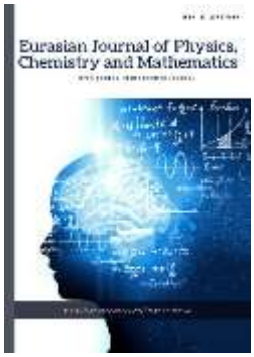

The modern X-ray imaging manners for diagnosis of the dental diseases

Assist. Lect. Atyaf Sarhan Farhan

atyaf.s.farhan@qu.edu.iq
The University of Al-Qadisiyah, College of Dentistry, - Basic Sciences

ABSTRACT

The Medical imaging procedures that help radiologists diagnose and treat health conditions showed a clear and exact description of the structure changes. There are many devices, apparatus, and technologies used in the medical field, such as x-ray applications which include computed tomography (Ct) Scanner, Tuned Aperture Computed Tomography (Tact), Cone Beam Computed Tomography (Cone). Recent medical imaging technologies have been used in tooth disease diagnostics for treatment purposes. The New x-ray Techniques can detect dental diseases and determine any structure changes for therapeutic purposes. These technologies help reduce morbidity and mortality and improve the quality of life. Our review sheds light on modern and modern techniques in the applications of x-ray technology in dentistry. It sheds light on some details related to it, such as the uses of x-rays and the risks of radiation in adults and children and the components and types of devices that make up these rays, especially those used in dentistry, in addition to a historical overview starting from Before the discovery of Roentgen.

Keywords: radiography, X-ray, applications, CT, Tact, Cone, dental diseases

General view:

Discovering:

1- Pre-Rontgen observations and research: X-rays were experimental discharge tube radiation. Scientists studying cathode rays from such tubes recognized them in 1869. Crookes tubes formed electrons by ionizing the air in the high voltage tube. This voltage accelerated cathode electrons to a high speed for X-ray production to hit the anode (Crookes, W. 1878).

William Morgan developed X-rays (unknowingly) first. In 1785, he described how sending electrical currents through a partially evacuated glass tube produced X-rays. Humphry Davy and Michael Faraday continued this work (Mosby's Dental Dictionary, 2008). Fernando Sanford's "electric photography" produced and identified X-rays. The cathode rays form in vacuum tubes if there is a high voltage between the electrodes (Tubiana and Wilhelm, 1996).

Philipp Lenard began testing cathode rays in the air in 1888. He created a Crookes tube with a thin aluminum facing the cathode to catch cathode rays. The exposure of the photographic plates is caused fluorescence. The rays' penetration is tested through different materials. Some "Lenard rays" may have been X-rays (Tubiana M. Wilhelm C., 1996). In 1889, Ivan Puluj had constructed several models of glass tubes to become dark if exposed to the

emanations from the tubes (Sansare, K., et, al. 2011) (Babic RR, et al. 2016).

Nikola Tesla started studying invisible, radiant energy in 1894 after seeing a damaged film from Crookes tube tests. Tesla started creating X-ray pictures after Röntgen discovered them, utilizing high voltages and his tubes as well as Crookes tubes (Mould RF. 1995) (berger et, al. 2018).

2-Discovery by Rontgen:

Wilhelm Rontgen discovered X-rays in 1895 while testing with Lenard and Crookes tubes. Rontgen called the unknown radiation X. Rontgen's colleagues recommended dubbing them Rontgen rays, but he objected. Rontgen's discovery won the first Physics Nobel Prize (frankel, R 1996) (Eisenberg and amorosa, 1995).

Biographers have reconstructed Rontgen's findings since he burnt his lab notes following his death. Rontgen is used a fluorescent screen lined by barium platinocyanide to study rays from a black-cardboard-wrapped Crookes tube. Rontgen found invisible radiation, and after two months, he published his article (Howell J. D. 2016) (Pallardy G. Röentgen, 1995).

Using medical first X-rays were done by Rontgen for his wife's hand in 1895 (Mowery ML, Singh V. 2012). Rontgen discovered their medicinal utility when he photographed his wife's hand using X-rays. X-rays were a sensation. Otto Glasser, Rontgen's biographer, calculated that 49 essays and 1044 pieces were published in 1896 alone. This was certainly a modest estimate, considering that practically every publication across the globe reported on the finding, with Science devoting 23 pieces to it in that year alone. Publications linked the new rays to occult and paranormal beliefs like telepathy (Berger, at al, 2018) (Tafti, and Maani, 2021).

3- Advances in radiology:

Late 1800s Crookes tube X-ray, center is the Crookes tube. The guy standing is a fluoroscope in his hand. The sitting guy is getting an x-ray of his hand. No radiation safeguards were adopted since its dangers were unknown. In 1897, Rontgen removed a bullet whose position was detected by X-rays. Alan Archibald created the first X-ray after Rontgen. John Hall-Edwards radiographed a needle inserted in a colleague's hand in 1896. Hall-Edwards used X-rays in a surgical procedure on 1896 (Nakashima and Duong, 2021).

