The Review Of
DIABETIC
STUDIES
OPEN ACCESS

Dental Radiology In Clinical Practice: Principles, Techniques, And Diagnostic Value

Hayat Nabil Alzaqy[1], Fahad Awadh Mohammed Alyami[2], Taghreed Abdalaziz Ahmed Alghamdi[3], Fahad Fasial Alotaibi[4], Emad Mohammed Altukhais[5], Meshal Eid Abdulrhman Alotaibi[6], Sameera Musif Salem Alharbi[7], Amirah Ahmed Mohamed baabbad[8], Majed Mohammed M Zelaee[9], Bushra Abdulmumin Abdullah[10], Areej Mosem Alsolame[11], Hanadi Ateeq Alansari[12]

[1]Dental Hygienist, Riyadh Second Health Cluster, Saudi Arabia.
[2]X-ray technician, Prince Sultan Center for Heart Treatment and Surgery in Al-Ahsa, Saudi Arabia.
[3]Dental assistant, Supervision of Al Baha sector, Saudi Arabia.
[4]Radiographer Technician, Compliance Assist Administration, Compliance Third West Office , Al Duwadimi , Saudi Arabia
[5]Radiologic Technologist, Dawadmi hospital, Saudi Arabia.
[6]X-ray technician, Dawadmi hospital, Saudi Arabia.
[7]XRAY TECHNICIAN, Al-Safiah Urgent Care Center, Saudi Arabia.
[8]Dental assistant, Al Quraniyah Medical Center, Saudi Arabia.
[9]Technician-Radiological Technology, Health Monitoring Center Management at King Abdulaziz International Airport in Jeddah, Saudi Arabia.
[10]Technician Dental Assistan, Alkr Shaddad Health Center, Saudi Arabia.
[11]Dental assistant, Harad health center, Saudi Arabia.
[12]Dental Assistant, King Abdulaziz Hospital-Makkah, Saudi Arabia.

Abstract
Modern dentistry uses dental radiography to make accurate diagnoses, plan treatments, and keep an eye on the health of the mouth and face. Modern imaging technology has greatly lowered radiation exposure while also making pictures clearer, diagnoses more accurate, and patient safety better. This review gives a full picture of dental radiology, from the basic principles of radiation physics to the main imaging techniques, radiation safety measures, clinical uses in different dental specialities, and new technologies like digital imaging and artificial intelligence. To achieve optimal patient outcomes and ensure evidence-based clinical decision-making, it is essential to understand the diagnostic efficacy of dental radiology.

Keywords Dental radiology, diagnostic imaging, CBCT, digital radiography, radiation safety, clinical dentistry

1. Introduction

Dental radiology is an important part of modern dentistry because it is a basic tool for accurate diagnosis, effective treatment planning, and long-term patient management. However, a clinical examination might miss a number of hidden pathological diseases, such as periapical lesions, impacted teeth, interproximal caries, and alveolar bone loss, to name a few. Radiographic imaging enhances diagnostic precision and clinical decision-making by enabling physicians to visualise structures that would otherwise remain inaccessible (Molteni., 2021).

The X-rays that Wilhelm Conrad Röntgen found in 1895 were the beginning of modern dental radiology. Early radiography techniques had a lot of problems, like long exposure times, bad picture quality, and higher radiation risks. Over the years, improvements in imaging technology have made patients much safer, lowered their radiation exposure, and made the pictures look better. Because of these changes, dental radiology is now a very reliable and useful branch of medicine (Tubiana et al., 1996).

Dental radiology now includes a wide range of imaging techniques, from traditional intraoral radiography to cutting-edge three-dimensional methods like cone-beam computed tomography (CBCT). These imaging tools help many different types of dentists, such as those who work in restorative dentistry, orthodontics, periodontics, endodontics, and oral and maxillofacial surgery.

Dentistry radiology is an important part of modern dental care. This review will try to explain its basic ideas, common procedures, and how useful it is for clinical diagnosis (Molteni., 2021).

