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College of Dentistry

Advance in Pediatric Radiographic Techniques

A Project Submitted to

The College of Dentistry, University of Baghdad, Department of Pedodontics & Preventive Dentistry in Partial Fulfillment for the Requirement to Award the Degree of Bachelor of Dentistry

By

Ther Sadiq Hammad

Supervised by:

Lect. Heba N. Yassin

B.D.S, M.Sc.(pediatric dentistry)

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قال الامام علي (عليه السلام) :

وكم لله من لطفٍ خفيٍّ
يَدِقّ خَفَاهُ عَنْ فَهْمِ الذَّكِيِّ
وَكَمْ يُسْرٍ أَتَى مِنْ بَعْدِ عُسْرٍ
فَفَرَّجَ كُرْبَةَ القَلْبِ الشَّجِيِّ
وكم أمرٍ تساءُ به صباحاً
وَتَأْتِيكَ المَسَرَّةُ بالعَشِيِّ
إذا ضاقت بك الأحوال يوماً
فَثِقْ بالواحدِ الفَرْدِ العَلِيِّ

Certification of the Supervisor

I certify that this project entitled " Advance in Pediatric Radiographic Techniques " was prepared by the fifth-year student " Ther Sadiq Hammad" under my supervision at the College of Dentistry/University of Baghdad in partial fulfillment of the graduation requirements for the Bachelor Degree in Dentistry.

Lect. : Heba N. yassin

DEDICATION

I dedicate this work to my father who never stop praying for me every day

To my mother and all her effort and hard work through all these years since I was a child.

To my brother and sister who stand by my side and support me

To my friends and my second family that make these five year best years I had

To everyone help me through these tough years and put smile on my face

Thank you all for being in my life

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Abbreviation	Meaning
ALARA	As low as reasonably achievable
CBCT	Cone-beam computed tomography
CBI	Cone-beam imaging
CBVT	Cone-beam volumetric tomography
CCD	Charged-coupled device
CMOS	Complementary metal oxide semiconductor
CT	Computed tomography
DCT	Dental computed tomography
DVT	Dental volumetric tomography
MCT	Medical computed tomography
MRI	Magnetic resonance imaging
MRMI	Magnetic resonance microimaging
PSP	Photo-stimuable phosphor-coated plate
TACT	Tuned aperture computed tomography

Introduction

Accurate diagnostic information forms the foundation of any treatment plan. This information comes from several sources: the patient history and physical examination, the clinical and radiographic examination, and other diagnostic sources. The dentist must critically analyze the information before recommending treatment options to the patient **(Stephen and Samuel , 2011).**

Radiographic examination in children is essential for diagnosis, treatment planning, and monitoring of several changes and pathologies related to teeth and jaws. However, since no exposure to X-rays can be considered completely free of risk, a radiographic examination should be performed only when it is likely that it will benefit the patient; for example, to improve the diagnosis and/or result in a more appropriate treatment considered more beneficial to the patient **(Hanne and Ivar, 2001).**

Digital radiography systems enable radiographers to reduce the radiation dose to patients while maintaining optimized image quality. However, concerns still exist about pediatric patients who may be exposed to an increased level of radiation dose which is not needed for clinical practice and may concern the parents **(Haney *et al*., 2019).**

Parents' resistance to the use of radiographs may be reduced by apprising parents of the need for radiographs to derive an accurate diagnosis, as well as educating them of the newer concepts and techniques for acquiring radiographs. Parents should also be informed that radiographs enable the dentist to detect the start of visually undetectable cavities between teeth, infections of the teeth, gums and bones, the shape of unerupted permanent teeth, missing permanent teeth, future orthodontic problems **(Jayaraman *et al*., 2021).**

Aims of the study:

1- To demonstrate about the conventional and advanced radiographic tech. and the difference between them.

2- How to manage the child for radiographic exposure.

Chapter One:

Review of literature

1.1 Definition

Dental radiography is a useful diagnostic aid in oral examination of children. In many cases the radiographic findings add important information, The major reasons for taking radiographs of teeth and supporting tissue in pediatric dentistry are: 1) detection of caries; 2) dental injuries; 3) disturbances in tooth development; 4) examination of pathological conditions other than caries **(Espelid, 2003).**

1.2 History:

It has been more than 120 years since the discovery of x-rays. Radiation can be best appreciated and understood by looking at the history of the development of the utilization of x-rays since the initial discovery, and learn about the hardships and injuries sustained by the early x-ray pioneers and how far science has come in reducing radiation exposure to patients and practitioners alike while improving diagnostic capabilities **(Jeanine, 2018).**

While Wilhelm Conrad Röntgen (1895) experimented and searched for the invisible light rays turned on a low-pressure Crooke's tube, completely enclosed in heavy black paper and applied power to the electrodes with a Ruhmkorff induction coil . Immediately to his surprise, a fluorescent screen, covered with barium platinocyanide standing on a table, some distance away, started to glow brightly. When he interposed objects between the tube and the screen, shadows were cast on the screen. Tracing back the rays to their source, he revealed that the rays were produced whenever and wherever the cathode rays encountered matter. While investigating Roentgen accidentally placed his hand between the tube and the fluorescent screen only to be surprised by seeing a faint but startling image of the bones within his hand on the screen, the property of fluorescence and penetration. He subsequently demonstrated that such images of the body could be recorded on photographic plates **(Freny, 2008).**

1.3 Techniques of x-ray:

Dentists in general practice commonly use several types of radiographs to examine the patient for signs of pathologic conditions, caries, periodontal or periapical problems, and remnants of missing teeth, and to examine the quality of existing dental restorations. The primary intraoral exposures are periapical, interproximal (or bitewing), and occlusal projections. The dentist can select from among several types of extraoral radiographs, with the panoramic being most frequently used for examining areas not readily visualized with intraoral films **(Stephen and Samuel, 2011).**