Ivan Romanovich used X-rays for imaging the frogs and the insects in 1896, weeks after Rontgen's discovery, and concluded that the rays have effects on life function. James Green used X-rays to examine delicate specimens about the same period (Tafti, and Byerly 2021). Pului's discharge tube produced the first U.S. medical X-ray. Frank Austin investigated all the discharge tubes. Pului added an oblique "target" of mica to the tube to retain fluorescent samples. Gilman Frost and Edwin Frost have exposed Eddie fractured wrist to X-rays and took the images' data (Akram, S. 2021).

Rontgen's early tests are X-rays on a luminous screen and coated with barium platinocyanide. Enrico Salvioni and McGie produced live imaging systems on 1896. Thomas Edison began his study immediately after Rontgen's discovery and found that calcium tungstate fluoresces best when exposed to X-rays. In 1896, he invented the "Vitascope. Edison stopped researching X-rays in 1903 before one of his glassblowers died. Dally examined X-ray inside the tubes with his hands; the cancer is occur after several weeks (Chen, H et, al. 2021).

William McKinley was assassinated in 1901. One bullet grazed his sternum, while another was lost in his belly. A anxious McKinley assistant sent word to Thomas Edison to send an X-ray machine to Buffalo. The gunshot wasn't fatal, but gangrene spread along the bullet's route, and McKinley died of septic shock six days later (Sy E. et, al. 2021)

4-Hazards discovered:

After X-rays were discovered in 1895, scientists, doctors, and innovators experimented with them widely, resulting in burns, hair loss, and worse. Professor John Daniel of Vanderbilt University and Dr. William Lofland Dudley reported hair loss in 1896. Daniel discovered a 5 cm (2 in) bald area 21

days after taking an hour-long X-ray of Dudley's skull (Pace, et, al. 2013) (Meo SA, et, al. 2006).

Dr. HD. Hawks, a Columbia College graduate, sustained hand and chest burns in 1896. Electrical Review publicized it, leading to numerous more instances of X-ray difficulties. Elihu reported burns due to exposure to X-ray. Elihu exposed his finger to an X-ray tube and experienced discomfort, swelling, and blistering. UV radiation and (according to Tesla) ozone were also implicated. Many doctors said X-rays had no effects. Elizabeth died due to continuous and long-time x-ray in San Francisco (Wall et, al. 2006) (Lindell, 1968).

By 1904, Hall-Edwards' cancer (then named X-ray dermatitis) had progressed enough for him to publish and speak on X-ray hazards. His left arm was severed at the elbow, and after that, four fingers. 1926 cancer death. Birmingham University keeps his left hand (Kim D., 2016) (Demir, & Akkas, 2019).

4- 20th century and beyond:

Ruhmkorff coil and Crookes tube X-ray systems are developed in the early 20th century. The tube's high voltage side had diagnostic spark gaps. Spark gap sensed polarity and measured voltage by spark length. Widening the spark gap tested the tube's hardness. The operator reduced coil spacing till sparks emerged. A soft (low vacuum) 6.4 cm (2.5 in) spark gap tube is appropriate for arms. 5-inch spark means shoulders and knees. 7- to 9-inch sparks suggest a larger vacuum for imaging larger abdomens. The spark gap had to be extended until the sparking ceased to run the tube for imaging. Hand takes 30 seconds, thorax two. Fluorescent salt on plates reduces exposure times (Frane et al., 2021) (Herzog and rieger, 2004).

Unreliable crooked tubes. A current cannot flow in a totally evacuated tube, hence they must include a tiny amount of gas (usually air). The X-rays led the glass to absorb the gas, leading the tube to produce "harder" X-rays until it ceased working. Larger, more frequently used tubes with softeners. These were generally little side tubes containing mica, a material that retains air (Naqvi, S., et, al. 2019).

John Ambrose Fleming created the vacuum tube in 1904. This employed a heated cathode to create a vacuum current. By 1920, heated-cathode X-ray tubes, termed "Coolidge tubes," had totally supplanted cold cathode tubes (Martin, 2007).

In 1906, Charles Barkla discovered that gases scatter X-rays, and each component has a unique spectra. In 1917, Nobel Prize for this discovery. Von Laue, Knipping, and Friedrich discovered X-ray refraction in 1912. William and Peter began X-ray crystallography with Paul. Henry Moseley performed crystallographic tests with X-rays from various metals and produced Moseley's law (Kemerink M, et al. 2011) (Regulla and Eder, 2005).

The new X-ray tubes can rotate for all directions to allowing for better heat dissipation (Simoni P. 2018) (Khare, et, al. 2014). Chandra's photograph of Abell 2125 shows merging multimillion-degree gas clouds. In 1908, X-ray dermatitis developed on his left arm, requiring amputation (Hwang SY, et, al. 2018).

