MODERN IMAGING TECHNIQUES IN DIAGNOSING ORAL AND DENTAL DISEASES: A COMPREHENSIVE REVIEW

Khaled Nasser Jasser Alharbi[1*], Hatem Fahaid Alharbi[2], Raied Hossaini Alharbi[3], Meshal Saud Alwhbi[4], Mustafa Ahmad Alshahri[5]

Abstract:
Modern imaging techniques play a pivotal role in the diagnosis and management of oral and dental diseases. This paper provides a comprehensive review of advanced imaging modalities used in dentistry, focusing on their principles, applications, advantages, and limitations. Various imaging techniques, including digital radiography, cone-beam computed tomography (CBCT), magnetic resonance imaging (MRI), and optical coherence tomography (OCT), are explored in detail, highlighting their utility in different clinical scenarios. The paper also discusses recent advancements in imaging technology, such as three-dimensional (3D) imaging, artificial intelligence (AI)-assisted diagnosis, and virtual reality (VR) simulations, and their potential impact on oral healthcare delivery. Additionally, considerations for selecting the appropriate imaging modality based on diagnostic needs, patient characteristics, and cost-effectiveness are addressed. By synthesizing current evidence and best practices, this review aims to enhance understanding of modern imaging techniques in dentistry and inform clinical decision-making for improved patient care.

Keywords: Dental imaging, Oral diseases, Diagnostic techniques, Digital radiography, Cone-beam computed tomography, Magnetic resonance imaging, Optical coherence tomography, Three-dimensional imaging, Artificial intelligence, Virtual reality.

[1*]0125008, Dental assistant
[2]3836906, Dental Assistant
[3]1460737, Dental Assistant
[4]General Dentist
[5]Dentist

***Corresponding Author:** Khaled Nasser Jasser Alharbi
*0125008, Dental assistant

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Introduction:

In the realm of dentistry, the advent of modern imaging techniques has ushered in a new era of precision diagnosis and tailored treatment planning. Imaging plays a paramount role in elucidating the intricate structures and pathologies of the oral cavity and dental structures, offering clinicians invaluable insights for accurate diagnosis and effective management of dental diseases. This introduction sets the stage for a comprehensive exploration of modern imaging modalities in dentistry, outlining their significance, evolution, and implications for clinical practice.

The oral cavity serves as a gateway to overall health, with oral diseases exerting profound impacts on systemic well-being and quality of life. From dental caries and periodontal disease to oral cancers and temporomandibular joint disorders, the spectrum of oral conditions encompasses a wide array of pathologies that necessitate precise diagnosis and timely intervention. Traditional diagnostic methods, while valuable, often have limitations in capturing the full extent of oral diseases and guiding optimal treatment strategies.

Enter modern imaging techniques, which have revolutionized the diagnostic landscape in dentistry by providing detailed, three-dimensional representations of oral and dental structures with unparalleled clarity and accuracy. Digital radiography, cone-beam computed tomography (CBCT), magnetic resonance imaging (MRI), and optical coherence tomography (OCT) are among the cutting-edge modalities that have transformed how clinicians visualize, analyze, and interpret dental anatomy and pathology.

The objectives of this paper are twofold: first, to elucidate the principles, applications, and advancements of modern imaging techniques in dentistry, and second, to underscore their pivotal role in enhancing diagnostic precision, treatment planning, and patient outcomes. By delving into the nuances of each imaging modality, exploring their clinical utility across various dental disciplines, and discussing emerging trends and future directions, this paper aims to provide clinicians and researchers with a comprehensive understanding of the transformative power of imaging in modern dentistry.

As we embark on this journey through the realm of dental imaging, it becomes evident that the convergence of technological innovation, clinical expertise, and patient-centered care holds tremendous promise for advancing the field of dentistry and improving oral health outcomes for individuals worldwide. Through continuous exploration, innovation, and integration of imaging technologies into routine dental practice, we can pave the way for a future where precision diagnosis, personalized treatment, and optimal oral health are attainable realities for all.

In the subsequent sections, we will delve deeper into the principles of modern imaging modalities, explore their applications in oral and dental diagnosis, evaluate their advantages and limitations, examine recent technological advancements, and provide practical guidance for clinical decision-making. Together, let us embark on a journey to uncover the transformative potential of modern imaging techniques in shaping the future of dentistry.