1.3.1- Conventional Intraoral radiographic techniques:

1.3.1.1 periapical view:

should show all a particular tooth and the surrounding bone. Useful for imaging the teeth, detecting caries, and documenting signs of periodontal and periapical disease, these radiographs are limited by their size and the need to be placed in the mouth. A complete mouth survey of a completely dentate patient usually consists of 16 to 20 periapical radiographs along with four interproximal radiographs **(Stephen and Samuel, 2011).**

The rule of thumb is that the size of the image receptor should fit the "size of the problem" in the best possible way to minimize the number of exposures. However, in children especially, this rule should be applied with great caution since the discomfort connected with a large receptor usually will have a negative affect on a child's cooperation and acceptance of the radiographic procedure, and in the end result in an inferior radiographic quality. Periapical radiographs can be performed by a paralleling or a bisecting-angle technique **(Hanne and Ivar, 2001)**:

A- Parallel technique:

The basic principles of the paralleling technique for intraoral periapical projections are that the receptor and the long axis of the tooth being radiographed must be parallel to each other, and the central ray of the x-ray beam must be directed perpendicular to both **(Jeanine, 2018).**

The paralleling technique is preferable because it is easier to perform and gives a more reliable image of the tooth and surrounding alveolar bone (minimal distortion), (Fig 1.1) **(Hanne and Ivar, 2001).**

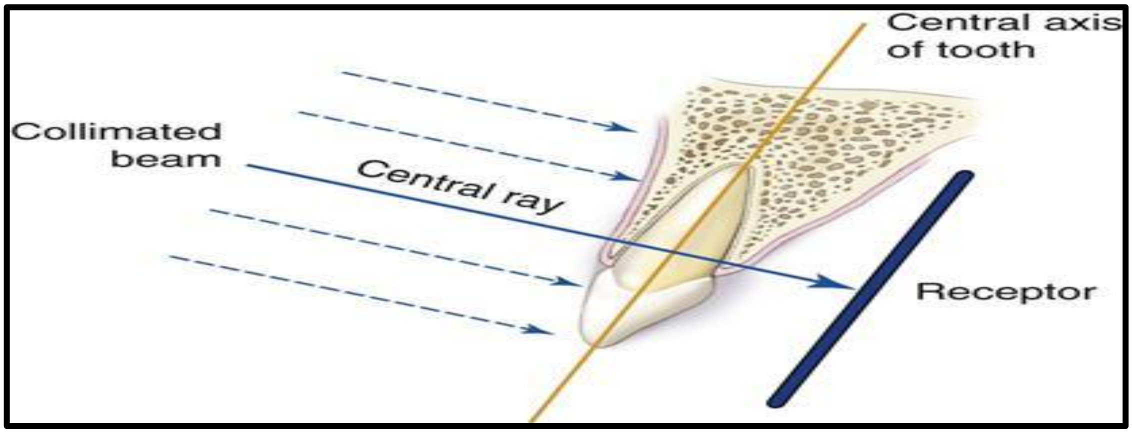

Figure 1.1 : Parallel technique **(Ruben, 2020)**

In children aged 0–3 years it is in general difficult to obtain periapical radiographs. When necessary due to trauma to the upper front teeth, for example, a dental size 2 image receptor fixed by a needle holder can be placed parallel to the occlusal plane and the X-ray beam angled perpendicularly to the imaginary line bisecting the angle between the surface of the receptor and the long axis of the front teeth in two identical halves. The use of a needle holder makes it easier for a parent to keep the receptor in the correct position during exposure (fig1.2) **(Hanne and Ivar, 2001).**

Figure 1.2 : The image receptor is placed in a needle holder parallel to the occlusal plane (**Hanne and Ivar, 2001).**

B- <u>Bisecting technique:</u>

In this technique, the receptor is held as close to the tooth as possible without bending the receptor. The long axis of the receptor therefore is not parallel to the long axis of the tooth. An imaginary bisecting line is drawn to bisect the angle formed by the long axis of the tooth and the plane of the receptor. The central ray of the x-ray beam is directed perpendicular to this bisecting line (fig 1.3) **(Jeanine, 2018).**