2. Principles of Dental Radiology

2.1 Basic Radiation Physics

X-rays are a type of ionising electromagnetic radiation that can go through biological tissues. They are the basis of dental radiography. When electrons moving quickly hit a metal target, usually tungsten, inside the X-ray tube, X-rays are made. This interaction changes kinetic energy into electromagnetic radiation, which makes X-rays that are great for use in diagnostic imaging. X-rays interact with oral and maxillofacial structures in different ways depending on the tissues' density, thickness, and atomic makeup. There are three possible outcomes: absorption, scattering, or transmission. Dense tissues like enamel, dentin, and cortical bone look radiopaque on X-rays because they absorb a lot of radiation. Radiolucent soft tissues, on the other hand, let more radiation pass through. A solid understanding of how these principles work together is necessary for making accurate clinical diagnoses and correctly interpreting pictures (Tafti and Maani., 2023).

2.2 Image Formation and Quality

Some of the technical and biological factors that affect the quality of a dental radiograph are contrast, density, sharpness, and spatial resolution. These standards decide how clear it is to see changes in diseases and anatomical structures. The main things that affect picture density and contrast are exposure settings like milliamperage (mA), kilovoltage peak (kVp), and exposure time. The sensitivity of the image receptor, whether it's digital or film-based, also has a big effect on the quality of the picture and the amount of radiation it gets. To avoid diagnostic mistakes caused by distortion, magnification, and overlapping structures, it is just as important to put the patient in the right position and line up the beam correctly. Optimising these factors ensures the production of high-quality diagnostic images while adhering to established radiation protection standards and minimising radiation exposure to an acceptable threshold (Hegde et al., 2023).

3. Dental Radiographic Techniques

Radiographs taken with a dental x-ray machine help dentists see things in the mouth that they couldn't see with just their eyes. Different types of imaging are needed for different types of diagnosis. These types are usually divided into intraoral and extraoral imaging. The selection of imaging technique is determined by diagnostic requirements, the specific anatomical region of interest, and clinical indications (Chaitanya et al., 2024).

3.1 Intraoral Radiography

Intraoral radiographs are often used by dentists because they give clear pictures of the teeth and bones in the mouth. Intraoral radiography is the most common type of imaging used in dental practice because it has great spatial resolution and can show teeth and the alveolar bone next to them in great detail. This method makes high-quality diagnostic images by putting the image receptor inside the patient's mouth, which brings it closer to the target area. Intraoral radiography is great for checking for dental caries, periodontal bone levels, periapical disease, and treatment outcomes. They are an important part of endodontic, restorative, and preventative dentistry because they are used so often (Hale., 2018).
There are three main types of intraoral radiography:

3.1.1 Periapical Radiographs

Radiographs from the periapical region show the whole tooth, including the crown, root, and bone around the root. It is very important to use them to find pulpal pathology, root fractures, and periapical infections. These pictures are absolutely necessary for planning endodontic treatment and checking on the results afterward (Martins et al., 2014).

3.1.2 Bitewing Radiographs

The main goals of taking bitewing radiographs are to find interproximal caries and check the levels of alveolar bone, especially in people with periodontal disease. They are an important part of preventive dental care and are used a lot during regular checkups (Grieco et al., 2022).

3.1.3 Occlusal Radiographs

Occlusal radiographs are useful for finding impacted teeth, cysts, fractures, foreign objects, and developmental problems because they show a lot of the maxilla or mandible. These tools are very useful in paediatric dentistry when patients can't have intraoral periapical imaging or when the patient is a child (Ozmen et al., 2024).

3.2 Extraoral Radiography

Extraoral radiography methods are widely used to look at larger craniofacial structures. Positioning the image receptor outside the oral cavity enables the visualisation of larger anatomical structures, as opposed to intraoral imaging. These procedures are very helpful when a full anatomical overview is needed, like when diagnosing a difficult case, doing orthodontics, or performing oral and maxillofacial surgery (Kumar et al., 2011).

3.2.1 Panoramic Radiography

The maxillofacial region, which includes the jaw, temporomandibular joints, maxillary sinuses, and growing teeth, can be seen in a two-dimensional panoramic image. It is commonly used for planning oral surgery and implant placement before surgery, evaluating orthodontics, and doing an initial assessment of a patient. This imaging technique has many benefits, such as making patients more comfortable, exposing them to less radiation, and covering a wide area of anatomy. In contrast, the images are worse than intraoral radiography because they are larger, distorted, and have a lower spatial resolution. Even with these warnings, panoramic imaging is still a great way to check your teeth on a regular basis (Kapila et al., 2011).