Medical Science studied human physiology using film. In 1913, the early X-ray film is included one still picture every 4 seconds. Lewis Gregory invented serial radiography. X-rays were utilized to capture the moving human skeleton in 1918. In 1920, England's Institute of Phonetics employed it to record tongue and dental motions for language studies (Chaparian, & Aghabagheri, 2013).

Marie Curie created radiological automobiles to help WWI troops. The automobiles would enable battlefield doctors to rapidly and precisely operate on injured troops. From the 1920s until the 1950s, shoe retailers marketed X-ray fitting machines. In the 1950s, concerns over frequent or poorly managed usage ended the practice (Huda and Abrahams, 2015) (Stahl, 1960).

Phase-contrast X-ray imaging has good sensitivity to density differences in several tested materials, especially in imaging soft tissues. It was an important technique for imaging the cellular and histological structures. Dentistry is one of the medical specials that use

X-rays on comprehensive imaging for imaging and determining the lesion (Hessenbruch A. 2002) (Roch L, et, al. 2019).

X-ray machine components:

An X-ray machine consists of an X-ray generator and an X-ray detector, as shown in figure (1).

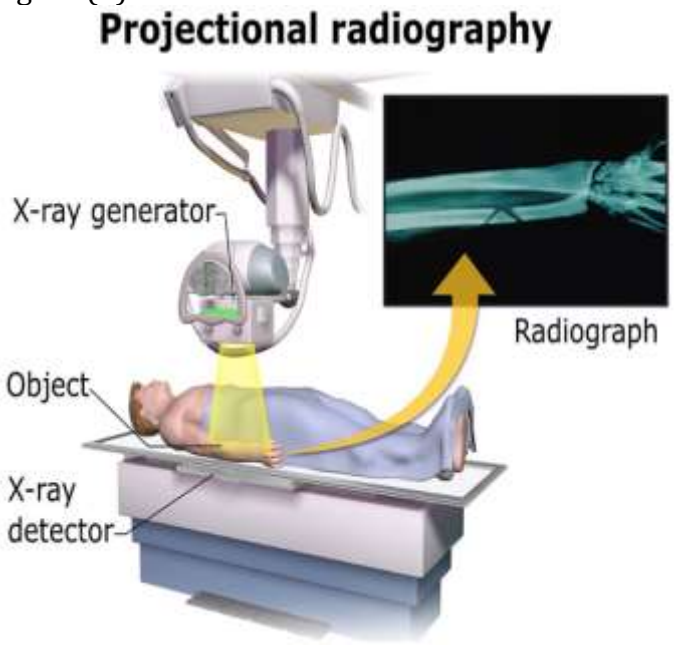

Figure (1): shows the main components of the x-ray machine, wherever, showed consist of two main parts (x-ray generator and x-ray detector) (Stryeski R. 1992).

General Uses of X-ray: The X-ray technology has proven to the scientific community that it is very efficient in medical diagnosis, as this technology has shown its high quality in providing basic medical services, which is an accurate medical diagnosis, especially imaging, and the common uses of this technology are as follows:

1- Decay detection inside and outside of the teeth
2- Bone loss diagnosis
3- Structures changes in the tooth root
4- Gum Abscesses
5- Gum Cysts
6- Mouth Tumors (Hewitt PJ. 1993).

Types of X-rays:

Intraoral X-rays are used inside the mouth and have several types:

A- **Bitewing X-rays:** showed lower and upper of the teeth. The bitewing detected from tooth crown to the supporting bone. Moreover, it can detect decay among the teeth and determine the width of the tooth, as shown in figure (2).

Figure (2): Showed imaging section for tooth by using Bitewing X-rays technique (Bitewing X-Ray).

B- **Periapical X-rays:** showed an entire tooth. This technique detects any changes in the bone and teeth, as shown in figure (3).

Figure (3): Showed imaging section for tooth by using Periapical X-rays technique (Periapical X-Rays)

C- **Occlusal X-rays showed** the development of teeth in the lower or upper jaw, as shown in figure (4).

D-

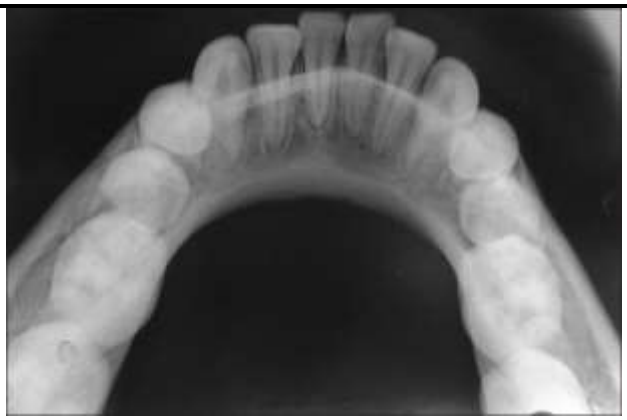

Figure (4): Showed imaging section for tooth by using Occlusal X-rays technique (Subramaniam et, al. 2013)

1- **Extraoral X-rays:** are used for imaging outside the mouth; it has several types:

A- **Panoramic X-rays:** showed the whole mouth (lower and upper). It can detect the emerged position, impacted teeth, and tumor diagnosis, as shown in figure (5).