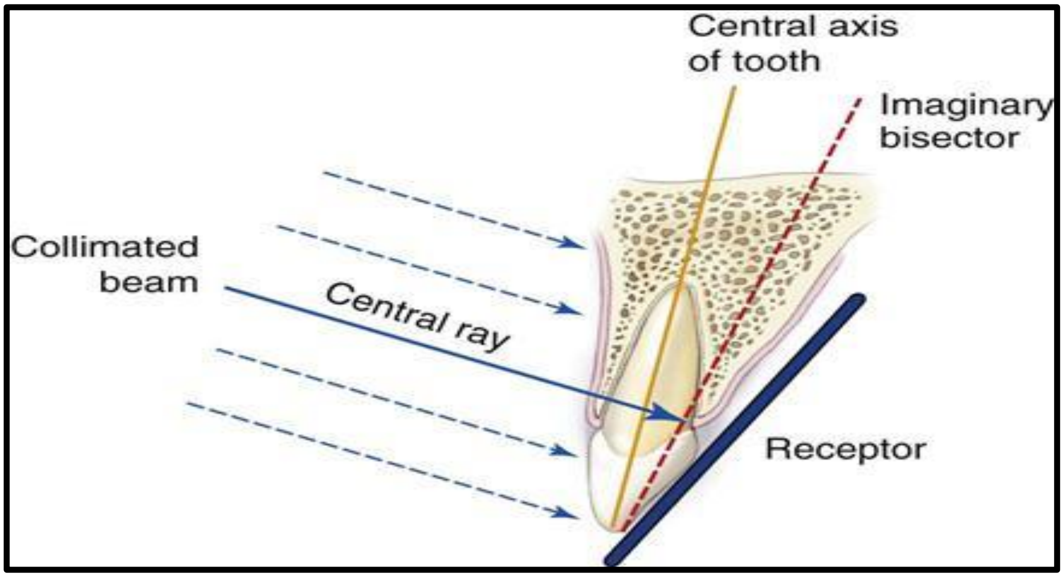

Figure 1.3 : Bisecting angle technique **(Ruben, 2020)**

<u>1.3.1.2- Bitewing radiographs:</u>

The bitewing projection is very useful for determining the presence and extent of caries in approximal and occlusal surfaces. It also gives information about the status of restorations (overhang, distance to the pulp, secondary caries) and the level of the marginal alveolar bone. The use of a wing-shaped device device is mandatory to place the image receptor correctly in relation to the teeth. A holder with an extraoral beam-aiming device is usually best if it can be tolerated by the patient **(Kaakko *et al.*, 1999).**

<u>1.3.1.3- Occlusal radiograph:</u>

Occlusal radiographs are placed over the teeth in the occlusal plane. In adults, their use is limited to visualizing palatal lesions and searching for impacted or supernumerary teeth. The film can also be helpful in documenting expansion of bone in the mandible or salivary stones in the ducts of the submandibular gland **(Stephen and Samuel, 2011).**

Extraoral Radiographs:

<u>1.3.1.4- Panoramic radiography:</u>

Panoramic radiography has been one of the most common imaging methods among dentists. This technique provides facial structures that includes both maxillary and mandibular teeth and their supporting structures to be imaged on a single film with a single exposure. It is simple and could be applied in cases when mouth opening is not enough to place an intraoral receptor, and an extreme gag reflex (fig 1.4) **(Alan, 2009).**

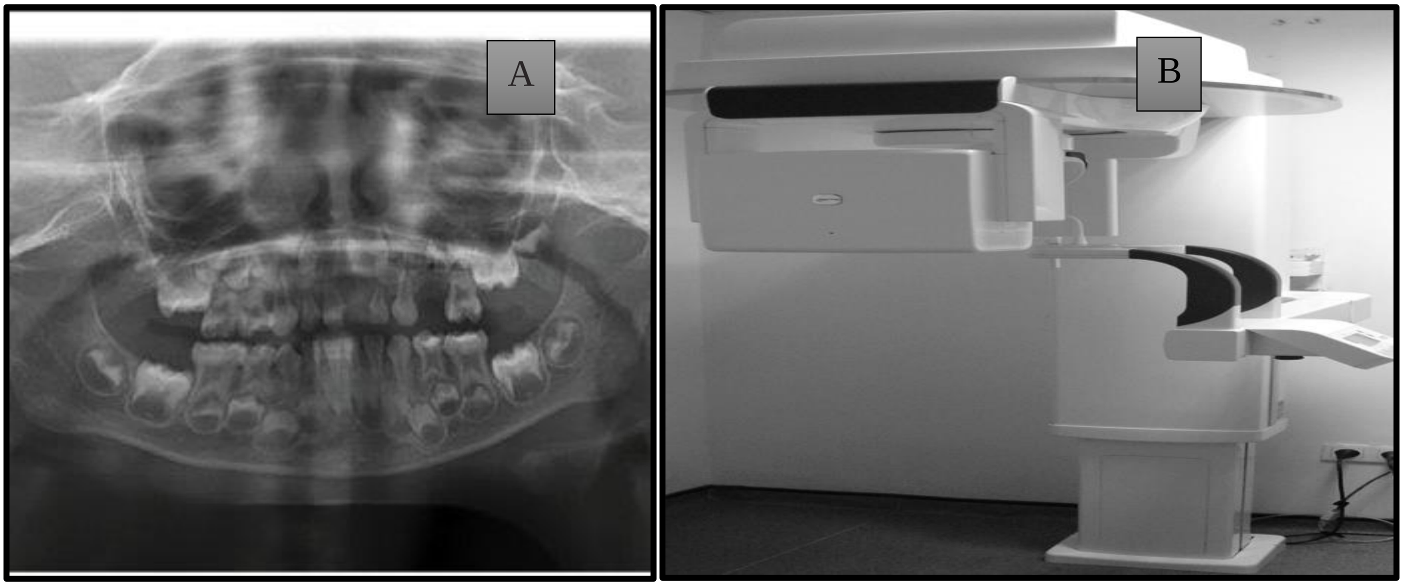

Figure 1.4: (A) An example of digital panoramic image (B) A digital panoramic unit **(Zühre and Ilkay, 2015).**

<u>1.3.1.5- Cephalometric radiography:</u>

Cephalometric radiography is a technique providing the image of the head in lateral and posteroanterior view, it is frequently used by orthodontists as a treatment planning tool. Some manufacturers made special digital units with a cephalometric attachment to allow exposure of standardized skull views. Digital cephalometric images make it possible to perform cephalometric analysis and superimposition on chair side computer, enhancement of the images for further aid in diagnosis, ease of storage and data transmission (fig 1.5) **(Brennan, 2002).**