3.2.2 Cephalometric Radiography

Cephalometric radiography is very important for figuring out what is wrong with your teeth and making a plan for treatment. It provides consistent frontal and lateral views of the head and face, facilitating the assessment of dental alignment, facial developmental patterns, and skeletal relationships. Cephalometric analysis is often used to look at craniofacial development, keep track of how well treatment is going, and see how well treatment works. Longitudinal studies and orthodontic research significantly benefit from its standardisation, as it facilitates consistent measurements (Ghodasra et al., 2023).

3.3 Advanced Imaging Modalities

Recent advances in imaging technology have made dental radiology much better at diagnosing problems. The use of modern imaging methods has made it much easier to see complex anatomical structures in three dimensions. This has made diagnosis and treatment planning more accurate in many areas of dentistry (Shah et al., 2014).

3.3.1 Cone-Beam Computed Tomography (CBCT)

Cone-beam computed tomography (CBCT) has changed dental imaging forever. It lets you see craniofacial anatomy in three dimensions with great detail and much lower radiation doses than regular computed tomography (CT). With CBCT, you can accurately see how teeth are positioned, how root canals are shaped, and how bones are shaped. This type of imaging is used a lot in oral and maxillofacial surgery, orthodontics, endodontics, and implant dentistry. Because it can give precise volumetric data, it can help doctors make more accurate diagnoses, plan surgeries better, and get more predictable clinical results. Even though CBCT has its benefits, it must be fully justified in order to follow rules for protecting against radiation (Venkatesh and Elluru., 2017).

3.3.2 Magnetic Resonance Imaging (MRI)

Magnetic resonance imaging (MRI) is the best way to look at the temporomandibular joint (TMJ), salivary glands, and other soft tissues. Magnetic resonance imaging (MRI) is safer than imaging

methods that use X-rays because it doesn't use ionising radiation. MRI is great for looking at disc position, inflammation, and soft tissue pathology in great detail because it shows soft tissues in high contrast. Magnetic resonance imaging (MRI) is very important for complicated diagnostic cases where there are problems with soft tissues, but it isn't used very often in everyday dental practice because it costs too much and is hard to get (Larheim., 2005).

3.3.3 Ultrasonography

Ultrasonography, a non-invasive imaging method that does not use radiation, is one of the most common ways to check the health of the soft tissues in the maxillofacial area. It is very good at finding problems in soft tissues that are close to the surface, cystic lesions, lymph nodes, and salivary glands. Ultrasonography is not commonly employed in dentistry due to its restricted penetration into osseous and aerated tissues. In some clinical situations, though, it is a useful extra diagnostic tool. Because it can take pictures in real time and doesn't use ionising radiation, it is a safe and useful alternative for some diagnostic needs (Rama et al., 2015).

4. Clinical Applications of Dental Radiology

Dental radiography is an important part of many dental specialities because it is an important tool for accurate diagnosis, effective treatment planning, and long-term patient care. Doctors can find problems earlier, keep an eye on how diseases are progressing, and judge how well treatments are working more accurately when they can see both hard and soft tissues (Xu., 2023).

Restorative Dentistry

Radiographic imaging is a very important part of restorative dentistry because it can help find dental caries, especially recurrent lesions and interproximal cavities, which are hard to see with the naked eye. Radiographs can also help find small problems, secondary caries, and see how close lesions are to the pulp. They can also help figure out how strong current restorations are. These results help with making plans for long-term repairs and maintenance (Abdelaziz., 2023).

Endodontics

Radiology is a big part of both diagnostic and therapeutic endodontic procedures. This method lets you see the shape of the root canals, diseases in the periapical space, and the health of the pulp and periapical area. Radiographic imaging is necessary to keep track of how treatment is going and to see if root canal therapy worked. This imaging helps find any infections or anatomical problems that are still there (Setzer and Lee., 2021).

Periodontology

Radiographic examination is an essential tool in periodontology for assessing the quantity of alveolar bone and monitoring the progression of periodontal disease. Imaging can show patterns of bone loss, furcation involvement, and periodontal problems that might not be easy to see right away. These findings lend support to accurate diagnosis, prognosis prediction, and the development of treatment strategies (Jacobs et al., 2024).

