 76, respectively), although there was a significant difference in the level of confidence in treatment plans for complex cases (Wilcoxon test; $P = .043$).

## DISCUSSION

Diagnostic and therapeutic decision-making should be secure and confident. CBCT has been widely discussed as an effective preoperative image modality in endodontics[13,14]. The AAE and the American Academy of Oral and Maxillofacial Radiology

**TABLE 1 -** Summary of Items on Questionnaires Q1 (using the periapical radiograph) and Q2 (using the CBCT multiplanar reconstruction)

| Question | Response choices |
|---|---|
| (1) What is your level of confidence in the case diagnosis? | (1) Not confident, (2) mildly under confident, (3) uncertain, (4) mildly confident, and (5) very confident |
| (2) After clinical analysis and imaging, which therapeutic decision would you take? | (1) Would not start the non-surgical clinical procedure and would request CBCT; (2) would not start the non-surgical clinical procedure and would perform clinical and radiographic follow-up; (3) would start the non-surgical clinical procedure; (4) would start the non-surgical procedure and request CBCT at the end of the appointment; (5) would choose a surgical endodontic procedure and would not require CBCT; (6) would choose surgical endodontic procedure and would request a CBCT; and (7) would perform extraction.<br>The same question for Q2 (CBCT), with the following response options:<br>(1) Clinical and radiographic follow-up; (2) start the clinical procedure without surgery; (3) start the surgical procedure; and (4) perform a dental extraction |
| (3) What is your level of confidence in the treatment plan? | (1) Not confident, (2) mildly under confident, (3) uncertain, (4) mildly confident, and (5) very confident |

**TABLE 2 -** Scores Chosen in Response to the Question "What Is Your Level of Confidence in the Case Diagnosis," with Relation to Clinical Cases Classified as Moderate and Complex Difficulty

| | After CBCT | | | | | |
|---|---|---|---|---|---|---|
| **Before CBCT** | **2** | **3** | **4** | **5** | **Total** | ***P* value** |
| Moderate | | | | | | |
| 1 | 0 | 1 | 1 | 0 | 2 | .413, NS |
| 2 | 0 | 1 | 4 | 1 | 6 | |
| 3 | 2 | 8 | 15 | 1 | 26 | |
| 4 | 1 | 11 | 41 | 20 | 73 | |
| 5 | 0 | 6 | 16 | 21 | 43 | |
| Total | 3 | 27 | 77 | 43 | 150 | |
| Complex | | | | | | |
| 1 | 0 | 1 | 0 | 1 | 2 | .010* |
| 2 | 1 | 1 | 6 | 2 | 10 | |
| 3 | 0 | 10 | 10 | 6 | 26 | |
| 4 | 1 | 8 | 36 | 20 | 65 | |
| 5 | 0 | 1 | 23 | 23 | 47 | |
| Total | 2 | 21 | 75 | 52 | 150 | |

NS, not significant.
Ten cases and 15 observers comprising 150 answers on a 5-point Likert scale (from 1, not confident to 5, very confident).
*Significant difference, $P \leq .05$; Wilcoxon test.

do not recommend routine use of CBCT for endodontic diagnosis or screening purposes, especially not for cases of low complexity[5]. However, endodontists often deal with complex clinical situations. Therefore, the present study evaluated the influence that CBCT has on endodontists' level of confidence in imaging-based diagnosis and treatment planning, when compared with periapical radiographs.

The clinical cases were classified according to an assessment form developed by the AAE to assist in clinical categorization of difficulty and case selection[12]. The characteristics adopted for categorization at various levels of complexity are inherent to the patient and the diagnosis, as well as any additional information that is provided. It should be noted that this study only used cases of moderate and high difficulty, because international guidelines do not indicate routine use of tomographic examinations, especially not for cases of low complexity.

Levels 3 and 4 from the hierarchical model of Fryback and Thornbury[8] were considered to determine whether additional information provided by CBCT would change endodontists' diagnostic thinking and the patient management plan through a paired analysis of questions and subsequent answers given to the questionnaires.