Figure (5): shows the front panorama imaging section for two jaws by using the Panoramic X-rays technique (What Exactly is a Panoramic X-Ray, 2022)

B- **Tuned Aperture Computed Tomography (TACT):** is a revolutionary technology that converts 2D photos to 3D. TACT-DSR may improve its utility in disease detection (6), as shown in figure (6).

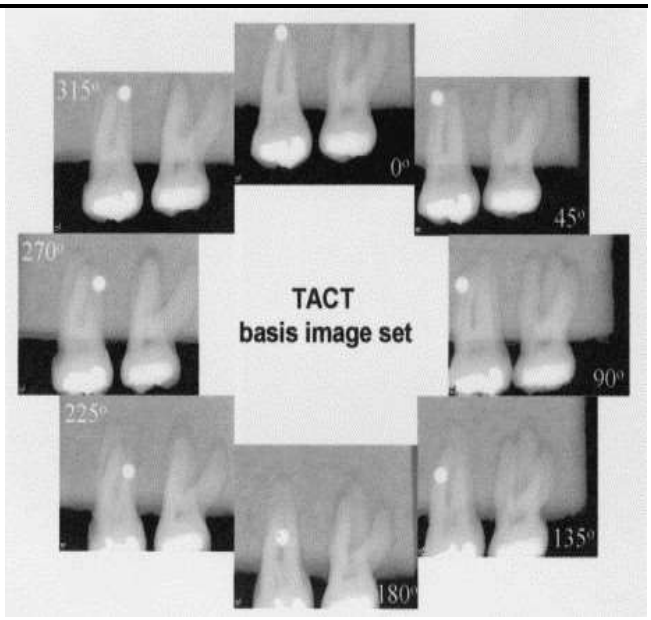

Figure (6): shows the imaging section for teeth by using the Tuned Aperture Computed Tomography (TACT) technique (Daniel J et, al. 2003).

C- **Tomogram X-rays demonstrated the structures and the components that** are difficult to detect because of closely related structures, as shown in figure (7).

Figure (7): shows the imaging section for two jaws by using the Tomograms X-rays technique (Lane, et, al. 2006).

D- **X-ray Cephalometric projections:** showed the whole of the head, wherever it reveals two jaws with the teeth as shown in figure (8).

Figure (8): shows the imaging section for the whole head by X-ray Cephalometric projections technique (CEPHALOMETRIC PROJECTION, 2022)

E- **Sialogram X-ray**: using a dye administrated in the salivary glands. Dentists need this technique to detect salivary gland diseases, as shown in figure (9).

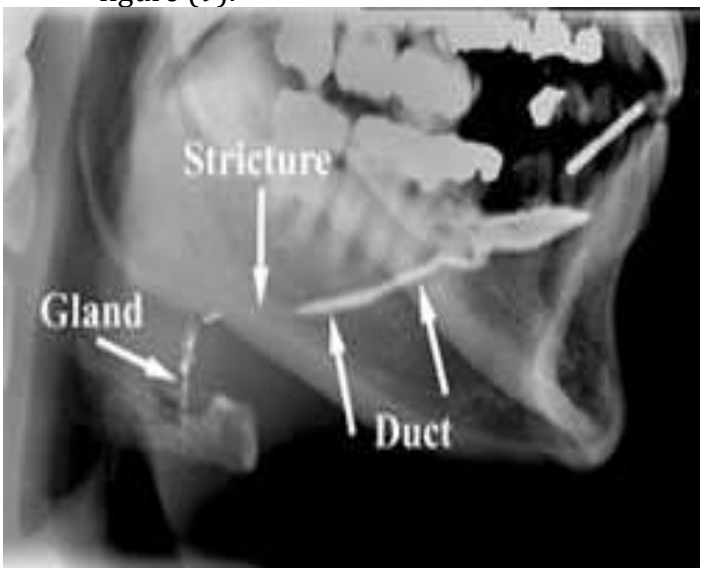

Figure (9): shows the imaging section for salivary glands by using Sialogram technique X-ray (UR Medicine Imaging Specialties, Sialogram, 2022)

F- **Dental computed tomography (CT):** 3-D imaging used to diagnose bone disorders. 1972: Godfrey N. Hounsfield develops the (CT) scanner. CT employs a fan-shaped beam to highlight mesiodistal and buccolingual morphology. The radiographic tube makes up CT scanner (10).