Orthodontics

Radiographic imaging is very important for orthodontists to use to look at patterns of craniofacial development, skeletal linkages, and dental progress. Tools like panoramic and cephalometric radiographs are very useful for planning treatments, keeping track of when teeth come in, and figuring out how well they work. Advanced imaging technologies make it even easier to get an accurate diagnosis in patients with complicated orthodontic problems (Ghodasra and Brizuela et al., 2023).

Oral and Maxillofacial Surgery

Radiographic imaging is very important for maxillofacial and oral surgery because it helps doctors figure out what is wrong with cysts, tumours, impacted teeth, and broken bones. Advanced imaging techniques, especially CBCT, give surgeons a lot of three-dimensional information that helps them plan surgery and lower the risk of complications during the procedure (Weiss and Read-Fuller., 2019).

Pediatric Dentistry
Radiology is very important in paediatric dentistry because it helps find developmental problems early, keep track of tooth eruption patterns, and overall development. During radiographic evaluation of paediatric patients, adherence to radiation safety protocols is upheld, facilitating the early identification of caries, supernumerary teeth, and developmental anomalies (Domyati et al., 2023).

5. Radiation Protection and Safety
Making sure that radiation safety is a part of dental care is very important. ALARA (As Low As Reasonably Achievable) is the main idea behind radiography techniques. Taking precautions includes wearing a lead apron or thyroid collar, making sure that equipment is set up correctly, and following the rules for exposure. Patients and doctors can both lower their risk of radiation exposure by staying informed and following international safety rules (Frane and Bitterman., 2023).

6. Digital Radiography and Artificial Intelligence
Digital radiography has made imaging more efficient, reduced radiation exposure, and improved diagnostic accuracy. Digital technology lets you store, improve, and quickly share images. AI is quickly becoming a part of dental radiology for helping with diagnosis, automating caries diagnosis, and checking bone levels. AI-powered solutions may improve treatment outcomes and make diagnoses more consistent (Al-Khalifa et al., 2024).

7. Advantages and Limitations of Dental Radiology

Advantages
One of the best things about dental radiology is that it can find oral problems early on, often before clinical signs show up. When dental caries, periapical lesions, and periodontal bone loss are identified early, treatment can commence swiftly, resulting in improved outcomes. Radiographic imaging gives doctors a clear picture of anatomical structures that can't be seen during a clinical exam, which makes diagnosis even more accurate. This clarity makes it possible to be more accurate in diagnosing, planning treatment, and keeping an eye on the disease's progress or treatment success. Also, dental radiography procedures are usually quick, painless, and don't require much time off for patients. Digital imaging technology has improved workflow efficiency, made diagnostic information easier to get, and reduced radiation exposure even more without lowering image quality (Alharbi and Alhasson., 2024).

8. Ethical and Legal Considerations
Ethical dental radiology includes getting informed consent, keeping patient information private, and giving a reason for exposing someone to radiation. Dentists must follow all local, state, and federal laws to keep their credibility and protect their patients (Weiss and Read., 2019).

9. Future Directions in Dental Radiology
The main areas where dental radiography is expected to improve in the future are integration with digital workflows like 3D printing and virtual treatment planning, as well as ultra-low-dose imaging and powerful artificial intelligence applications. Personalized imaging procedures based on a patient's specific risk factors could make diagnoses even more accurate (YILDIRIM., 2024).

Limitations
There are many uses for dental radiology, but it does expose patients to ionising radiation, which can hurt living things if not used properly. Even though dental imaging uses very low doses of radiation, it is still very important to follow all safety rules for radiation exposure to keep it as low as possible. Another possible problem is not understanding the results of radiography, especially when anatomical structures overlap, the picture is distorted, or the image quality is poor. Correct interpretation requires the right education, hands-on experience, and clinical correlation. Also, traditional radiographic methods have problems when it comes to seeing soft tissues, which can make them less useful for diagnosis in some cases. Doctors may need to use special imaging methods like magnetic resonance imaging (MRI) or ultrasound to get a complete picture of the problem (Hwang et al., 2018).

10. Conclusion

Dental radiography is an important part of modern dentistry because it gives important diagnostic information that helps doctors give the best care to their patients. Digital innovation, safety measures, and the constant advancement of imaging technology have all greatly improved the accuracy of diagnoses and the effectiveness of treatments. As technology gets better, dentists will still need dental radiology to give patients the best care possible.