In this study, endodontists felt greater confidence in making diagnoses using three-dimensional examinations. The proportion of responses in which the level of confidence increased from Q1 to Q2 was 27.5% for moderate cases and 31.3% for complex cases. There are conflicting results in the literature on this aspect. Mota de Almeida et al[14] showed that availability of CBCT

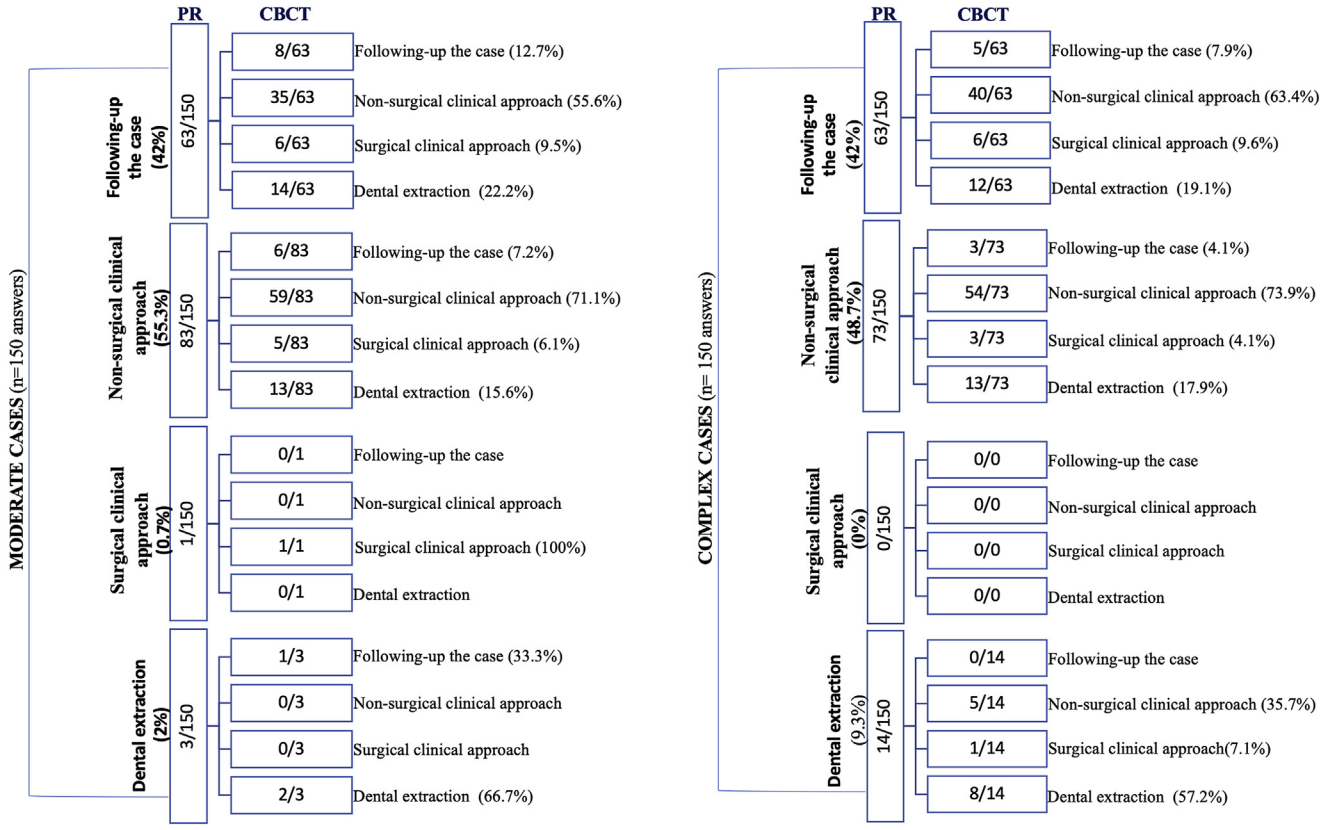


**FIGURE 2 –** Flowchart illustrating the distribution of answers for treatment decisions on moderate and complex cases evaluated before and after CBCT. PR, periapical radiography.

