

# American Academy of Periodontology Best Evidence Consensus Statement on Selected Oral Applications for Cone-Beam Computed Tomography

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**Background:** The American Academy of Periodontology (AAP) recently embarked on a Best Evidence Consensus (BEC) model of scientific inquiry to address questions of clinical importance in periodontology for which there is insufficient evidence to arrive at a definitive conclusion. This review addresses oral indications for use of cone-beam computed tomography (CBCT).

**Methods:** To develop the BEC, the AAP convened a panel of experts with knowledge of CBCT and substantial experience in applying CBCT to a broad range of clinical scenarios that involve critical structures in the oral cavity. The panel examined a clinical scenario or treatment decision that would likely benefit from additional evidence and interpretation of evidence, performed a systematic review on the individual, debated the merits of published data and experiential information, developed a consensus report, and provided a clinical bottom line based on the best evidence available.

**Results:** This BEC addressed the potential value and limitations of CBCT relative to specific applications in the management of patients requiring or being considered for the following clinical therapies: 1) placement of dental implants; 2) interdisciplinary dentofacial therapy involving orthodontic tooth movement in the management of malocclusion with associated risk on the supporting periodontal tissues (namely, dentoalveolar bone); and 3) management of periodontitis.

**Conclusion:** For each specific question addressed, there is a critical mass of evidence, but insufficient evidence to support broad conclusions or definitive clinical practice guidelines. *J Periodontol* 2017; 88:939-945.

## KEY WORDS

Cone-beam computed tomography; consensus; dental implants; orthodontics; periodontal diseases; radiation exposure.

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## **BENEFITS OF CONE-BEAM COMPUTED TOMOGRAPHY FOR SELECTED THERAPEUTIC APPROACHES IN THE ORAL CAVITY**

The use of cone-beam computed tomography (CBCT) as indicated below should provide enhanced care for patients who may require certain therapeutic approaches such as dental implants or orthodontic tooth movement.

CBCT inherently offers increased diagnostic information and increased accuracy when compared to two-dimensional (2D) digital (periapical and panoramic exposures) diagnostic data.<sup>1</sup> This information can be valuable when considering prognosis evaluation, treatment planning, and surgical management of complex cases that involve implant therapy or periodontal-orthodontic collaboration.<sup>2</sup> There is insufficient evidence to date that CBCT imaging provides added benefit in the management of periodontitis.

CBCT imaging can also be used as a communication tool with patients and with other dental-medical colleagues involved in certain cases, such as prosthodontists, pediatric dentists, endodontists, orthodontists, oral and maxillofacial surgeons, otolaryngologists, sleep physicians, orofacial myologists, oral and maxillofacial radiologists, oral and maxillofacial pathologists, restorative dentists, and laboratory technicians. Collaboration among all caregivers involved in complex cases may be necessary to develop a treatment plan for optimal patient outcomes.

## **LIMITATIONS OF CONE-BEAM COMPUTED TOMOGRAPHY FOR SELECTED THERAPEUTIC APPROACHES IN THE ORAL CAVITY**

Some aspects of CBCT imaging influence effective dose of radiation to the patient and are controllable by the clinician, i.e., field of view (FOV), time of exposure, and resolution. Other aspects of radiation exposure are intrinsic to the imaging device or unit and beyond the clinician's control. The clinician must be aware of any limitations inherent to the CBCT unit being used. Variations in equipment and software make it difficult to standardize outcome measures. However, CBCT technology is evolving at a rapid pace, and improvements continue to be introduced.

## **POTENTIAL RISKS OF CONE-BEAM COMPUTED TOMOGRAPHY FOR SELECTED THERAPEUTIC APPROACHES IN THE ORAL CAVITY**

Currently, the long-term radiation hazards of effective dose accumulation from CBCT are unknown. When susceptible tissues are shielded and the field of view is limited to the area of interest (maxilla or mandible), the risk is estimated to be low. However, to minimize patient risk, adherence to judicious principles of radi-

ation exposure is imperative. In addition, the age of the patient is a consideration in assessing risks of CBCT imaging, specifically, the consideration of cumulative radiation exposure among pediatric and adolescent patients. Clinicians should constantly strive to use a radiation dose "as low as reasonably achievable" (ALARA) to secure clinically useful diagnostic information. This is largely dependent upon the individual circumstances of the patient presenting for treatment.

