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About This Document

The following statement was prepared by the Special Committee to Revise the Joint American Association of Endodontists/American Academy of Oral and Maxillofacial Radiology Position Statement on the Use of Cone Beam Computed Tomography in Endodontics. It was approved by the AAE Board of Directors and AAOMR Executive Council in May 2015. Recommendations 13 and 14 were added by the Committee and approved in May 2016.

AAE and AAOMR Joint Position Statement

Use of Cone Beam Computed Tomography in Endodontics—2015/2016 Update

INTRODUCTION

This updated joint position statement of the American Association of Endodontists and the American Academy of Oral and Maxillofacial Radiology is intended to provide scientifically based guidance to clinicians regarding the use of cone beam computed tomography in endodontic treatment and reflects new developments since the 2010 statement (1). The guidance in this statement is not intended to substitute for a clinician's independent judgment in light of the conditions and needs of a specific patient.

Endodontic disease adversely affects quality of life and can produce significant morbidity in afflicted patients. Radiography is essential for the successful diagnosis of odontogenic and non-odontogenic pathoses, treatment of the root canal systems of a compromised tooth, biomechanical instrumentation, evaluation of final canal obturation, and assessment of healing.

Until recently, radiographic assessments in endodontic treatment were limited to intraoral and panoramic radiography. These radiographic technologies provide two-dimensional representations of three-dimensional anatomic structures. If any element of the geometric configuration is compromised, the image may demonstrate errors (2). In more complex cases, radiographic projections with different beam angulations can allow parallax localization. However, complex anatomy and surrounding structures can render interpretation of planar images difficult.

The advent of CBCT has made it possible to visualize the dentition, the maxillofacial skeleton, and the relationship of anatomic structures in three dimensions (3). CBCT, as with any technology, has known limitations, including a possible higher radiation dose to the patient. Other limitations include potential for artifact generation, high levels of scatter and noise, and variations in dose distribution within a volume of interest (4).

CBCT should be used only when the patient's history and a clinical examination demonstrate that the benefits to the patient outweigh the potential risks. CBCT should not be used routinely for endodontic

diagnosis or for screening purposes in the absence of clinical signs and symptoms. Clinicians should use CBCT only when the need for imaging cannot be met by lower dose two-dimensional radiography.

Volume Size(s)/Field of View

There are numerous CBCT equipment manufacturers, and several models are available. In general, CBCT is categorized into large, medium and limited-volume units based on the size of their “field of view.” The size of the FOV describes the scan volume of CBCT machines. That volume determines the extent of anatomy included. It is dependent on the detector size and shape, beam projection geometry and the ability to collimate the beam. To the extent practical, FOV should only slightly exceed the dimensions of the anatomy of interest.

Generally, the smaller the FOV, the lower the dose associated with the study. Beam collimation limits the radiation exposure to the region of interest and helps ensure that an optimal FOV can be selected based on disease presentation. Smaller scan volumes generally produce higher-resolution images. Because endodontics relies on detecting small alterations such as disruptions in the periodontal ligament space, optimal resolution should be sought (5).

The principal limitations of large FOV CBCT imaging are the size of the field irradiated and the reduced resolution compared to intraoral radiographs and limited-volume CBCT units with inherent small voxel sizes (5). The smaller the voxel size, the higher the spatial resolution. Moreover, the overall scatter generated is reduced due to the limited size of the FOV. Optimization of the exposure protocols keeps doses to a minimum without compromising image quality. If a low-dose protocol can be used for a diagnostic task that requires lower resolution, it should be employed, absent strong indications to the contrary.

In endodontics, the area of interest is limited and determined prior to imaging. For most endodontic applications, limited FOV CBCT is preferred to medium or large FOV CBCT because there is less radiation dose to the patient, higher spatial resolution and shorter volumes to be interpreted.

Dose Considerations

Selection of the most appropriate imaging protocol for the diagnostic task must be consistent with the ALARA principles that every effort should be made to reduce the effective radiation dose to the patient “as low as reasonably achievable.” Because radiation dose for a CBCT study is higher than that for an intraoral radiograph, clinicians must consider overall radiation dose over time.

For example, will acquiring a CBCT study now eliminate the need for additional imaging procedures in the future? It is recommended to use the smallest possible FOV, the smallest voxel size, the lowest mA setting (depending on the patient’s size) and the shortest exposure time in conjunction with a pulsed exposure-mode of acquisition.