**TABLE 3 -** Scores Chosen in Response to the Question "What Is Your Level of Confidence in the Treatment Plan?" with Relation to Clinical Cases Classified as Moderate and Complex Difficulty

| | After CBCT | | | | | | |
|---|---|---|---|---|---|---|---|
| **Before CBCT** | **1** | **2** | **3** | **4** | **5** | **Total** | ***P* value** |
| Moderate | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | 1 | 1 | .827, NS |
| 2 | 0 | 0 | 0 | 3 | 0 | 3 | |
| 3 | 0 | 1 | 8 | 10 | 4 | 23 | |
| 4 | 0 | 2 | 9 | 37 | 20 | 68 | |
| 5 | 0 | 0 | 5 | 17 | 33 | 55 | |
| Total | 0 | 3 | 22 | 67 | 58 | 150 | |
| Complex | | | | | | | |
| 1 | 0 | 0 | 0 | 1 | 0 | 1 | .043* |
| 2 | 0 | 0 | 0 | 1 | 4 | 5 | |
| 3 | 0 | 0 | 6 | 10 | 6 | 22 | |
| 4 | 0 | 1 | 8 | 30 | 20 | 59 | |
| 5 | 1 | 0 | 5 | 17 | 40 | 57 | |
| Total | 1 | 1 | 19 | 59 | 70 | 150 | |

NS, not significant.
Ten cases and 15 observers comprising 150 answers on a 5-point Likert scale (from 1, not confident to 5, very confident).
*Significant difference, $P \leq .05$; Wilcoxon test.

increases professional confidence. However, Al-Salehi and Horner[15] indicated that evidence was inconclusive.

In 50% of all answers, the endodontists responded that they would request the CBCT examination, irrespective of the level of complexity. This result indicates that two-dimensional examination is often inconclusive in moderate and complex cases. Although CBCT involves higher levels of radiation compared with a single periapical radiograph, it increases the degree of confidence in diagnostic decision-making and treatment approach planning, especially in complex cases. Therefore, the decision to request a CBCT is justified, in line with the ALADA principle of "as low as diagnostically acceptable"[16].

The decision-making process is reliant on analysis of both clinical description and imaging interpretation. Although they did not perform a clinical examination, providing a standard clinical history for each case made it possible to ensure that all of the evaluators were working with a standardized scenario. The responses to the question about the treatment plan were restricted to general options because the aim of the study was not to determine procedure details or techniques, which can be associated with institution-specific conduct.

Some studies declare that preoperative CBCT provides additional information when compared with periapical radiographs, leading to changes in the treatment plan in 27.3%[17], 53%[18], 57.8%[14], and 62%[13] of cases for clinical and radiographic follow-up, nonsurgical clinical approach, clinical surgical approach, and dental extraction, respectively. In this study, after the CBCT examination, the treatment plan changed in 54% of the answers for cases of moderate complexity and 56% of the answers for complex cases. Therefore, CBCT can be recognized as a useful adjunct for decision-making in endodontic cases. This high percentage of change, as also observed by Mota de Almeida et al[14], can be explained by the selection criteria applied, which were adopted from the SEDENTEXCT project[6] and AAE guidelines[12].

There were significant changes to the treatment plans for both moderate and complex cases. There was a considerable decrease in the number of "clinical and radiographic follow-up" responses after CBCT evaluation, when compared with radiographs for the same clinical situation (42% for both moderate and complex cases using radiographs, contrasting with 12.7% for moderate cases and 7.9% for complex cases after CBCT). A similar pattern (40% before CBCT and 10% afterwards) was also described by Mota de Almeida et al[18]. The nonsurgical clinical approach was the treatment option with the highest proportion of changed responses. The reason for this general pattern may be that CBCT is more accurate than radiographs for providing detail on anatomic structures[19–21]. Use of three-dimensional images allows the endodontist to obtain a proper understanding of the anatomy of the root canal system or pathologies involving it, when defining the treatment plan for clinical cases. Endodontists therefore tend to be more likely to recommend intervention when CBCT is available. Mota de Almeida et al[14–18] observed that CBCT analysis increased endodontists' confidence in their chosen therapy. Our results provide complementary information, because we observed this effect in complex cases.

## CONCLUSION

The CBCT examination increased endodontists' confidence in their diagnoses and treatment plans, especially in complex endodontic cases. Endodontists tended to recommend intervention when the periapical images were supplemented with CBCT. CBCT influenced professional confidence when assessing endodontic cases, conducting preoperative analysis, and deciding on treatment method.

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*The authors deny any conflicts of interest related to this study.*

## REFERENCES

1. Kvist T, Heden G, Reit C. Endodontic retreatment strategies used by general dental practitioners. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004;97:502–7.
2. Estrela C, Bueno MR, Leles CR, et al. Accuracy of cone beam computed tomography and panoramic and periapical radiography for detection of apical periodontitis. J Endod 2008;34:273–9.