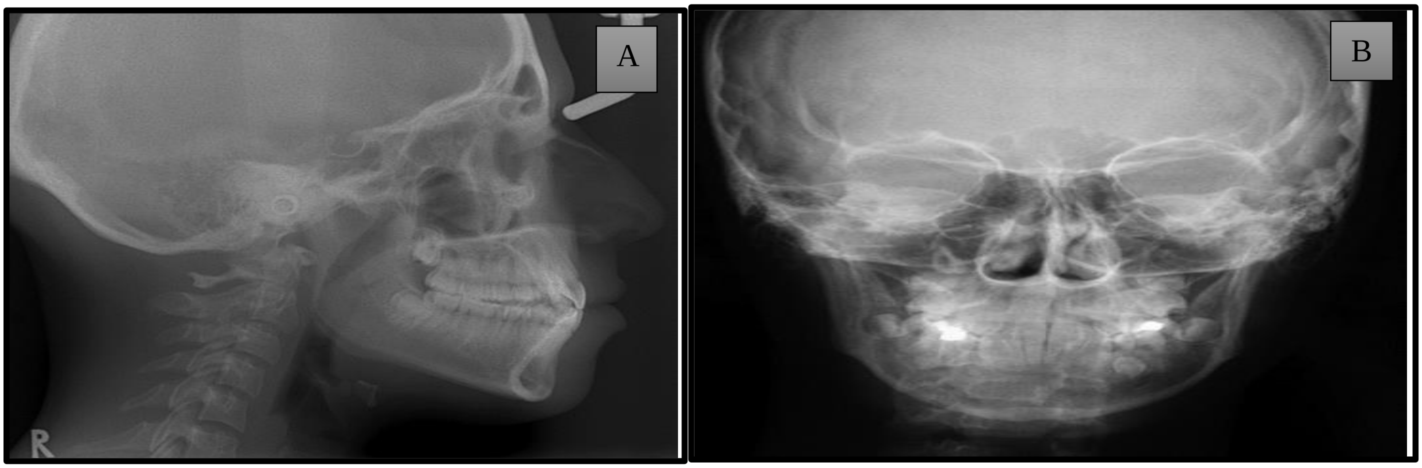

Figure 1.5:(A) lateral cephalometric image (B) Digital posteroanterior (**Zühre and Ilkay, 2015).**

1.4- Advance Radiography

1.4.1-Digital intraoral imaging:

Digital intraoral imaging could be achieved by periapical, bitewing and occlusal projections. Although two-dimensional intraoral digital imaging is useful and has several advantages, the superimposition of unwanted structures is the main problem in capable of decision-making for correct diagnosis and treatment planning. Intraoral digital imaging could be achieved with indirect, semi-direct and direct digital intraoral techniques **(Ernest and sanjay, 2009).**

1.4.1.1-Indirect Digital Intraoral Imaging:

In this method, conventional radiographs (analog images) are transferred to digital medium with the aid of a flat-bed scanner with a transparency adapter, a slide scanner and a digital camera. It is a simple way to obtain a digital image and it is less expensive compared to semi-direct and direct digital systems. This technique was used more commonly at the beginning of digital image acquisition. With the improvement and widespread of other digital techniques, it has lost its popularity **(Wakoh and Kuroyanagi, 2001).**

1.4.1.2-Semi-Direct Digital Intraoral Imaging:

Semi-direct digital intraoral imaging is possible with a system using Photo-Stimulable Phosphor Coated Plates (PSP). These plates are placed in the mouth of the patient and exposed to x-rays. After exposure, they are scanned with a special laser scanner system and the latent image becomes visible on the computer monitor (fig 1.6) **(Pai and Zimmerman, 2002).**

The latent image is erased by exposing the plates with bright light prior to a new x-ray exposure after the plates are scanned, the plates should not be exposed to light because this will release some of the energy captured by the plate before it is scanned and degrade the quality of the radiographic image. Hence, the plates exposed to x-ray should be kept in subdued light environment prior to scanning **(Molteni, 2003).**

Semi-direct digital imaging is a more comfortable technique for patients compared to direct digital intraoral imaging as the plates are flexible to some extent and the size, shape and thickness are similar to films used in conventional radiography **(Wenzel *et al.*, 2000).**

Figure 1.6 : (A) PSP plates (B) plates scanning system **(Zühre and Ilkay, 2015).**

1.4.1.3-Direct Digital Intraoral Imaging:

Direct digital intraoral images could be achieved with solid state sensors. There are two types of solid state-sensors: charged-coupled device (CCD) and complementary metal oxide semiconductor (CMOS) **(Ludlow and Mol, 2009).**

CCD sensors: A solid state silicon chip is used to record the image in this technology. Silicon crystals convert absorbed radiation to light and the electrons constitutes the latent image according to the light intensity. This signal is sent to the computer with a cable connecting the sensor and the computer, and the image becomes visible on the screen (fig 1.7) **(Ludlow and Mol, 2009).**