All radiographic exposures require a comprehensive diagnostic interpretation, including the responsibility to rule out any pathology within the FOV. CBCT data must be read by the practitioner within his/her realm of expertise or referred to an oral and maxillofacial radiologist or other qualified radiologist for further analysis, interpretation, and documentation.

## **FOCUSED CLINICAL QUESTION I**

**Should CBCT imaging replace two-dimensional (2D) radiographic analysis of regional anatomy in the surgical management of patients requiring dental implants?**

The application of CBCT in dentistry has grown greatly with a clear impact on implant dentistry. This consensus report is based on a review of the best available evidence on this topic (Rios, Borgnakke, Benavides<sup>3</sup> 2017) as well as expert opinion as to whether CBCT imaging should become the standard of care for patients requiring dental implants.

### ***Evidence Search Strategy***

An extensive literature search of CBCT applications in implant dentistry was performed using the PubMed database. A total of 559 studies published between January 1, 2000, and June 24, 2017, were identified, and 176 articles were selected for review. These were divided into three categories: 1) diagnosis and treatment outcome assessment, 2) implant treatment planning, and 3) anatomic characterization. It should be noted that the systematic review did not include any assessment of the quality (e.g., study design and potential sources of bias) of the included studies. (See Rios, Borgnakke, Benavides<sup>3</sup> for detailed information on the literature review and results.)

### ***Consensus Conclusions***

The decision about whether, and in what circumstances, to use CBCT must be made by the clinician in light of the needs of the patient. However, current evidence, predominantly from observational studies (cohort and case series), supports the use of CBCT in the surgical implant management of patients to assess the following:

- Evaluation of root morphology and associated pathology for extractions and reconstruction
- Location of relevant anatomic structures and their relation to implant placement

- Sinus grafting preimplant evaluation
- Evaluation of autogenous bone donor sites
- Fabrication of static surgical guides and dynamic navigation of implant placement
- Post-bone augmentation implant planning
- Complications with previously placed implants
- Team communication with implant restorative colleagues

Expert opinion supports the potential applications of CBCT in the surgical management of patients requiring dental implants in the following scenarios:

- When there is a question regarding selection of implant sites, number, diameter, length, or loading strategy
- When the patient presents with a thin phenotype or there are esthetic concerns (risk for bone or soft tissue deformities)

### ***Benefits of CBCT for Surgical Management of Patients Requiring Dental Implants***

Current available evidence supports the conclusion that CBCT can be useful in evaluating regional anatomy as appropriate for implant planning.

CBCT imaging can be inherently valuable for the following clinical uses:

- As a means to identify incidental findings that may influence treatment decisions and execution of therapy, such as periapical and other odontogenic-related pathologies, root fractures, aberrant dental anatomy, and non-odontogenic pathologies and conditions
- As a vehicle to support minimally invasive therapy
- As a method to educate patients and provide information of value when obtaining patients' consent for planned surgical procedures

CBCT technology provides the clinician with the opportunity to improve presurgical planning as well as surgical execution through:

- Three-dimensional (3D) presurgical anatomic measurement and virtual implant placement simulation
- Construction of computer-generated static surgical guides via 3D printing or stereolithography
- Application of dynamic surgical navigation technology

### ***Limitations of CBCT for Surgical Management of Patients Requiring Dental Implants***

Further research and development are needed to enhance applications of CBCT technology to plan, treat, and monitor placement of dental implants. In addition, education in correct usage and interpretation of CBCT data are essential to provide clinical value

and assure safe use of CBCT technology. Specifically, additional research is required to:

- Reduce radiation artifact, beam hardening, and scatter to improve overall image resolution and quality for optimal interpretation
- More accurately quantify bone density and linear remodeling changes over time
- Increase availability and use of 3D printing for static guide fabrication and tissue engineering (bone augmentation) applications
- Minimize radiation exposure
- Reduce equipment costs

### ***Potential Risks of CBCT for Surgical Management of Patients Requiring Dental Implants***

Since the long-term radiation hazards of effective dose accumulation are unknown, adherence to judicious principles of radiation exposure is imperative to minimize patient risk. (See "Potential Risks of Cone-Beam Computed Tomography for Selected Therapeutic Approaches in the Oral Cavity" above for further information.)