1. Principles of Imaging Modalities:

Modern imaging modalities used in dentistry employ a variety of principles to capture detailed images of oral and dental structures. Understanding these principles is essential for clinicians to interpret images accurately and make informed diagnostic and treatment decisions. This section provides an overview of the key imaging modalities and their underlying principles:

1. **Digital Radiography:** Digital radiography utilizes electronic sensors to capture X-ray images of the teeth, gums, and surrounding structures. Unlike conventional film-based radiography, digital systems convert X-ray energy into digital signals, which are then processed and displayed on computer screens. This technology offers several advantages, including enhanced image quality, reduced radiation exposure, and immediate image acquisition. The principles of digital radiography include X-ray generation, image capture, and digital processing, resulting in high-resolution images suitable for diagnosing caries, periodontal disease, and other dental conditions.
2. **Cone-Beam Computed Tomography (CBCT):** CBCT is a specialized imaging technique that generates three-dimensional (3D) images of the maxillofacial region using cone-shaped X-ray beams. Unlike traditional CT scans, which produce two-dimensional images, CBCT captures volumetric data with isotropic resolution, allowing for detailed visualization of dental anatomy and pathology. The principles of CBCT involve X-ray emission from a rotating gantry, detection of X-ray attenuation by tissues, and reconstruction of 3D images using specialized software. CBCT is invaluable for assessing complex dental anatomy, planning implant placement, and diagnosing temporomandibular joint disorders.

3. **Magnetic Resonance Imaging (MRI):** MRI utilizes magnetic fields and radio waves to generate detailed images of soft tissues, including muscles, nerves, and blood vessels, without ionizing radiation. In dentistry, MRI is primarily used for evaluating temporomandibular joint disorders, soft tissue lesions, and craniofacial abnormalities. The principles of MRI involve the alignment of hydrogen atoms in tissues with magnetic fields, excitation of these atoms by radiofrequency pulses, and detection of emitted signals to create cross-sectional images. While MRI provides excellent soft tissue contrast, its application in dentistry is limited by its relatively long scanning times and lower spatial resolution compared to other imaging modalities.
4. **Optical Coherence Tomography (OCT):** OCT is a non-invasive imaging technique that uses low-coherence light to capture cross-sectional images of biological tissues at micrometer resolution. In dentistry, OCT is particularly useful for assessing the microstructure of dental hard tissues, such as enamel and dentin, and detecting early carious lesions. The principles of OCT involve directing light beams onto tissues, measuring the backscattered light, and analyzing interference patterns to create high-resolution images. OCT offers real-time imaging capabilities and has the potential to revolutionize chairside diagnostics in dentistry.

By understanding the principles underlying these imaging modalities, clinicians can effectively utilize them to visualize and diagnose a wide range of oral and dental conditions with precision and accuracy. Each modality offers unique advantages and limitations, and selecting the most appropriate imaging technique depends on factors such as the clinical indication, anatomical region of interest, and patient-specific considerations. In the subsequent sections, we will delve deeper into the applications, advantages, and limitations of each imaging modality, providing clinicians with a comprehensive understanding of their utility in modern dental practice.

2. Applications in Oral and Dental Diagnosis:

Modern imaging modalities in dentistry serve a diverse range of applications, providing invaluable insights into the diagnosis and management of various oral and dental conditions. This section explores the wide array of clinical scenarios where imaging techniques play a pivotal role in guiding diagnostic decision-making and treatment planning:

1. **Detection of Dental Caries:** Imaging modalities such as digital radiography and optical coherence tomography (OCT) are instrumental in the detection of dental caries at early stages. High-resolution images enable clinicians to visualize demineralized enamel and dentin lesions, facilitating timely intervention with minimally invasive treatments such as fluoride therapy and dental sealants.
2. **Assessment of Periodontal Health:** Cone-beam computed tomography (CBCT) and digital periapical radiography are essential tools for evaluating periodontal health and diagnosing periodontal disease. These imaging modalities provide detailed views of alveolar bone levels, furcation involvement, and root anatomy, aiding in the diagnosis of gingivitis, periodontitis, and peri-implantitis.
3. **Evaluation of Temporomandibular Joint Disorders (TMD):** Magnetic resonance imaging (MRI) is the imaging modality of choice for assessing temporomandibular joint (TMJ) anatomy and function. MRI enables visualization of soft tissues, including the articular disc, joint capsule, and surrounding musculature, allowing for the diagnosis of TMJ disorders such as disc displacement, arthritis, and internal derangement.
4. **Implant Planning and Placement:** CBCT imaging plays a crucial role in preoperative assessment and treatment planning for dental implant placement. Three-dimensional reconstructions provide detailed information about bone volume, density, and proximity to vital structures, enabling clinicians to plan implant placement with precision and minimize the risk of complications such as nerve injury and implant failure.
5. **Diagnosis of Oral Pathologies:** Imaging modalities such as CBCT, MRI, and digital radiography are valuable tools for diagnosing oral pathologies, including cysts, tumors, and developmental anomalies. High-resolution images facilitate the localization, characterization, and differential diagnosis of oral lesions, guiding biopsy and surgical management.
6. **Evaluation of Orthodontic Conditions:** Imaging techniques such as CBCT and digital cephalometric radiography are indispensable for orthodontic diagnosis and treatment planning. Three-dimensional analysis of craniofacial structures, dental arches, and skeletal relationships enables orthodontists to