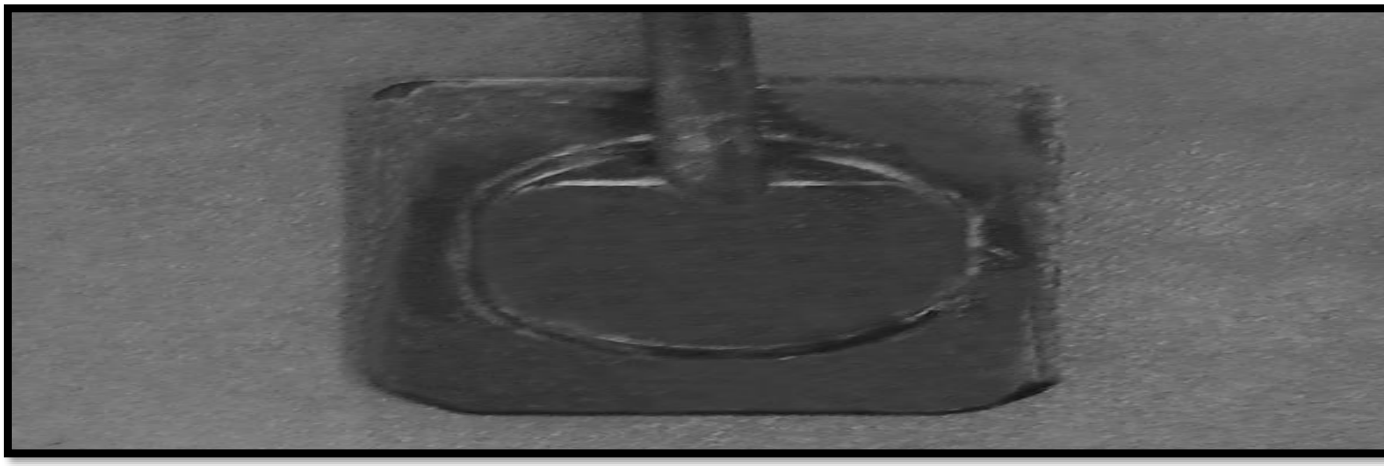

Figure 1.7 : Cabled CCD sensor **(Zühre and Ilkay, 2015).**

CMOS sensors: This technology was adapted to intraoral digital imaging after the CCD sensors were invented. These sensors have a similar working principle with CCD, only the chip design differ in terms of integration of the control circuitry directly into the sensor, CMOS sensors are less expensive than CCD **(Wakoh and Kuroyanagi, 2001).**

1.5-Digital extraoral imaging

The revolution in digital extraoral radiography includes digital panoramic imaging and digital cephalometric imaging. Digital extraoral and panoramic systems have not been widely adopted since their first introduction in the dental market, this was due to their very high costs. Sometime after their invention, relatively cost-effective systems with improved computer settings (computer speed, data storage capacities) have been manufactured and they have been started to be adopted in dental practice **(Farman and Farman, 2005)**.

Three-dimensional imaging gives the opportunity to the practitioner to examine the dento maxillofacial region without superimposition and distortion of the image. Three-dimensional imaging was acquired with conventional tomography and tuned aperture computed tomography techniques in the past years but, with the introduction of cone-beam computed tomography (CBCT) it left its place to this imaging modality **(Frederiksen, 2009).**

1.5.1Cone Beam Computed Tomography

Cone beam computed tomography (CBCT) is a relatively new digital imaging technology. Although, it has been given several names including dental volumetric tomography (DVT), cone beam volumetric tomography (CBVT), dental computed tomography (DCT) and cone beam imaging (CBI), the most preferred name is cone-beam computed tomography (CBCT) **(Scarfe and Farman, 2009).**

This technique has the advance of three-dimensional imaging of the area of interest without superimposition of other structures. Multiplanar and Three-Dimensional images could be achieved with this technique with lower radiation dose and higher spatial resolution relative to computed tomography (CT) providing better visualization of structures with mineralized tissue. Although CBCT images have high spatial resolution, the data from which images are created contains considerable noise caused by scattered radiation. Thus, soft tissue contrast in CBCT images is inferior to that in CT images **(Tyndall *et al.*, 2012).**

The CBCT system works with a flat panel detector and special scanner using collimated x-ray source that produces a cone-or pyramid-shaped beam of x-radiation making a single full or partial circular rotation around the head of the patient. A sequence of discrete planar projection images using a digital detector is produced after exposure. Subsequently, these two-dimensional images are reconstructed into a three-dimensional volume (fig 1.8) **(Scarfe and Farman, 2009).**

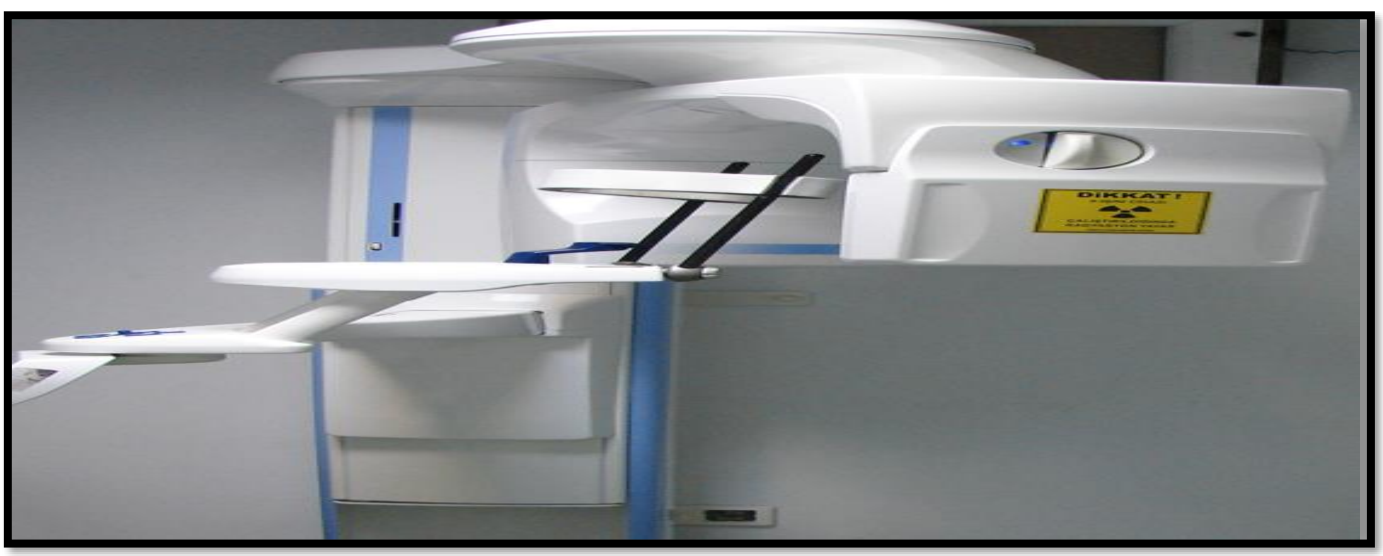

Figure 1.8 : A CBCT unit **(Zühre and Ilkay, 2015).**

1.5.1.1- Applications of CBCT in Dentistry

1- Oral and maxillofacial surgery **(Tyndall and Brooks, 2000).**

2- Orthodontics and pediatric dentistry: It have been suggested that information obtained from a CBCT scan has the potential to improve orthodontic diagnosis and treatment planning in airway analysis before and after orthognathic surgical planning, cleft lip palate, root position and structure and mini screw placement **(Adams *et al.*, 2004).**