If extension of pathoses beyond the area surrounding the tooth apices or a multifocal lesion with possible systemic etiology is suspected, and/or a nonendodontic cause for devitalization of the tooth is established clinically, appropriate larger field of view protocols may be employed on a case-by-case basis.

There is a special concern with overexposure of children (up to and including 18 years of age) to radiation, especially with the increased use of CT scans in medicine. The AAE and the AAOMR support the Image Gently Campaign led by the Alliance for Radiation Safety in Pediatric Imaging. The goal of the campaign is “to change practice; to raise awareness of the opportunities to lower radiation dose in the imaging of children.” Information on use of CT is available at www.imagegently.org/Procedures/ComputedTomography.aspx.

Interpretation

If a clinician has a question regarding image interpretation, it should be referred to an oral and maxillofacial radiologist (6).

RECOMMENDATIONS

The following recommendations are for limited FOV CBCT scans.

Diagnosis

Endodontic diagnosis is dependent upon thorough evaluation of the patient’s chief complaint, history and clinical and radiographic examination. Preoperative radiographs are an essential part of the diagnostic phase of endodontic therapy. Accurate diagnostic imaging supports the clinical diagnosis.

Recommendation 1: Intraoral radiographs should be considered the imaging modality of choice in the evaluation of the endodontic patient.

Recommendation 2: Limited FOV CBCT should be considered the imaging modality of choice for diagnosis in patients who present with contradictory or nonspecific clinical signs and symptoms associated with untreated or previously endodontically treated teeth.

Rationale

- In some cases, the clinical and planar radiographic examinations are inconclusive. Inability to confidently determine the etiology of endodontic pathosis may be attributed to limitations in both clinical vitality testing and intraoral radiographs to detect odontogenic pathoses. CBCT imaging has the ability to detect periapical pathosis before it is apparent on 2-D radiographs (7).
- Preoperative factors such as the presence and true size of a periapical lesion play an important role in endodontic treatment outcome. Success, when measured by radiographic criteria, is higher when teeth are endodontically treated before radiographic signs of periapical disease are detected (8).
- Previous findings have been validated in clinical studies in which primary endodontic disease detected with intraoral radiographs and CBCT was 20% and 48%, respectively. Several clinical studies had similar findings, although with slightly different percentages (9,10). Ex vivo experiments in which simulated periapical lesions were created yielded similar results (11,12). Results of in vivo animal studies, using histologic assessments as the gold standard, also showed similar results observed in human clinical and ex vivo studies (13).
- Persistent intraoral pain following root canal therapy often presents a diagnostic challenge. An example is persistent dentoalveolar pain also known as atypical odontalgia (14). The diagnostic yield of conventional intraoral radiographs and CBCT scans was evaluated in the differentiation between patients presenting with suspected atypical odontalgia versus symptomatic apical periodontitis, without radiographic evidence of periapical bone destruction (15). CBCT imaging detected 17% more teeth with periapical bone loss than conventional radiography.

Initial Treatment

Preoperative

Recommendation 3: Limited FOV CBCT should be considered the imaging modality of choice for initial treatment of teeth with the potential for extra canals and suspected complex morphology, such as mandibular anterior teeth, and maxillary and mandibular premolars and molars, and dental anomalies.

Intraoperative

Recommendation 4: If a preoperative CBCT has not been taken, limited FOV CBCT should be considered as the imaging modality of choice for intra-appointment identification and localization of calcified canals.

Postoperative

Recommendation 5: Intraoral radiographs should be considered the imaging modality of choice for immediate postoperative imaging.

Rationale

- Anatomical variations exist among different types of teeth. The success of nonsurgical root canal therapy depends on identification of canals, cleaning, shaping and obturation of root canal systems, as well as quality of the final restoration.
- 2-D imaging does not consistently reveal the actual number of roots and canals. In studies, data acquired by CBCT showed a very strong correlation between sectioning and histologic examination (16,17).
- In a 2013 study, CBCT showed higher mean values of specificity and sensitivity when compared to intraoral radiographic assessments in the detection of the MB2 canal (18).

Nonsurgical Retreatment

Recommendation 6: Limited FOV CBCT should be considered the imaging modality of choice if clinical examination and 2-D intraoral radiography are inconclusive in the detection of vertical root fracture.