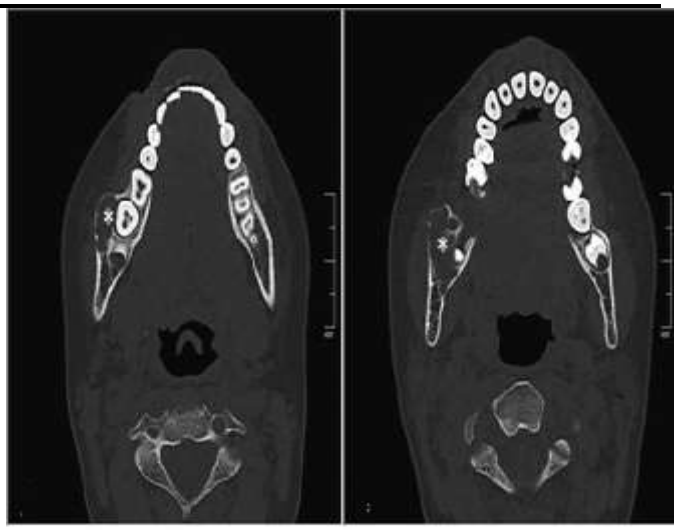

Figure (10): Showed imaging section of upper and lower jaw by using Dental computed tomography (CT) (Eyselbergs, et, al. 2014).

G- **Cone beam CT:** Are formed 3D images for nerves, soft tissue, and bone. This technique can be used to detect gum diseases, teeth roots, and jaws. Cone beam CT produces accurate and high-quality images. The cone beam CT machine can rotate around the head and take the images (higher level of radiation), as shown in figure (11).

Figure (11): Showed front imaging section of two jaws together by using Cone beam CT (CBCT Scan, 2022).

H- **Digital imaging:** is a 2D type of imaging; the images can be viewed on-screen and stored. Digital imaging is used for tooth imaging. This makes it easier for the dentist to see the small changes. The images can be sent

electronically to another dentist for taking opinion, as shown in figure (12).

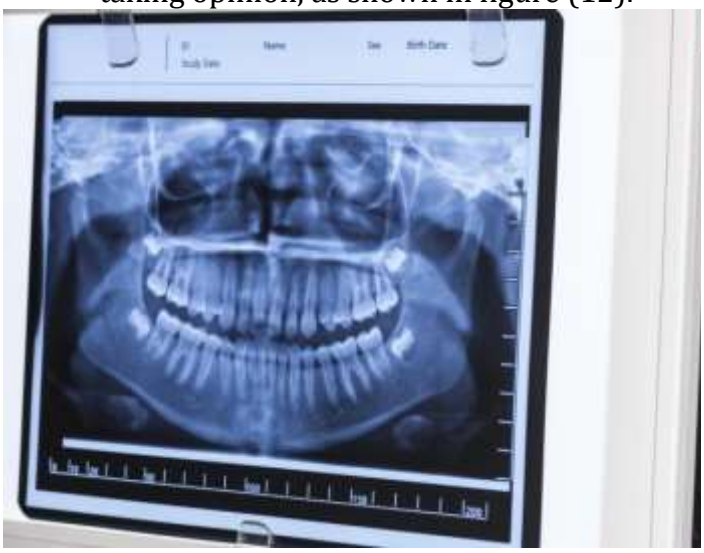

Figure (12) shows the imaging section for two jaws using the digital imaging technique (Digital Imaging, 2022).

I- Magnetic Resonance Imaging (MRI) imaging technique: is an imaging technique 3D of the oral cavity involving teeth and jaws, as shown in figure (13).

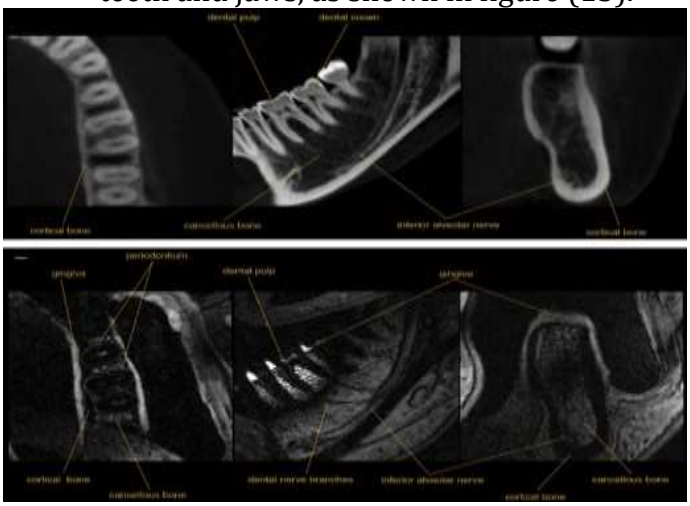

Figure (13): shows imaging for soft tissues surrounded by the tooth by using Magnetic Resonance Imaging (MRI) imaging (Husniye Demirturk et, al. 2018)

X-ray safety:

X-ray emissions are low. X-ray equipment confines radiation to a narrow region; high-speed X-rays (Skinner S. 2013). Lead-lined, full-body aprons and federal legislation requiring accuracy and safety inspections for X-ray equipment reduce radiation exposure (Lakhwani, O. et al. 2019) (Barker D. 1978).