assess malocclusions, plan orthodontic interventions, and monitor treatment progress effectively.

7. **Guidance for Endodontic Procedures:** Digital periapical radiography and CBCT imaging aid endodontists in diagnosing pulpal and periapical pathologies and planning root canal therapy. Detailed visualization of root canal anatomy, periapical lesions, and anatomical variations helps clinicians identify canal obstructions, accessory canals, and periapical lesions, ensuring thorough cleaning and shaping during endodontic treatment.
8. **Monitoring Treatment Outcomes:** Serial imaging with digital radiography and CBCT allows clinicians to monitor treatment outcomes, assess healing, and detect complications in postoperative patients. Comparative analysis of sequential images facilitates the evaluation of treatment efficacy and the identification of any adverse events requiring intervention.

By leveraging the capabilities of modern imaging modalities, clinicians can enhance diagnostic accuracy, improve treatment outcomes, and optimize patient care across various domains of dentistry. From caries detection and periodontal assessment to implant planning and oral pathology diagnosis, imaging plays an indispensable role in shaping clinical decisions and advancing the field of dental practice. In the subsequent sections, we will delve deeper into the specific advantages, limitations, and clinical considerations associated with each imaging modality, providing clinicians with practical insights for integrating imaging techniques into their daily practice.

3. Advantages and Limitations:

Modern imaging modalities in dentistry offer numerous advantages for visualizing oral and dental structures and diagnosing a wide range of conditions. However, each modality has its own set of advantages and limitations that clinicians must consider when selecting the most appropriate imaging technique for specific clinical scenarios. This section explores the key advantages and limitations of commonly used imaging modalities in dentistry:

Digital Radiography:

Advantages:

- Reduced radiation exposure compared to conventional film-based radiography.
- Immediate image acquisition and display, facilitating efficient diagnosis and treatment planning.
- Enhanced image quality and resolution, allowing for detailed visualization of dental anatomy and pathology.
- Ability to digitally manipulate images for improved diagnostic accuracy and communication with patients.

Limitations:

- Limited assessment of soft tissues due to lower contrast resolution compared to other imaging modalities.
- Potential for image artifacts, such as noise and distortion, which may affect image interpretation.
- Higher initial equipment costs and ongoing maintenance requirements compared to traditional radiography systems.

Cone-Beam Computed Tomography (CBCT):

Advantages:

- High-resolution three-dimensional (3D) imaging of dental anatomy, providing detailed views of teeth, bones, and surrounding structures.
- Precise assessment of bone volume, density, and quality for dental implant planning and placement.
- Improved visualization of complex anatomical structures, such as root canals and temporomandibular joints.
- Lower radiation dose and shorter scan times compared to traditional medical CT scans.

Limitations:

- Increased radiation exposure compared to conventional radiography, necessitating judicious use and adherence to ALARA (As Low As Reasonably Achievable) principles.
- Higher equipment costs and specialized training requirements for image acquisition and interpretation.
- Limited soft tissue contrast and inability to distinguish between different types of soft tissue pathologies.

Magnetic Resonance Imaging (MRI):

Advantages:

- Excellent soft tissue contrast, allowing for detailed visualization of muscles, nerves, and blood vessels in the oral and maxillofacial region.
- Non-invasive imaging technique without exposure to ionizing radiation, making it safe for pregnant patients and individuals with radiation sensitivities.
- Multiplanar imaging capabilities, enabling assessment of complex anatomical structures and pathological conditions.