3- Endodontics **(Tyndall and Kohltfarber, 2012).**

1.5.2-Ultrasound Imaging

Most people associate ultrasound imaging with pregnancy, but this technique is also excellent for investigation of soft tissues, such as the floor of the mouth, salivary glands, and lymph nodes in the head and neck region. As the technique does not involve ionizing radiation, it can be repeated as many times as necessary, without exposing the patient to any risks (fig 1.9) **(Dean *et al.*, 2009).**

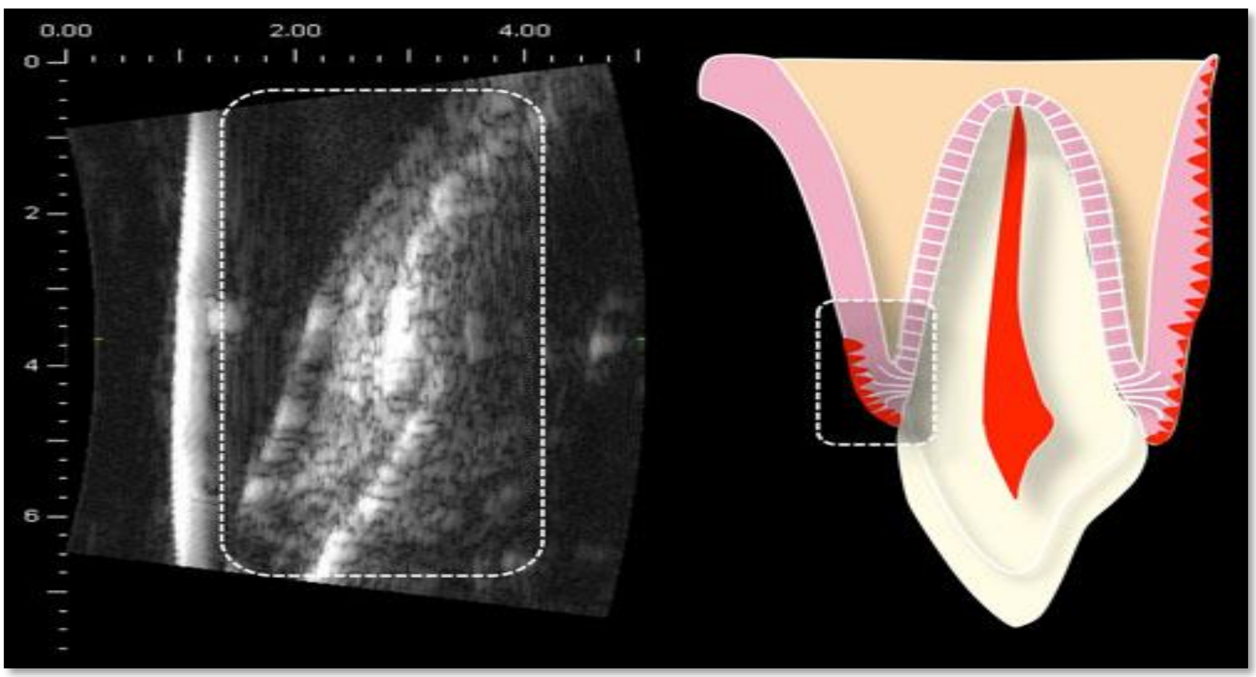

Figure 1.9 : Ultrasound image of a maxillary canine periodontium **(Benjamin and Dominique, 2011).**

1.5.3-Magnetic Resonance Imaging

The Magnetic Resonance Imaging MRI evaluates the hydrogen content of tissues and uses a magnetic field to differentiate among different tissue types. As there are more hydrogen atoms in soft tissues than in cortical bone, this technique is especially useful with soft tissue, The most common dental indication for the use of MRI is for imaging the soft tissues of the temporomandibular joint. Contraindications for MRI include claustrophobia and the presence of metallic clips or metallic foreign bodies. **(Dean *et al.*, 2009).**

1.5.4-Magnetic Resonance Microimaging

The basis of Magnetic Resonance Microimaging (MRMI) is that different species of atomic nucleus have different intrinsic nuclear spins.When a magnetic field is applied, the nuclear spins align in a finite number of allowed orientations. If these orientations are perturbed by a pulse of radio frequency energy. The energy gets absorbed and then re-transmitted. The chemical environment of tooth determines the frequency of the re-transmitted energy, Advantage is that this technique is noninvasive and allows a specimen to be re-imaged after further exposure to clinically relevant environment. Major drawbacks include cost and clinical testing **(Marwah, 2008)**

1.5.5-Tuned Aperture Computed Tomography

Tuned Aperture Computed Tomography (TACT) is a new imaging device which enhances the image by decreasing the superimposition of anatomical structures, It uses digital radiographic images and its software correlates these images into layers so that sliced sections can be viewed. A series of 8 radiographs can be assimilated in one TACT image. It is effective in evaluating primary stimulated recurrent caries and simulated osseous defects and can localize a lesion accurately with minimal radiation (fig 1.10) **(Marwah, 2008).**