Risks of dental X-rays:

Repeated exposure to X-rays in the mouth area will increase the forming risk of thyroid cancer in the brain and soft tissues around the mouth. More than three thousand cases of thyroid gland tumor are diagnosed yearly in Brittan; furthermore, there has been an increase in thyroid cancer in many countries during the last thirty years (Vanzant and Mukhdomi, 2022).

Greater thyroid malignancies are "probably attributable to increased monitoring, screening, and overdiagnosis, but additional reasons require exploration." Dental X-rays will disclose the thyroid gland which covers the brain and spinal cord. Both organs are radiosensitive when young. Low-dose dental radiography is commonly neglected as a concern to these organs. The study's synthesis suggests future studies using dental X-rays (Han MA, Kim JH. 2018).

Conclusion:

Recent Medical Imaging Technologies Have Used In Tooth Diseases Diagnostics For Treatment Purposes. The Newer Radiographic Techniques Help Detect Dental Pathologies For Reduce Morbidity And Mortality And Improve The Quality Of Life. The Common Technologies reviewed in our work are included X-Ray technologies such as Computed Tomography (Ct) Scanner, Tuned Aperture Computed Tomography (Tact), Cone Beam Computed Tomography (Cone).

References:

1. Akram S, Chowdhury YS. (2021). Radiation Exposure of Medical Imaging. Available from: https://www.ncbi.nlm.nih.gov/books/NBK565909/
2. Babic RR, Stankovic Babic G, Babic SR, Babic NR (2016). 120 YEARS SINCE THE DISCOVERY OF X-RAYS. Med Pregl.;69(9-10):323-330. doi: 10.2298/mpns1610323b. PMID: 29693857.
3. Barker D. (1978). Protection and safety in the X-ray department. Radiography. ;44(518):45-9. PMID: 625547.

4. Berger M, Yang Q, Maier A (2018). X-ray Imaging. In: Maier A, Steidl S, Christlein V, et al., editors. Medical Imaging Systems: An Introductory Guide. Springer; Chapter 7. https://www.ncbi.nlm.nih.gov/books/NBK546155/ doi: 10.1007/978-3-319-96520-8_7
5. Berger M, Yang Q, Maier A. X-ray Imaging. 2018 Aug 3. In: Maier A, Steidl S, Christlein V, et al., editors. Medical Imaging Systems: An Introductory Guide, Springer; Chapter 7. Available from: https://www.ncbi.nlm.nih.gov/books/NBK546155/ doi: 10.1007/978-3-319-96520-8_7
6. Bitewing X-Ray, viewed at 19-5-2022, website: https://lowcountryfamilydentistry.com/dental-services/general-dentistry/dental-x-rays/bitewing-x-ray.
7. CBCT Scan, 2022, website: https://highcliffedentalcare.co.uk/innovations/cbct-scan/
8. CEPHALOMETRIC PROJECTION, viewed at 19-5-2022, website: https://www.orbitimaging.com/imaging-services/digital-x-ray/cephalometric-projections-2/
9. Chaparian, A., & Aghabagheri, M. (2013). Fetal radiation doses and subsequent risks from X-ray examinations: Should we be concerned?. Iranian journal of reproductive medicine, 11(11), 899–904.
10. Chen, H., Rogalski, M. M., & Anker, J. N. (2012). Advances in functional X-ray imaging techniques and contrast agents. Physical chemistry chemical physics : PCCP, 14(39), 13469–13486. https://doi.org/10.1039/c2cp41858d
11. Crookes, William (1878). On the illumination of lines of molecular pressure, and the trajectory of molecules. Phil. Trans. 170: 135–164. doi:10.1098/rstl.1879.0065.
12. Daniel J Barton, Stephen J Clark, Paul D Eleazer, James P Scheetz, Allan G Farman, (2003). Tuned-aperture computed tomography versus parallax analog and digital radiographic images in detecting second mesiobuccal canals in maxillary first molars, ENDONTICS| VOLUME 96, ISSUE 2, P223-228, AUGUST 01, 2003 DOI: https://doi.org/10.1016/S1079-2104(03)00061-1
13. Demir, M. C., & Akkas, M. (2019). Awareness of Risks Associated with the Use of Plain X-Ray, Computed Tomography, and Magnetic Resonance Imaging Among Emergency Physicians and Comparison with that of Other Physicians: A Survey from Turkey. Medical science monitor : international medical journal of experimental and clinical research, 25, 6587–6597. https://doi.org/10.12659/MSM.918381
14. Digital Imaging, 2022, viewed at 2022, website: https://cosmeticdentistryoflascolinas.com/our-procedures/dental-technology/digital-imaging/
15. Eisenberg R, Amorosa JK. The discoverer of x-rays: Wilhelm Conrad Roentgen. N J Med. 1995 Nov;92(11):723-4. PMID: 8570103.
16. Eyselbergs, M & Vanhoenacker, Filip & Hintjens, J & Dom, Marie & Devriendt, K & Van Dijck, Herwig. (2014). Unilateral giant cell lesion of the jaw in Noonan syndrome. JBR-BTR (Journal Belge de Radiologie - Belgisch Tijdschrift voor Radiologi). 97. 90-3. 10.5334/jbr-btr.20.
17. Frane N, Bitterman A. (2021). Radiation Safety and Protection. Available from: https://www.ncbi.nlm.nih.gov/books/NBK557499/
18. Frankel R. I. (1996). Centennial of Röntgen's discovery of x-rays. The Western journal of medicine, 164(6), 497–501.
19. Han MA, Kim JH. (2018). Diagnostic X-Ray Exposure and Thyroid Cancer Risk: Systematic Review and Meta-Analysis. Thyroid. ;28(2):220-228. doi: 10.1089/thy.2017.0159. Epub 2017 Dec 22. PMID: 29160170.