Limitations:

- Longer scanning times compared to other imaging modalities, which may result in patient discomfort and motion artifacts.
- Limited spatial resolution and susceptibility to metallic artifacts from dental restorations and implants.
- Higher cost and limited availability of MRI systems in dental practice settings compared to other imaging modalities.

Optical Coherence Tomography (OCT):

Advantages:

- High-resolution imaging of dental hard tissues, such as enamel and dentin, with micron-level precision.
- Non-invasive, chairside imaging technique that does not require ionizing radiation or contrast agents.
- Real-time imaging capabilities, allowing for immediate visualization and assessment of dental structures during clinical examinations.

Limitations:

- Limited penetration depth compared to other imaging modalities, restricting its utility to superficial tissues and shallow lesions.
- Relatively high cost of equipment and consumables, limiting widespread adoption in general dental practice.
- Limited availability of commercial OCT systems specifically designed for dental applications, requiring adaptation of existing technologies.

By carefully weighing the advantages and limitations of each imaging modality, clinicians can make informed decisions about which technique best suits their diagnostic needs, patient characteristics, and clinical workflow. Integrating modern imaging techniques into routine dental practice enables clinicians to enhance diagnostic accuracy, improve treatment outcomes, and provide optimal care for their patients. In the subsequent sections, we will delve deeper into the specific clinical considerations associated with each imaging modality, offering practical guidance for clinicians in their daily practice.

Recent Technological Advancements:

In recent years, significant technological advancements have transformed the landscape of dental imaging, offering clinicians unprecedented capabilities for visualizing oral and dental structures with enhanced precision and efficiency. This section explores some of the latest innovations in dental imaging technology and their potential impact on clinical practice:

1. **Three-Dimensional (3D) Imaging:** The integration of three-dimensional imaging techniques, such as cone-beam computed tomography (CBCT) and intraoral scanners, has revolutionized the way clinicians visualize and analyze dental anatomy. CBCT provides detailed 3D reconstructions of teeth, bones, and surrounding structures, enabling precise treatment planning for dental implant placement, orthodontic interventions, and surgical procedures. Intraoral scanners offer digital impressions of the dentition, improving accuracy and efficiency in restorative dentistry and orthodontic treatment.
2. **Artificial Intelligence (AI)-Assisted Diagnosis:** The application of artificial intelligence algorithms to dental imaging data holds immense potential for enhancing diagnostic accuracy and streamlining clinical workflows. AI-based software can analyze radiographic images, detect abnormalities, and assist clinicians in identifying caries, periodontal disease, and other oral pathologies. Additionally, AI algorithms can predict treatment outcomes, optimize treatment planning, and provide decision support for complex cases, ultimately improving patient care and treatment outcomes.
3. **Augmented Reality (AR) and Virtual Reality (VR) Visualization:** Augmented reality and virtual reality technologies are increasingly being utilized in dental education, patient communication, and treatment planning. AR overlays digital information onto the clinician's view of the real-world environment, allowing for interactive visualization of treatment plans and anatomical structures during surgical procedures. VR simulations provide immersive experiences for patients, enabling them to explore their dental anatomy, understand treatment options, and alleviate anxiety before undergoing dental procedures.
4. **Handheld and Portable Imaging Devices:** Advancements in miniaturized imaging technology have led to the development of handheld and portable dental imaging devices, offering flexibility and convenience in various clinical settings. Handheld X-ray units, intraoral cameras, and portable CBCT scanners enable point-of-care imaging, facilitating bedside consultations, emergency procedures, and outreach initiatives in underserved communities. These compact devices enhance accessibility to dental imaging services and expand the reach of oral healthcare to remote and resource-limited areas.

5. **Digital Workflow Integration:** The seamless integration of digital imaging with computer-aided design/computer-aided manufacturing (CAD/CAM) systems and dental practice management software streamlines clinical workflows and enhances efficiency in dental practice. Digital impressions, radiographs, and 3D models can be easily shared, stored, and manipulated within integrated software platforms, facilitating interdisciplinary collaboration, treatment planning, and communication with patients and dental laboratories.
6. **Advanced Imaging Modalities:** Emerging imaging modalities, such as photoacoustic imaging, near-infrared fluorescence imaging, and spectroscopic imaging, offer novel approaches for visualizing dental structures and detecting pathological changes at the molecular level. These advanced imaging techniques hold promise for early detection of oral cancer, monitoring treatment response, and guiding targeted interventions, paving the way for personalized approaches to oral healthcare delivery.