References

1. Abdelaziz M. Detection, Diagnosis, and Monitoring of Early Caries: The Future of Individualized Dental Care. Diagnostics (Basel). 2023 Dec 12;13(24):3649. doi: 10.3390/diagnostics13243649. PMID: 38132233; PMCID: PMC10742918.
2. Alharbi SS, Alhasson HF. Exploring the Applications of Artificial Intelligence in Dental Image Detection: A Systematic Review. Diagnostics (Basel). 2024 Oct 31;14(21):2442. doi: 10.3390/diagnostics14212442. PMID: 39518408; PMCID: PMC11545562.
3. Al-Khalifa, K. S., Ahmed, W. M., Azhari, A. A., Qaw, M., Alsheikh, R., Alqudaihi, F., & Alfaraj, A. (2024). The Use of Artificial Intelligence in Caries Detection: A Review. Bioengineering, 11(9), 936. https://doi.org/10.3390/bioengineering11090936
4. Molteni R. The way we were (and how we got here): fifty years of technology changes in dental and maxillofacial radiology. Dentomaxillofac Radiol. 2021 Jan 1;50(1):20200133. doi: 10.1259/dmfr.20200133. Epub 2020 Jun 11. PMID: 32525697; PMCID: PMC7780828.
5. Chaitanya NC, Padmanabhan V, Islam MS, Hashim NT, Mohammed R, Allam NS, Omar JJ, Zakaria A, Pranathi S, Apoorva M. Enhancing intraoral radiographic technique: introducing "Nallan's Lines". Front Oral Health. 2024 Dec 20;5:1498117. doi: 10.3389/froh.2024.1498117. PMID: 39758275; PMCID: PMC11695278.
6. Domyati, Roaa & Zagzoog, Ghaida & Obaid, Abdulrahman & Shehri, Rawad & Blowi, Randah & Shibatalhamd, Khalid & Bahkali, Rahmah & Munthery, Ahmed & Demyati, Mawadh & Alshehri, Shahad & Hakami, May. (2023). Pediatric dental radiography: safety, techniques and diagnostic applications. International Journal Of Community Medicine And Public Health. 11. 533-539. 10.18203/2394-6040.ijcmph20234153.
7. Frane N, Bitterman A. Radiation Safety and Protection. [Updated 2023 May 22]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. Available from: https://www.ncbi.nlm.nih.gov/books/NBK557499/
8. Ghodasra R, Brizuela M. Orthodontics, Malocclusion. [Updated 2023 Apr 23]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK592395/
9. Grieco P, Jivraj A, Da Silva J, Kuwajima Y, Ishida Y, Ogawa K, Ohyama H, Ishikawa-Nagai S. Importance of bitewing radiographs for the early detection of interproximal carious lesions and the impact on healthcare expenditure in Japan. Ann Transl Med. 2022 Jan;10(1):2. doi: 10.21037/atm-21-2197. PMID: 35242847; PMCID: PMC8825540.
10. Hale F. Intraoral radiographic tips and tricks. Can Vet J. 2018 Feb;59(2):191-197. PMID: 29386685; PMCID: PMC5764209.
11. Hegde S, Gao J, Vasa R, Cox S. Factors affecting interpretation of dental radiographs. Dentomaxillofac Radiol. 2023 Jan;52(2):20220279. doi: 10.1259/dmfr.20220279. Epub 2022 Dec 22. PMID: 36472942; PMCID: PMC9974235.
12. Hwang SY, Choi ES, Kim YS, Gim BE, Ha M, Kim HY. Health effects from exposure to dental diagnostic X-ray. Environ Health Toxicol. 2018 Dec;33(4):e2018017. doi: 10.5620/eht.e2018017. Epub 2018 Nov 21. PMID: 30661338; PMCID: PMC6341170.
13. Jacobs R, Fontenele RC, Lahoud P, Shujaat S, Bornstein MM. Radiographic diagnosis of periodontal diseases - Current evidence versus innovations. Periodontol 2000. 2024 Jun;95(1):51-69. doi: 10.1111/prd.12580. Epub 2024 Jun 3. PMID: 38831570.
14. Kapila S, Conley RS, Harrell WE Jr. The current status of cone beam computed tomography imaging in orthodontics. Dentomaxillofac Radiol. 2011 Jan;40(1):24-34. doi: 10.1259/dmfr/12615645. PMID: 21159912; PMCID: PMC3611465.