Rationale

- In nonsurgical retreatment, the presence of a vertical root fracture significantly decreases prognosis. In the majority of cases, the indication of a vertical root fracture is more often due to the specific pattern of bone loss and periodontal ligament space enlargement than direct visualization of the fracture. CBCT may be recommended for the diagnosis of vertical root fracture in unrestored teeth when clinical signs and symptoms exist.
- Higher sensitivity and specificity were observed in a clinical study where the definitive diagnosis of vertical root fracture was confirmed at the time of surgery to validate CBCT findings, with sensitivity being 88% and specificity 75% (19). Several case series studies have concluded that CBCT is a useful tool for the diagnosis of vertical root fractures. In vivo and laboratory studies (20, 21) evaluating CBCT in the detection of vertical root fractures agreed that sensitivity, specificity, and accuracy of CBCT were generally higher and reproducible. The detection of fractures was significantly higher for all CBCT systems when compared to intraoral radiographs. However, these results should be interpreted with caution because detection of vertical root fracture is dependent on the size of the fracture, presence of artifacts caused by obturation materials and posts and the spatial resolution of the CBCT.

Recommendation 7: Limited FOV CBCT should be the imaging modality of choice when evaluating the nonhealing of previous endodontic treatment to help determine the need for further treatment, such as nonsurgical, surgical or extraction.

Recommendation 8: Limited FOV CBCT should be the imaging modality of choice for nonsurgical retreatment to assess endodontic treatment complications, such as overextended root canal obturation material, separated endodontic instruments, and localization of perforations.

Rationale

- It is important to evaluate the factors that impact the outcome of root canal treatment. The outcome predictors identified with periapical radiographs and CBCT were evaluated by Liang et al. (22) The results showed that periapical radiographs detected periapical lesions in 18 roots (12%) as compared to 37 on CBCT scans (25%). Eighty percent of apparently short root fillings based on intraoral radiographs images appeared flush on CBCT. Treatment outcome, length and density of root fillings and outcome predictors determined by CBCT showed different values when compared with intraoral radiographs.
- Accurate treatment planning is an essential part of endodontic retreatment. Incorrect, delayed or inadequate endodontic diagnosis and treatment planning places the patient at risk and may result in unnecessary treatment. Treatment planning decisions using CBCT versus intraoral radiographs were compared to the gold standard diagnosis (23). An accurate diagnosis was reached in 36%-40% of the cases with intraoral radiographs compared to 76%-83% with CBCT. A high level of misdiagnosis was noted in invasive cervical resorption and vertical root fracture. In this study, the examiners altered their treatment plan after reviewing the CBCT in 56%-62.2% of the cases, thus indicating the significant influence of CBCT.

Surgical Retreatment

Recommendation 9: Limited FOV CBCT should be considered as the imaging modality of choice for presurgical treatment planning to localize root apex/apices and to evaluate the proximity to adjacent anatomical structures.

Rationale

The use of CBCT has been recommended for treatment planning of endodontic surgery (24, 25). CBCT visualization of the true extent of periapical lesions and their proximity to important vital structures and anatomical landmarks is superior to that of periapical radiographs.

Special Conditions

Implant Placement

Recommendation 10: Limited FOV CBCT should be considered as the imaging modality of choice for surgical placement of implants (26).

Traumatic Injuries

Recommendation 11: Limited FOV CBCT should be considered the imaging modality of choice for diagnosis and management of limited dento-alveolar trauma, root fractures, luxation, and/or displacement of teeth and localized alveolar fractures, in the absence of other maxillofacial or soft tissue injury that may require other advanced imaging modalities (27).

Resorptive Defects

Recommendation 12: Limited FOV CBCT is the imaging modality of choice in the localization and differentiation of external and internal resorptive defects and the determination of appropriate treatment and prognosis (28, 29).

Outcome Assessment

Recommendation 13: In the absence of clinical signs or symptoms, intraoral radiographs should be considered the imaging modality of choice for the evaluation of healing following nonsurgical and surgical endodontic treatment.

Recommendation 14: In the absence of signs and symptoms, if limited FOV CBCT was the imaging modality of choice at the time of evaluation and treatment, it may be the modality of choice for follow-up evaluation. In the presence of signs and symptoms, refer to Recommendation #7.