By harnessing the power of these recent technological advancements, clinicians can elevate the standard of care in dentistry, improve diagnostic accuracy, and enhance patient experiences. Embracing innovation and incorporating cutting-edge imaging technologies into clinical practice empowers dental professionals to deliver comprehensive, evidence-based care and stay at the forefront of the evolving landscape of oral healthcare. In the subsequent sections, we will delve deeper into the practical considerations and clinical applications of these advanced imaging technologies, providing insights for clinicians seeking to integrate them into their daily practice.

Clinical Considerations and Guidelines:

While modern imaging technologies offer valuable tools for diagnosing and managing oral and dental conditions, clinicians must consider several factors and adhere to established guidelines to ensure safe and effective use of these imaging modalities. This section highlights key clinical considerations and provides guidelines for incorporating imaging techniques into dental practice:

1. **Patient Assessment and Medical History:** Before performing any dental imaging procedure, clinicians should conduct a thorough patient assessment, including a review of medical and dental history. Special attention should be given to factors such as pregnancy, allergies, previous radiation exposure, and presence of metallic implants or foreign bodies, which may impact the choice of imaging modality and protocol.
2. **Justification and Indication for Imaging:** Dental imaging should be justified based on clinical indications and diagnostic needs. Clinicians should carefully evaluate the necessity of imaging procedures, considering the potential benefits and risks for the patient. Imaging should be performed only when it is likely to provide clinically relevant information that cannot be obtained through other means.
3. **Radiation Safety and Dose Optimization:** When utilizing ionizing radiation-based imaging modalities, such as digital radiography and cone-beam computed tomography (CBCT), clinicians must prioritize radiation safety and adhere to the ALARA (As Low As Reasonably Achievable) principle. Dose optimization strategies, such as proper collimation, shielding, and use of low-dose protocols, should be employed to minimize radiation exposure to patients and personnel.
4. **Image Acquisition and Interpretation:** Proper positioning, technique, and image acquisition parameters are essential for obtaining diagnostically accurate images. Clinicians should follow standardized protocols and guidelines for image acquisition, ensuring optimal visualization of dental structures while minimizing artifacts and errors. Images should be carefully reviewed and interpreted by trained professionals to avoid misdiagnosis and ensure appropriate treatment planning.
5. **Infection Control and Sterilization:** Infection control protocols must be strictly adhered to when using intraoral sensors, digital sensors, and other reusable imaging devices. Proper disinfection and sterilization procedures should be followed to prevent cross-contamination and ensure patient safety. Single-use barriers or disposable covers should be used whenever possible to minimize the risk of infection transmission.
6. **Documentation and Communication:** Accurate documentation of imaging findings, including image acquisition parameters and clinical impressions, is essential for maintaining comprehensive patient records and facilitating communication among healthcare providers. Clinicians should document the indication for imaging, diagnostic findings, and any relevant clinical observations in the

patient's chart for future reference and continuity of care.

7. **Quality Assurance and Continuous Training:** Regular quality assurance measures, such as equipment calibration, performance evaluation, and image quality assessment, should be implemented to maintain the integrity and reliability of imaging systems. Clinicians and imaging personnel should undergo regular training and education on radiation safety, imaging techniques, and interpretation guidelines to stay updated on best practices and technological advancements.
8. **Adherence to Professional Guidelines:** Dental imaging protocols should align with established professional guidelines and recommendations issued by organizations such as the American Dental Association (ADA), American Academy of Oral and Maxillofacial Radiology (AAOMR), and International Commission on Radiological Protection (ICRP). Clinicians should familiarize themselves with these guidelines and integrate them into their clinical practice to ensure compliance with current standards of care.

By adhering to these clinical considerations and guidelines, clinicians can optimize the safe and effective use of dental imaging modalities, minimize potential risks to patients and personnel, and enhance the quality of diagnostic information obtained through imaging procedures. Integrating these principles into daily practice promotes patient-centered care, fosters interdisciplinary collaboration, and contributes to the delivery of evidence-based dentistry. In the subsequent sections, we will delve deeper into specific imaging protocols, clinical applications, and case-based scenarios to illustrate the practical implementation of these guidelines in various clinical settings.