### ***Clinical Bottom Line on Use of CBCT for Surgical Management of Patients Requiring Dental Implants***

CBCT has diverse applications for dental implant therapy and should be used as an adjunct to 2D dental radiology when, in the reasonable judgment of the clinician, the specific benefits to the patient as outlined above outweigh the risks.

### ***Advisory Provisions for Use of CBCT for Surgical Management of Patients Requiring Dental Implants***

The responsible use of CBCT for dental implant therapy is based on case-specific patient selection where such imaging analysis is likely to offer both a significant patient and clinician/operator benefit by providing 3D regional anatomy information. Dental health care professionals should consider CBCT imaging when they expect the diagnostic information acquired will lead to better patient care, higher levels of safety, and improved clinical outcomes.

## **FOCUSED CLINICAL QUESTION 2**

**Is CBCT imaging useful in determining risk to periodontal structures in patients requiring tooth movement?**

CBCT imaging has demonstrated that changes occur to the buccal plate and general alveolar bone structure following orthodontic tooth movement. Expert panel members have concluded that CBCT imaging is the only radiographic modality with which such changes can be objectively detected and preoperative

risk determined. This consensus report is based on a review of the best available evidence on this topic (Mandelaris, Neiva, Chambrone<sup>4</sup> 2017) as well as expert opinion relative to how CBCT imaging can be used to assess risk to the periodontium in patients requiring tooth movement.

### **Evidence Search Strategy**

A search of observational and interventional trials published in English through July 2016 that reported on the use of CBCT imaging to assess the impact of orthodontic-dentofacial orthopedic treatment on periodontal tissues was conducted. Changes in alveolar bone thickness, height around natural teeth, and treatment costs were evaluated and organized into evidence tables. Thirteen studies involving human patients and that recorded positive or negative changes on alveolar bone surrounding natural teeth undergoing orthodontic tooth movement or being influenced by orthopedic forces through fixed appliances were identified. The majority of the available evidence for this focused question derives from observational studies with low methodologic quality. (See Mandelaris, Neiva, Chambrone<sup>4</sup> for detailed information on the literature review and results.)

### **Consensus Conclusions**

There is limited current evidence to support specific applications of CBCT as a routine part of periodontal-orthodontic treatment. However, expert opinion suggests that CBCT may be useful in the management of patients requiring periodontal-orthodontic therapy in the following scenarios:

- When the orthodontic patient is skeletally mature and presents with a malocclusion requiring fixed orthodontic appliances for decompensation
- When the orthodontic patient has a thin dentoalveolar phenotype and dentoalveolar bone deficiencies are suspected
- When the malocclusion patient requires advanced tooth movement and there is increased risk for positioning the roots outside of the orthodontic boundary conditions
- When the orthodontic patient is skeletally immature and requires an interdisciplinary approach to treatment (i.e., periodontal-orthodontic-restorative or multispecialist care)
- When the orthodontic patient presents with concomitant mucogingival deformities (recession)
- When the patient presents with other specific treatment considerations requiring more global analysis (e.g., temporomandibular joint disorders, dentofacial disharmonies requiring orthodontic-periodontal-orthognathic approaches for management, congenitally missing teeth, or requirement for skeletal anchorage)

Further, expert opinion suggests that CBCT may be useful in the management of a patient requiring other interdisciplinary therapy in the following clinical scenarios:

- When the patient presents with impacted third molars requiring extraction with or without potential pathologies
- When the patient presents with impacted teeth requiring surgical exposure and bonding of an orthodontic bracket for eruption
- When the cleft palate patient presents for periodontal-orthodontic therapy requiring decompensation and/or more extensive collaborative interdisciplinary management
- When the adult patient presents with dentoalveolar deficiencies (i.e., dental crowding) and/or transverse maxillary deficiencies that might require surgical intervention to help ensure orthodontic boundary conditions are respected

### **Benefits of CBCT Imaging for Determining Risk to Periodontal Structures in Patients Requiring Tooth Movement**

Expert opinion supports the use of CBCT to identify patients undergoing orthodontic treatment who are at risk for alveolar bone (dehiscences or fenestrations) or soft tissue (recessions) deficiencies.