Rationale

- Use of limited FOV CBCT for evaluation of healing following nonsurgical and surgical treatment must be considered on a case-by-case basis, with due consideration given the risks and benefits of exposing the patient to ionizing radiation, the patient's history, clinical findings, mode of endodontic intervention, pre-existing radiographic appearance, temporal changes and any other systemic or extraneous factors that could confound the healing process.
- Accurate diagnosis of complete and uneventful healing as determined radiographically, with unequivocal clinical correlation supporting the radiographic diagnosis, is challenging (30, 31, 32, 33). The healing process is dependent on various factors, both extraneous and

host-related. In the future, once the parameters associated with healing are fully confirmed by evidence-based studies, the use of limited FOV CBCT for outcome assessment can be better interpreted.

CONCLUSION

CBCT is an emerging technology that is revolutionizing the approach to endodontic care of dental patients. The guidance in this statement is not intended to substitute for a clinician's independent judgment in patient care. The use of limited FOV CBCT should be considered on a case-by-case basis, with due consideration given to the risks and benefits of exposing the patient to ionizing radiation, the patient's history, clinical findings and pre-existing radiographs so that superior treatment can be provided to the general public in need of endodontic care.

REFERENCES

1. American Association of Endodontists; American Academy of Oral and Maxillofacial Radiology. Use of cone-beam computed tomography in endodontics Joint Position Statement of the American Association of Endodontists and the American Academy of Oral and Maxillofacial Radiology. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2011;111(2):234-7.
2. Grondahl HG, Huumonen S. Radiographic manifestations of periapical inflammatory lesions. *Endodontic Topics.* 2004;8:55-67.
3. Patel S, Durack C, Abella F, Shemesh H, Roig M, Lemberg K. Cone beam computed tomography in Endodontics – a review. *Int Endod J* 2015;48:3-15.
4. Suomalainen A, Pakbaznejad Esmaeili E, Robinson S. Dentomaxillofacial imaging with panoramic views and cone beam CT. *Insights imaging* 2015;6:1-16.
5. Venskutonis T, Plotino G, Juodzbaly G, Mickevičienė L. The importance of cone-beam computed tomography in the management of endodontic problems: a review of the literature. *J Endod* 2014;40(12):1895-901.
6. Carter L, Farman AG, Geist J, Scarfe WC, Angelopoulos C, Nair MK, Hildebolt CF, Tyndall D, Shrout M. American Academy of Oral and Maxillofacial Radiology executive opinion statement on performing and interpreting diagnostic cone beam computed tomography. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2008;106(4):561-2.
7. De Paula-Silva FW, Wu MK, Leonardo MR, da Silva LA, Wesselink PR. Accuracy of periapical radiography and cone-beam computed tomography scans in diagnosing apical periodontitis using histopathological findings as a gold standard. *J Endod* 2009;35(7):1009-12.
8. Friedman S. Prognosis of initial endodontic therapy. *Endodontic Topics* 2002;2:59-98.
9. Patel S, Wilson R, Dawood A, Mannocci F. The Detection of periapical pathosis using periapical radiography and cone beam computed tomography – part 1: preoperative status. *Int Endod J* 2012;8:702-10.
10. Abella F, Patel S, Duran-Sindreu F, Mercad M, Bueno R, Roig M. Evaluating the periapical status of teeth with irreversible pulpitis by using cone-beam computed tomography scanning and periapical radiographs. *J Endod* 2012;38(12):1588-91.
11. Cheung G, Wei L, MvGrath 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(10):889-95.
12. Sogur E, Grondahl H, Bakst G, Mert A. Does a combination of two radiographs increase accuracy in detecting acid-induced periapical lesions and does it approach the accuracy of cone-beam computed tomography scanning. *J Endod* 2012;38(2):131-6.
13. Patel S, Dawood A, Mannocci F, Wilson R, Pitt Ford T. Detection of periapical bone defects in human jaws using cone beam computed tomography and intraoral radiography. *Int Endod J* 2009;42(6):507-15.
14. Nixdorf D, Moana-Filho E. Persistent dento-alveolar pain disorder (PDAP): Working towards a better understanding. *Rev Pain.* 2011;5(4):18-27.
15. Pigg M, List T, Petersson K, Lindh C, Petersson A. Diagnostic yield of conventional radiographic and cone-beam computed tomographic images in patients with atypical odontalgia. *Int Endod J* 2011;44(12):1365-2591.
16. Blattner TC, Goerge N, Lee CC, Kumar V, Yelton CGJ. Efficacy of CBCT as a modality to accurately identify the presence of second mesiobuccal canals in maxillary first and second molars: a pilot study. *J Endod* 2012;36(5):867-70.
17. Michetti J, Maret D, Mallet J-P, Diemer F. Validation of cone beam computed tomography as a tool to explore root canal anatomy. *J Endod* 2010;36(7):1187-90.
18. Vizzotto MB, Silveira PF, Arús NA, Montagner F, Gomes BP, Da Silveira HE. CBCT for the assessment of second mesiobuccal (MB2) canals in maxillary molar teeth: effect of voxel size and presence of root filling. *Int Endod J* 2013;46(9):870-6.
19. Edlund M, Nair MK, Nair UP. Detection of vertical root fractures by using cone-beam computed tomography: a clinical study. *J Endod* 2011;37(6):768-72.
20. Metska ME, Aartman IH, Wesselink PR, Özok AR. Detection of vertical root fracture in vivo in