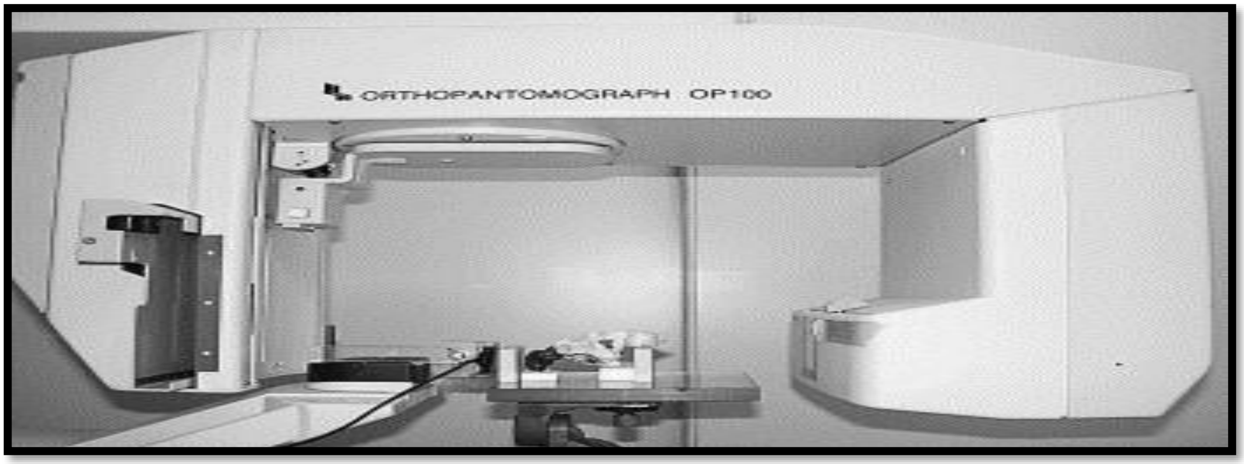

Figure 1.10 : Tuned Aperture Computed Tomography (TACT) **(Yuichi *et al*., 2015)**

1.5.6-Medical Computed Tomography

Medical CT is responsible for the highest radiation doses a patient can receive from diagnostic imaging. The fan shaped beam rotates around the patient's body (part) in a helical motion. The space between two rotations of the beam (pitch) determines the resolution of the image and hence the radiation dose. Medical CT is useful for the imaging of hard and soft tissues and provides the clinician with the ability to detect very small differences in density in the image (contrast resolution). The technique is usually used to identify malignancies, tumors, and other symptoms of pathology, with or without the use of contrast medium **(Dean *et al*., 2009).**

1.5.7-Digital Subtraction Radiography

It is a more advanced image analysis tools which allows to distinguish small differences between subsequent radiographs that otherwise would have remained unobserved because of overprojection of anatomical structures or differences in density that are too small to be recognized by the human eye. The procedure is based on the principle that two digital radiographic images obtained under different time intervals, with the same projection geometry, are spatially and densitometrically aligned using specific software. If the two digital images are identical, this method will produce an image without details (the result is zero). However, if caries has regressed or progressed in the mean time, the result will be different from zero. When there is caries progression, the outcome will be a value above zero (increase in pixel values) In case of caries regression, the result is opposite and the outcome will be a value below zero (decrease in pixel values).The major disadvantage of this technique is very sensitive to any physical noise occurring between the radiographs and even minor changes leads to large errors in the results (fig 1.11) **(Hekmatian *et al*., 2005).**

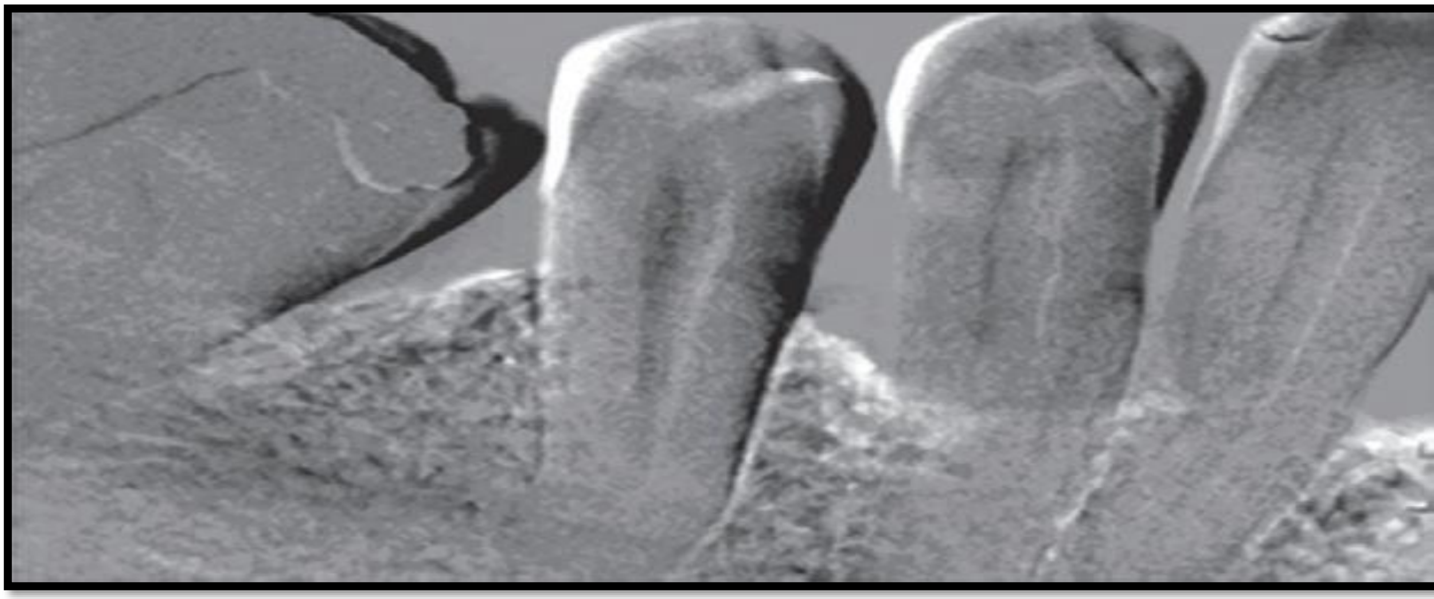

Figure 1.11 : Digital Subtraction Radiography **(Hekmatian *et al*., 2005).**

1.6-Advantages of digital imaging in comparison with conventional radiography

1.6.1-Image enhancement:

Image enhancement is the improvement of the original image to make the image visually more appealing. This could be both applied to digital intraoral and extraoral images. Image enhancement could be made by adjusting the contrast and brightness, applying various filters to reduce unsharpness and noise and zooming the image (**Wenzel *et al.*, 2000)**

1.6.2-Image analysis:

Image analysis functions help to obtain diagnostically relevant information from the image. Linear, curved and angle measurements, area calculation, densitometric analysis **(Ludlow and Mol, 2009).**

1.6.3- Decrease in radiographic working time:

CCD and CMOS sensors provide an important decrease in radiographic working time, especially for radiographic evaluation during endodontic treatment or surgical procedures **(Wenzel and Møystad, 2010)**.

1.6.4- Ease in archiving and electronically transmission of the images:

Images can be easily archived in digital medium and can be electronically transferred to other clinics or for consultation without any impairment in the image quality by web or CD, flash disk **(Ludlow and Mol, 2009).**

1.6.5- Elimination of film processing step and hazardous wastes:

One of the important advantages of digital systems is the elimination of a dark room, film processing equipment and hazardous wastes such as processing chemicals, lead foil present in the film package and rare earth products in extraoral film cassettes **(Brennan, 2002).**

1.6.6- Radiation dose:

It was suggested that direct digital intraoral systems and direct digital cephalometric systems require less radiation dose to obtain an image compared with conventional film in the first presentation of the systems **(Näslund *et al.*, 2003).**

1.7-disadvantages of digital imaging in comparison with conventional radiography:

1.7.1- Cost:

The cost of shifting from film-based systems to digital intraoral and extraoral systems is very expensive **(Brennan, 2002).**

1.7.2- Lack in cross infection control:

Compared with films, the sensors and plates used in digital imaging are not disposable and could not be sterilized; thus, special attention is required for infection control. The sensors and plates could be covered with a special film protecting cover, traditional plastic sheaths or latex finger coats **(Hokett *et al*., 2000).**

1.7.3- Structures of sensors and plates:

CCD and CMOS sensors are thicker and stiff than conventional films and the patients feel more uncomfortable during the radiographic process compared with film. Besides, the cable attached to the sensor makes sensor placement in the oral cavity difficult **(Tsuchida *et al.*, 2005).**

1.8-Radiation protection:

1.8.1- Patient protection in general:

It is recommended that patient doses are kept as low as reasonably achievable (ALARA). Since the latent period between X-ray exposure and clinical diagnosis of a resultant tumor is expected to be many years (20-45 years), children are at a higher risk than middle-aged and elderly adults and therefore should be protected most carefully **(Dean *et al.*, 2009).**

1.8.2- Beam collimation*:*

For intraoral radiography, a rectangular collimator offers a significant dose reduction to the patient compared with a traditional circular collimator with an opening of maximum size (6–7 cm in diameter). In addition, a rectangular collimator results in higher image contrast owing to lower scattered radiation **(Dean *et al.*, 2009).**

1.8.3- Lead protection*:*

An apron protects against external scattered radiation but seems to have no effect on the gonad dose. If the apron is supplemented with a thyroid collar, the dose from both primary and scattered radiation to the thyroid gland might be reduced. However, thyroid shielding is not possible in panoramic radiography, for example. For intraoral radiography, a neck shield can be used instead of an apron (fig 1.12) **(Dean *et al.*, 2009).**

Figure 1.12 : A neck shield **(Dean *et al.*, 2009).**

1.9-Child Management:

One of the most challenging tasks for the clinical staff is to obtain diagnostic quality radiographs on a young patient, (particularly those under three years of age) without causing psychological trauma, Radiographs are rarely taken for infants, for example, eruption cyst associated with natal or neonatal teeth. In such situations, the infant is held comfortably by the parent seated in the dental chair. For toddlers, it is preferred to desensitize the child to the dental experience by explaining to the child what you plan to do in words easily comprehended by the child. Using a “tell, show, do” technique, the clinician explains to the child a tooth picture will be taken of the child’s tooth with tooth film and a tooth camera. The child is allowed to touch and examine the radiographic film and camera. The child is positioned to gain maximum cooperation. In the child less than three years of age it may be necessary for the child to sit in the parent’s lap while the radiograph is exposed. If the child is uncooperative, then additional restraint by a second adult may be necessary, however If a second adult is not available, it may be necessary to place the child in a mechanical restraining device (Papoose Board). If the child is still too uncooperative, it may be necessary to manage the child pharmacologically with inhalation, oral, or parental sedatives **(Jayaraman *et al*., 2021)**

Chapter Two:

Conclusion

Digital radiography is no longer an experimental modality. It is a reliable and versatile technology that expands the diagnostic and image-sharing possibilities of radiography in dentistry. Optimization of brightness and contrast, task-specific image processing and sensor-independent archiving are important advantages that digital radiography has over conventional film-based imaging, it can be concluded that digital imaging certainly has great potential, especially with respect to improvement of diagnostic quality and automated image analysis

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