3. Patel S, Dawood A, Whaites E, Pitt Ford T. New dimensions in endodontic imaging: part 1—conventional and alternative radiographic systems. Int Endod J 2009;42:447–62.
4. Uraba S, Ebihara A, Komatsu K, et al. Ability of cone-beam computed tomography to detect periapical lesions that were not detected by periapical radiography: a retrospective assessment according to tooth group. J Endod 2016;42:1186–90.
5. Special Committee to Revise the Joint AAE/AAOMR Position Statement on use of CBCT in Endodontics. AAE and AAOMR joint position statement: use of cone beam computed tomography in endodontics 2015 update. Oral Surg Oral Med Oral Pathol Oral Radiol 2015;120:508–12.
6. SEDENTEXCT guidelines. Safety and efficacy of a new and emerging dental X-ray modality: radiation protection no. 172—cone beam CT for dental and maxillofacial radiology. In: *Evidence based guidelines*. Geneva, Switzerland: European Commission; 2012. Available at: http://www.sedentexct.eu/files/radiation_protection_172.pdf. Accessed August 3, 2019.
7. Kruse C, Spin-Neto R, Wenzel A, Kirkevang L-L. Cone beam computed tomography and periapical lesions: a systematic review analysing studies on diagnostic efficacy by a hierarchical model. Int Endod J 2015;48:815–28.
8. Fryback DG, Thornbury JR. The efficacy of diagnostic imaging. Med Decis Making 1991;11:88–94.
9. Matzen LH, Wenzel A. Efficacy of CBCT for assessment of impacted mandibular third molars: a review—based on a hierarchical model of evidence. Dentomaxillofacial Radiol 2015;44:20140189. https://doi.org/10.1259/dmfr.20140189.
10. Rosen E, Taschieri S, Del Fabbro M, et al. The diagnostic efficacy of cone-beam computed tomography in endodontics: a systematic review and analysis by a hierarchical model of efficacy. J Endod 2015;41:1008–14.
11. Dhand NK, Khatkar MS. Statulator: an online statistical calculator—sample size calculator for estimating a single mean. Avaliable at: http://statulator.com/SampleSize/ss1P.html. Accessed August 3, 2019.
12. AAE endodontic case difficulty assessment form and guidelinesAvailable at: https://www.aae.org/specialty/wp-content/uploads/sites/2/2017/10/2006casedifficultyassessmentformb_edited2010.pdf. Accessed August 3, 2019.
13. Ee J, Fayad MI, Johnson BR. Comparison of endodontic diagnosis and treatment planning decisions using cone-beam volumetric tomography versus periapical radiography. J Endod 2014;40:910–6.
14. Mota de Almeida FJ, Knutsson K, Flygare L. The impact of cone beam computed tomography on the choice of endodontic diagnosis. Int Endod J 2015;48:564–72.
15. Al-Salehi SK, Horner K. Impact of cone beam computed tomography (CBCT) on diagnostic thinking in endodontics of posterior teeth: a before- after study. J Dent 2016;53:57–63.
16. Ludlow JB, Timothy R, Walker C, et al. Effective dose of dental CBCT: a meta analysis of published data and additional data for nine CBCT units. Dento Maxillo Facial Radiol 2015;44:20140197.
17. Rodríguez G, Abella F, Durán-Sindreu F, et al. Influence of cone-beam computed tomography in clinical decision making among specialists. J Endod 2017;43:194–9.
18. Mota de Almeida FJ, Knutsson K, Flygare L. The effect of cone beam CT (CBCT) on therapeutic decision-making in endodontics. Dento Maxillo Facial Radiol 2014;43:20130137.
19. Abella F, Patel S, Duran-Sindreu F, et al. Evaluating the periapical status of teeth with irreversible pulpitis by using cone-beam computed tomography scanning and periapical radiographs. J Endod 2012;38:1588–91.
20. Lofthag-Hansen S, Huumonen S, Gröndahl K, Gröndahl H-G. Limited cone-beam CT and intraoral radiography for the diagnosis of periapical pathology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;103:114–9.
21. Cheung GSP, Wei WLL, McGrath C. Agreement between periapical radiographs and cone-beam computed tomography for assessment of periapical status of root filled molar teeth. Int Endod J 2013;46:889–95.