### **Limitations of CBCT Imaging for Determining Risk to Periodontal Structures in Patients Requiring Tooth Movement**

Further research is needed to determine how the application of CBCT impacts treatment planning, decision making, therapies, and evaluation of outcomes. The following issues warrant further research as they relate to periodontal-orthodontic considerations evaluated by CBCT:

- Preventive soft tissue and bone augmentation indications and requirements
- Limitations to the directions and amount of tooth movement
- Upper airway volume and anatomic considerations as a possible adjunct to other airway measurements
- Alternative orthodontic applications related to malocclusion types
- Surgically facilitated orthodontic therapy
- Skeletal malocclusions requiring dental decompensation movements as part of comprehensive orthodontic therapy
- Orthognathic surgery treatment planning
- Other treatment considerations (temporomandibular joint disorders, congenitally missing teeth, need for skeletal anchorage)
- Development of approaches to CBCT imaging that provide the best cost-to-benefit ratio

### **Potential Risks of CBCT Imaging for Determining Risk to Periodontal Structures in Patients Requiring Tooth Movement**

As noted above, since the long-term radiation hazards of effective dose accumulation are unknown, adherence to judicious principles of radiation exposure is imperative to minimize patient risk. (See “Potential Risks of Cone-Beam Computed Tomography for Selected Therapeutic Approaches in the Oral Cavity” above for further information.)

### **Clinical Bottom Line on Use of CBCT Imaging for Determining Risk to Periodontal Structures in Patients Requiring Tooth Movement**

CBCT imaging can, in appropriate circumstances, improve periodontal risk assessment and assist in planning a safer approach to orthodontic therapy, particularly in the skeletally mature patient.

CBCT should be considered as a means to identify those at increased risk of developing dentoalveolar bone deficiencies related to orthodontic tooth movement, particularly in skeletally mature patients presenting with thin periodontal phenotypes. With CBCT, clinicians and patients can be better informed regarding risk of adverse sequelae related to tooth movement. CBCT imaging can also help clinicians develop approaches to prevent adverse sequelae or plan interceptive periodontal augmentation (bone and/or soft tissue) for patients undergoing orthodontic tooth movement.

### **Advisory Provisions of CBCT Imaging for Determining Risk to Periodontal Structures in Patients Requiring Tooth Movement**

CBCT exposes patients to radiation and should be considered an adjunctive diagnostic method after a comprehensive periodontal examination is performed to assess potential risks to the periodontal structures from tooth movement. In addition, the age of the patient should be considered in assessing the risks of CBCT imaging and cumulative radiation exposure, especially among pediatric and adolescent patients.

## **FOCUSED CLINICAL QUESTION 3**

### **Does CBCT imaging add clinical value in diagnostic assessment and treatment planning for the management of periodontitis?**

Clinical and radiographic examinations are essential in establishing an accurate periodontal diagnosis and in suggesting appropriate treatment options. However, 2D intraoral radiographic images provide limited information, especially regarding the severity of periodontitis (e.g., furcation, intrabony defects, and buccal plate), and there is a need to investigate alternative imaging methods. This best evidence consensus report ex-

amines when CBCT imaging is appropriate for diagnostic inquiry in the management of periodontitis.

This consensus report is based on a review of the best available evidence on this topic (Kim and Bassir<sup>5</sup> 2017) as well as expert opinion as to whether CBCT imaging adds clinical value in the management of periodontitis.

### **Evidence Search Strategy**

The authors performed an extensive search of MEDLINE for studies aimed at answering the following clinically relevant questions: 1) In patients with periodontitis, what (if any) clinical situations exist where CBCT imaging improves diagnostic acumen and subsequent treatment recommendations compared to 2D radiographic interpretation? 2) Does CBCT imaging improve the accuracy of diagnosis and the establishment of a prognosis in the analysis of furcation and/or intrabony defects? Is the execution of therapy improved, facilitated, or therapeutically challenged? 3) Does the use of CBCT imaging provide superior short- or long-term clinical outcomes, more favorable patient-reported outcomes, or more consistent clinical treatment decisions affecting tooth prognosis (as measured by defect fill, improvements in bone anatomy, mobility patterns, and ultimate tooth survival)?