20. Herzog P, Rieger CT. (2004). Risk of cancer from diagnostic X-rays. Lancet. 31;363(9406):340-1. doi: 10.1016/S0140-6736(04)15470-6. PMID: 15070557.
21. Hessenbruch A. (2002). A brief history of x-rays. Endeavour. 2002 Dec;26(4):137-41. doi: 10.1016/s0160-9327(02)01465-5. PMID: 12535920.
22. Hewitt PJ. (1993). Occupational health problems in processing of X-ray photographic films. Ann Occup Hyg. ;37(3):287-95. doi: 10.1093/annhyg/37.3.287. PMID: 8346876.
23. Howell J. D. (2016). EARLY CLINICAL USE OF THE X-RAY. Transactions of the American Clinical and Climatological Association, 127, 341–349.
24. Huda W, Abrahams RB. (2015). X-ray-based medical imaging and resolution. AJR Am J Roentgenol. ;204(4):W393-7. doi: 10.2214/AJR.14.13126. PMID: 25794088.
25. Husniye Demirturk Kocasarac, Hassem Geha, Laurence R. Gaalaas, Donald R. Nixdorf, (2018). MRI for Dental Applications, REVIEW ARTICLE| VOLUME 62, ISSUE 3, P467-480, https://doi.org/10.1016/j.cden.2018.03.006
26. Hwang SY, Choi ES, Kim YS, Gim BE, Ha M, Kim HY. (2018). Health effects from exposure to dental diagnostic X-ray. Environ Health Toxicol.;33(4):e2018017. doi: 10.5620/eht.e2018017. Epub 2018 Nov 21. PMID: 30661338; PMCID: PMC6341170.
27. Kemerink M, Dierichs TJ, Dierichs J, Huynen HJ, Wildberger JE, van Engelshoven JM, Kemerink GJ. (2011). Characteristics of a first-generation x-ray system. Radiology. ;259(2):534-9. doi: 10.1148/radiol.11101899.
28. Khare, P., Nair, P., Khare, A., Singh, V., & Chatterjee, R. (2014). The road to radiation protection: a rocky path. Journal of clinical and diagnostic research : JCDR, 8(12), ZE01–ZE4. https://doi.org/10.7860/JCDR/2014/5832.5223
29. Kim D. I. (2016). PREFACE: How Dangerous Are X-ray Studies That We Undertake Every Day?. Journal of Korean medical science, 31 Suppl 1(Suppl 1), S2–S3. https://doi.org/10.3346/jkms.2016.31.S1.S2
30. Lakhwani, O. P., Dalal, V., Jindal, M., & Nagala, A. (2019). Radiation protection and standardization. Journal of clinical orthopaedics and trauma, 10(4), 738–743. https://doi.org/10.1016/j.jcot.2018.08.010
31. Lane, John I.; Lindell, E. Paul; Witte, Robert J.; DeLone, David R.; Driscoll, Colin L. W. (2006). Middle and Inner Ear: Improved Depiction with Multiplanar Reconstruction of Volumetric CT Data". RadioGraphics. 26 (1): 115–124. doi:10.1148/rg.261055703. PMID 16418247.
32. Lindell B. (1968). Occupational hazards in x-ray analytical work. Health Phys. ;15(6):481-6. doi: 10.1097/00004032-196812000-00001. PMID: 5688314.
33. Martin C. (2007). The importance of radiation quality for optimisation in radiology. Biomedical imaging and intervention journal, 3(2), e38. https://doi.org/10.2349/biij.3.2.e38
34. Meo SA, Al Drees AM, Zadi SZ, Al Damgh S, Al-Tuwaijri AS. (2006). Hazards of X-ray radiation on the quantitative and phagocytic functions of polymorphonuclear neutrophils in X-ray technicians. J Occup Health. 2006 Mar;48(2):88-92. doi: 10.1539/joh.48.88. PMID: 16612036.
35. Mosby's Dental Dictionary, (2008). 2nd ed., Elsevier, Inc. cited in "X-ray tube". The Free Dictionary. Farlex, Inc. 2008. Retrieved 2008-11-11.
36. Mould RF. (1995). review: Röntgen and the discovery of X-rays. Br J Radiol. 1995 Nov;68(815):1145-76. doi:

10.1259/0007-1285-68-815-1145. PMID: 8542220.
37. Mowery ML, Singh V. (2012). X-ray Production Technical Evaluation. Available from: https://www.ncbi.nlm.nih.gov/books/NBK564332/
38. Nakashima J, Duong H. (2021). Radiology, Image Production and Evaluation. Available from: https://www.ncbi.nlm.nih.gov/books/NBK553145/
39. Naqvi, S., Batool, S. W., Rizvi, S., & Farhan, K. (2019). Awareness of Hazards of X-Ray Imaging and Perception Regarding Necessary Safety Measures to be Taken During X-Ray Imaging Procedures Among Patients in Public Sector Tertiary Hospitals of Karachi, Pakistan. Cureus, 11(5), e4756. https://doi.org/10.7759/cureus.4756
40. Pace, N., Ricci, L., & Negrini, S. (2013). A comparison approach to explain risks related to X-ray imaging for scoliosis, 2012 SOSORT award winner. Scoliosis, 8(1), 11. https://doi.org/10.1186/1748-7161-8-11
41. Pallardy G. Röentgen (1995). découverte des rayons X-rays [Roentgen and the discovery of X-rays]. J Radiol. ;76(11):1033-6. French. PMID: 8594183.
42. Periapical X-Rays, viewed at 19-5-2022, website: https://nickdental.com/services/general-dentistry/periapical-x-rays/
43. Regulla DF, Eder H. (2005). Patient exposure in medical X-ray imaging in Europe. Radiat Prot Dosimetry. ;114(1-3):11-25. doi: 10.1093/rpd/nch538. PMID: 15933076.
44. Roch L, Bianchi C, Castioni J, Beigelman-Aubry C. (2019). Analyse de la radiographie thoracique, une systématique à rappeler [Analysis of chest x-rays, a systematic to remember]. Rev Med Suisse. 20;15(672):2137-2144. French. PMID: 31746570.
45. Sansare, K., Khanna, V., & Karjodkar, F. (2011). Early victims of X-rays: a tribute and current perception. Dento maxillo facial radiology, 40(2), 123–125. https://doi.org/10.1259/dmfr/73488299
46. Simoni P. (2018). Optimisation of X-Rays Imaging Techniques for the Assessment of Joint Space. Journal of the Belgian Society of Radiology, 102(1), 23. https://doi.org/10.5334/jbsr.1447
47. Skinner S. (2013). Radiation safety. Aust Fam Physician. ; 42 (6):387-9. PMID: 23781545.
48. STAHL W. R. (1960). X-ray protection techniques. Public health reports (Washington, D.C. : 1896), 75(6), 513–526.
49. Stryeski R. (1992). X-ray hazards in the OR. Am J Nurs.;92(10):24. PMID: 1466381.
50. Subramaniam, Priya & Kumar, Krishna & Ramakrishna, T & Bhadranna, Abhishek. (2013). Bone regeneration with plasma-rich-protein following enucleation of traumatic bone cyst. European journal of dentistry. 7. 377-81. 10.4103/1305-7456.115427.
51. Sy E, Samboju V, Mukhdomi T. (2021). X-ray Image Production Procedures. Available from: https://www.ncbi.nlm.nih.gov/books/NBK564352/
52. Tafti A, Byerly DW. (2021). X-ray Image Acquisition. Available from: https://www.ncbi.nlm.nih.gov/books/NBK563236/
53. Tafti D, Maani CV. X-ray Production. [Updated 2021 Aug 3]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK537046/
54. Tubiana M. Wilhelm Conrad Röntgen (1996). Wilhelm Conrad Röntgen and the discovery of X-rays. Bull Acad Natl Med.180(1):97-108. French. PMID: 8696882.

55. Tubiana M. Wilhelm Conrad Röntgen (1996). Wilhelm Conrad Röntgen and the discovery of X-rays. Bull Acad Natl Med.;180(1):97-108. French. PMID: 8696882.
56. UR Medicine Imaging Specialties, Sialogram, viewed at 2022, website: https://www.urmc.rochester.edu/imaging/specialties/procedures/sialogram.aspx
57. Vanzant D, Mukhdomi J. (2022). Safety of Fluoroscopy in Patient, Operator, and Technician. Available from: https://www.ncbi.nlm.nih.gov/books/NBK570567/
58. Wall BF, Kendall GM, Edwards AA, Bouffler S, Muirhead CR, Meara JR. (2006). What are the risks from medical X-rays and other low dose radiation? Br J Radiol. ;79(940):285-94. doi: 10.1259/bjr/55733882. PMID: 16585719.
59. What Exactly is a Panoramic X-Ray? Viewed at 19-5-2022, website: https://www.minthilldentistry.com/panoramic-x-ray