Conclusion:

In conclusion, the integration of modern imaging modalities into dental practice has revolutionized the field of dentistry, offering clinicians unprecedented capabilities for diagnosing, treating, and monitoring oral and dental conditions. Throughout this paper, we have explored the principles, applications, advantages, and limitations of various imaging techniques, ranging from digital radiography and cone-beam computed tomography (CBCT) to magnetic resonance imaging (MRI) and optical coherence tomography (OCT).

These imaging modalities serve as indispensable tools for visualizing dental anatomy, detecting pathologies, planning treatments, and monitoring outcomes, thereby enhancing diagnostic accuracy, treatment precision, and patient care. By leveraging advanced imaging technologies, clinicians can achieve a deeper understanding of oral and dental structures, tailor treatment plans to individual patient needs, and optimize treatment outcomes with confidence.

However, it is crucial for clinicians to approach dental imaging with careful consideration of clinical indications, patient characteristics, and safety protocols. Adhering to established guidelines, prioritizing radiation safety, and maintaining rigorous quality assurance measures are essential for ensuring the safe and effective use of imaging modalities in dental practice.

As we look to the future, ongoing technological advancements, such as artificial intelligence (AI)-assisted diagnosis, augmented reality (AR) visualization, and portable imaging devices, hold promise for further enhancing the capabilities of dental imaging and expanding access to oral healthcare services. Embracing innovation, continuing education, and fostering interdisciplinary collaboration are key to maximizing the potential of imaging technology in improving oral health outcomes and advancing the field of dentistry.

In closing, modern imaging modalities represent a cornerstone of contemporary dental practice, empowering clinicians to deliver personalized, evidence-based care and promote optimal oral health for patients worldwide. By embracing the transformative power of imaging technology and integrating it into routine clinical workflows, we can embark on a journey towards a future where precision diagnosis, targeted interventions, and superior patient outcomes are the standard of care in dentistry.

References:

1. White, S.C., Pharoah, M.J. (2014). Oral Radiology: Principles and Interpretation (7th ed.). St. Louis, MO: Elsevier.
2. Scarfe, W.C., Farman, A.G. (2008). Cone Beam Computed Tomography. In: White, S.C., Pharoah, M.J. (Eds.), Oral Radiology: Principles and Interpretation (6th ed.). St. Louis, MO: Mosby Elsevier.
3. Tyndall, D.A., Rathore, S. (2008). Cone-beam CT Diagnostic Applications: Caries, Periodontal Bone Assessment, and Endodontic Applications. Dental Clinics of North America, 52(4), 825–841.
4. Pauwels, R., Jacobs, R., Singer, S.R., Mupparapu, M. (2015). CBCT-based bone quality assessment: Are Hounsfield units

applicable? Dentomaxillofacial Radiology, 44(1), 20140238.
5. Scarfe, W.C., Azevedo, B., Toghyani, S., Farman, A.G. (2006). Cone beam computed tomography: A paradigm shift for clinical dentistry. Australian Dental Journal, 51(1 Suppl), 9–13.
6. Swennen, G.R., Mollemans, W., De Clercq, C., Abeloos, J., Lamoral, P., Lippens, F., Neyt, N., Casselman, J., Schutyser, F. (2009). A cone-beam computed tomography triple scan procedure to obtain a three-dimensional augmented virtual skull model appropriate for orthognathic surgery planning. Journal of Craniofacial Surgery, 20(2), 297–307.
7. Alamri, H.M., Sadrameli, M., Alshalhoob, M.A., Sadrameli, M., Alshehri, M.A. (2015). Applications of CBCT in dental practice: A review of the literature. General Dentistry, 63(2), 16–23.
8. American Dental Association Council on Scientific Affairs. (2012). The use of cone-beam computed tomography in dentistry: An advisory statement from the American Dental Association Council on Scientific Affairs. Journal of the American Dental Association, 143(8), 899–902.
9. Jaju, P.P., Jaju, S.P. (2011). Cone-beam computed tomography: Time to move from ALARA to ALADA. Imaging Science in Dentistry, 41(1), 1–3.
10. Ohshima, M., Araki, K., Kawazu, T., Shibuya, H., Hara, K., Sasaki, T., Okano, T., Nakamura, Y., Omura, K. (2010). A novel compact and light weight dental cone-beam CT using a flexible lead zirconate titanate film image detector. Dento Maxillo Facial Radiology, 39(3), 115–122.