The electronic search identified 885 papers, and a manual search yielded five additional citations. Twelve articles met inclusion criteria for determining the role of CBCT in diagnosis and treatment of both intrabony and/or furcation defects. (See Kim and Bassir<sup>5</sup> for detailed information on the literature review and results.)

### **Consensus Conclusions**

Current evidence supports the use of 2D full-mouth radiographic series in addition to clinical probing parameters as the gold standards for comprehensively evaluating periodontal structures. Little evidence currently supports CBCT as a routine replacement or adjunct to 2D imaging in the management of periodontitis. CBCT imaging may add information for treatment planning of the full-mouth advanced periodontitis case.

Expert opinion suggests that CBCT may be useful in the management of patients with periodontitis according to the following scenarios:

- When an advanced furcation lesion has been detected and dental implants are being considered as an alternative treatment option
- When advanced bone loss has encroached on anatomic structures, such as sinus cavities or the inferior alveolar nerve
- When there is a questionable root fracture, root resorption, or periodontal-endodontic lesion present that could not be identified by 2D imaging and/or clinical evaluation

- In the retreatment of cases that don't respond favorably to localized periodontal therapy
- To enhance the diagnosis and management of peri-implantitis when determined necessary

### ***Benefits of CBCT Imaging in the Diagnostic Assessments and Treatment Planning for the Management of Periodontitis***

Current available evidence does not support the routine use of CBCT in managing periodontitis. Expert opinion, however, suggests that CBCT may be a useful diagnostic adjunct to conventional 2D imaging and clinical probing in advanced cases with concurrent endodontic pathologies or in patients who are being considered for dental implant therapy. Assuming metal artifact is limited or non-existent, additional benefits may be realized on a case-by-case basis to assess the geometric morphology of furcations or intrabony lesions to help determine regenerative potential and associated prognostic surgical outcome. Because the management of periodontitis often requires an interdisciplinary approach, such as orthodontics, advanced imaging may be beneficial on a case-by-case basis depending on the individual needs of the patient for comprehensive management. In selected patients, 3D imaging may also improve determination of hopeless tooth prognosis to aid in treatment planning and improve understanding of defect morphology to aid in flap design, especially as it relates to minimally invasive therapeutic approaches.

### ***Limitations for Use of CBCT for Diagnosis and Treatment Planning in the Management of Periodontitis***

At this time, limited evidence supports the use of CBCT for the detection and characterization of furcation and intrabony defects. Further research is needed to determine the utility of CBCT imaging in supporting minimally invasive therapies, in assessing periodontal regenerative outcomes, and in determining the necessity of combination therapy (orthodontics, guided periodontal tissue regeneration, soft tissue grafting) in complex cases. In addition, the development of new, cost-effective approaches to CBCT imaging is also indicated.

### ***Potential Risks for Use of CBCT for Diagnosis and Treatment Planning in the Management of Periodontitis***

As noted above, since the long-term radiation hazards of effective dose accumulation are unknown, adherence to judicious principles of radiation exposure is imperative to minimize patient risk. (See "Potential Risks of Cone-Beam Computed Tomography for Selected Therapeutic Approaches in the Oral Cavity" above for further information.)

### ***Clinical Bottom Line on Use of CBCT for Diagnosis and Treatment Planning in the Management of Periodontitis***

In select cases, as detailed above, limited-FOV CBCT can add useful 3D information on periodontitis (severity and presence of defects). However, in most cases with periodontitis, CBCT imaging provides little benefit to the clinician in making decisions on the management of periodontitis alone. Because the management of more advanced forms of periodontitis often requires an interdisciplinary approach to treat optimally, advanced imaging may be valuable on a case-by-case basis depending on the individual needs and circumstances of the patient.

### ***Advisory Provisions for Use of CBCT for Diagnosis and Treatment Planning in the Management of Periodontitis***

Despite the fact that there is rapidly accruing literature on CBCT and its potential diagnostic applications, to date there is insufficient evidence to support its use and implementation for routine periodontal treatment planning. Expert opinion, however, suggests that CBCT may have value in the management of patients with periodontitis in selected scenarios described above. This represents an opportunity for additional well-designed clinical studies.

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