15. Kumar R, Khambete N, Priya E. Extraoral periapical radiography: an alternative approach to intraoral periapical Radiography. Imaging Sci Dent. 2011 Dec;41(4):161-5. Doi: 10.5624/Isd.2011.41.4.161. Epub 2011 Dec 19. PMID: 22232725; PMCID: PMC3251789.
16. Larheim TA. Role Of Magnetic Resonance Imaging In The Clinical Diagnosis Of The Temporomandibular Joint. Cells Tissues Organs. 2005;180(1):6-21. doi: 10.1159/000086194. PMID: 16088129.
17. Martins, Jorge & Canta, João & Baharestani, Michael. (2014). Vertical root fracture diagnosis of crowned premolars with root canal treatment – Two case reports. Revista Portuguesa de Estomatologia, Medicina Dentária e Cirurgia Maxilofacial. 55. 60-64. 10.1016/j.rpemd.2013.11.002.
18. Ozmen B, Ayna NB. Occlusal Radiographs in a Turkish Pediatric Subpopulation. Acta Stomatol Croat. 2024 Mar;58(1):52-58. doi: 10.15644/asc58/1/5. PMID: 38562222; PMCID: PMC10981912.
19. Rama Mohan K, Koteswara Rao N, Leela Krishna G, Santosh Kumar V, Ranganath N, Vijaya Lakshmi U. Role of ultrasonography in oral and maxillofacial surgery: a review of literature. J Maxillofac Oral Surg. 2015 Jun;14(2):162-70. doi: 10.1007/s12663-014-0616-x. Epub 2014 Mar 14. PMID: 26028830; PMCID: PMC4444684.
20. Setzer FC, Lee SM. Radiology in Endodontics. Dent Clin North Am. 2021 Jul;65(3):475-486. doi: 10.1016/j.cden.2021.02.004. Epub 2021 May 3. PMID: 34051926.
21. Shah N, Bansal N, Logani A. Recent advances in imaging technologies in dentistry. World J Radiol. 2014 Oct 28;6(10):794-807. doi: 10.4329/wjr.v6.i10.794. PMID: 25349663; PMCID: PMC4209425.
22. Tafti D, Maani CV. X-ray Production. [Updated 2023 Jul 31]. In: StatPearls [Internet]. Treasure Island (FL): Available from: https://www.ncbi.nlm.nih.gov/books/NBK537046/
23. Tubiana M. Wilhelm Conrad Röntgen et la découverte des rayons X [Wilhelm Conrad Röntgen and the discovery of X-rays]. Bull Acad Natl Med. 1996 Jan;180(1):97-108. French. PMID: 8696882.
24. Venkatesh E, Elluru SV. Cone beam computed tomography: basics and applications in dentistry. J Istanb Univ Fac Dent. 2017 Dec 2;51(3 Suppl 1):S102-S121. doi: 10.17096/jiufd.00289. PMID: 29354314; PMCID: PMC5750833.
25. Weiss R 2nd, Read-Fuller A. Cone Beam Computed Tomography in Oral and Maxillofacial Surgery: An Evidence-Based Review. Dent J (Basel). 2019 May 2;7(2):52. doi: 10.3390/dj7020052. PMID: 31052495; PMCID: PMC6631689.
26. Weiss R 2nd, Read-Fuller A. Cone Beam Computed Tomography in Oral and Maxillofacial Surgery: An Evidence-Based Review. Dent J (Basel). 2019 May 2;7(2):52. doi: 10.3390/dj7020052. PMID: 31052495; PMCID: PMC6631689.
27. Xu, Y. (2023). Dental radiography: An invaluable tool for modern dentistry. JBR Journal of Interdisciplinary Medicine and Dental Sciences, 6(4).
28. Yildirim, Levent. (2024). Digital Restorative Procedures In Dentistry: Digital Dentistry. Brazilian Journal of Implantology and Health Sciences. 6. 191-221. 10.36557/2674-8169.2024v6n9p191-221.