- endodontically treated teeth by cone-beam computed tomography scans. *J Endod* 2012;38(10):1344-7.
21. Brady E, Mannocci F, Wilson R, Brown J, Patel S. A comparison of CBCT and periapical radiography for the detection of vertical root fractures in non-endodontically treated teeth. *Int Endod J* 2014;47(8):735-46.
 22. Liang H, Li Gang, Wesselink P, WuM. Endodontic outcome predictors identified with periapical radiographs and cone-beam computed tomography scans. *J Endod* 2011;37(3):326-31.
 23. Ee J, Fayad I M, Johnson B. Comparison of endodontic diagnosis and treatment planning decisions using cone-beam volumetric tomography versus periapical radiography. *J Endod* 2014;40(7):910-6.
 24. Venskutonis T, Plotino G, Tocci L, Gambarini G, Maminkas J, Juodzbalys G. Periapical and Endodontic status scale based on periapical bone lesions and endodontic treatment quality evaluation using cone-beam computed tomography. *J Endod* 2015;41(2):190-6.
 25. Low KM, Dula K, Bürgin W, Arx T. Comparison of periapical radiography and limited cone-beam tomography in posterior maxillary teeth referred for apical surgery. *J Endod* 2008;34(5):557-62.
 26. Tyndall D, Price J, Tetradis S, Ganz S, Hildebolt C, Scarf W. Position statement of the American Academy of Oral and Maxillofacial Radiology on selection criteria for the use of radiology in dental implantology with emphasis on cone beam computed tomography. *Oral Surg Oral Med Oral Pathol Oral Radiol* 2012;113(6):817-26.
 27. May JJ, Cohenca N, Peters OA. Contemporary management of horizontal root fractures to the permanent dentition: diagnosis, radiologic assessment to include cone-beam computed tomography. *Pediatric Dentistry* 2013;35:120-4.
 28. Estrela C, Bueno MR, De Alencar AH, Mattar R, Valladares Neto J, Azevedo BC, De Araújo Estrela CR. Method to evaluate Inflammatory Root Resorption by using Cone Beam computed tomography. *J Endod* 2009;35(11):1491-7.
 29. Durack C, Patel S, Davies J, Wilson R, Mannocci F. Diagnostic accuracy of small volume cone beam computed tomography and intraoral periapical radiography for the detection of simulated external inflammatory root resorption. *Int Endod J* 2011;44(2):136-47.
 30. Cheung G, Wei W, 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(10):889-95.
 31. Estrela C, Bueno MR, Azevedo BC, Azevedo JR, Pecora JD. A new periapical index based on cone beam computed tomography, *J Endod* 2008;34(11):1325-31.
 32. Tanomaru-Filho M, Jorge EG, Guerreiro-Tanomaru JM, Ries JM. Spin-Neto, R, Goncalves M. Two- and tridimensional analysis of periapical repair after endodontic surgery. *Clin Oral Investig* 2015;19(1):17-25.
 33. von Arx T, Janner SF, Hanni S, Bornstein MM. Agreement between 2D and 3D radiographic outcomes assessment one year after periapical surgery. *Int Endod J* 2015.

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