Recent advances in dental radiography for pediatric patients: A review
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Abstract
Dental radiography is considered to be a diagnostic tool for a proper treatment planning of the disorders of oral cavity like periodontal diseases, different oral pathologies, and dental caries. In pediatric dentistry, radiography is a part of daily practice because of its unusual and unique role. As the child is brought in the clinic for the 1st time, radiology has been proven to be an acceptable and a painless method to introduce a child for a dental treatment. The confidence of the patient can be successfully achieved. Thus, this review aims to give a brief overview of dental radiography in children including specialized radiographic techniques and different modifications that can successfully be used in infants, in young and handicapped children, children with gag reflex and mentally disabled children.

Keywords
Dental radiography, management techniques, modified projection techniques, specialized radiographic techniques

Introduction
Dental radiology is considered to be best and a useful diagnostic aid for a proper and thorough examination of the oral cavity of a child. It is considered to be the most reliable and valuable diagnostic tool especially for infant, children, adolescent and patients with special health care needs. It helps to arrive at a correct diagnosis, followed by a proper treatment planning. Before undergoing any procedure for taking radiograph, a thorough medical, dental and clinical examination of the patient should be performed. 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.

Modified Projection Techniques
Radiographs being a valuable tool are essential to diagnose oral diseases and to timely monitor the development of dentofacial structures and the results of the treatment outcomes. Because each patient is unique, initially a proper medical and dental history of the patient is required for determining the need for dental radiograph along with a complete clinical examination, and assessing the patient’s vulnerability to environmental factors that affect oral health. There are certain modifications for taking radiographs in infants, in young and handicapped children, children with gag reflex, and in special cases. Several radiographic techniques may be used to obtain films of these patients. For example, intraoral radiographs may be made with the parent or guardian holding the films in place. Film holding devices such as bite blocks or a hemostat extended through a rubber stopper may also be employed to retain the film. In addition a film can be retained with the patient’s occlusion, thus not being dependent on digital fixation.

In infants
For an infant below 3 years of age, it is always recommended to use size 0 intraoral periapical films for the exposures. At times, it becomes difficult for a young child to manage the films that have been placed for molar projections. With the help of digital pressure, it becomes very difficult for the child to hold the film especially for maxillary molars. Similarly, the mandibular molar films and the bitewing radiographs impinge on the sublingual tissues thus causing irritation of the tissues.

Young children usually experience difficulty while taking a radiograph. In such cases, it becomes necessary to take parental help in which the parent is asked to hold the film or to hold both the child as well as the film. Both of them are asked to face in the same direction, and the patients head is stabilized with
the parents shoulder and the radiograph is taken. If the adult attending is pregnant, someone else should hold the child.\[1\]

**Mentally disabled children**

For patients with limited ability, to control film position, an intraoral film with bitewing tabs is used for all bitewing and periapical radiographs. An 18-inch length of floss is attached through a hole made in the tab (to facilitate retrieval of the film). The patient should wear a lead apron with a thyroid shield, and anyone who helps hold the patients and films or sensor should wear lead-lined apron and gloves.\[5\]

**Children with Gag Reflex**

Occasionally the child may express his apprehension by an increased tendency to gag. Gagging has been interpreted as an effort by the child to defend himself consciously otherwise against the invasion of the oral cavity. For this reason, it is necessary to acquaint the patient thoroughly with the radiographic procedure prior to filming. One of the most effective methods of reducing gagging is a distraction. The child is asked to concentrate intensely on something spatially removed from the oral cavity. The task may be to raise one leg, and his toes, make a fist or hold his breath. Furthermore, it is advisable to perform the examination in the morning when the individual is well rested, rather than in the afternoon or evening.\[6\] Also, it has been observed that the chance of gagging is reduced when the stomach is empty or half filled.

Pharmacological techniques for managing gag response include the use of sedative and topical anesthetic. Few agents that have been recommended for decreasing the gag reflex includes phenothiazine derivatives, antihistamines, barbiturates, and nitrous oxide. For temporary relieving the gag reflex, use of local anesthetics such as xylocaine or dyclone in topical or rinse form appears to be effective. General anesthesia is generally not considered as an approach for obtaining radiographs.\[6\] Film size positioning and manner of placement may also be varied to accommodate the child who gags during radiography. Children have smaller jaws, shallow lingual vestibule, which requires the use of smaller films. It is sometimes useful to place posterior film toward the front of the mouth initially and allow the child to move the film posteriorly into position himself.

**Handicapped children**

Many mentally handicapped children will not allow an intraoral film to be placed in their mouths. Intraoral radiographs of these children are usually obtained with the parent holding the film in position. A holding device that fixes the film in position while the patient occludes is more effective than trying to hold the film by digital placement.

Such patients cannot or will not open their mouth for radiographic procedures. In these cases, extraoral radiographs like panoramic, lateral jaw or 45° projections are used.\[7\]

Use of intraoral holder at times becomes difficult in handicapped children or young patients, wherein Rinn Snap-A-Ray is used instead of the use of conventional holders. With the help of these modifications holding the film in the oral cavity becomes easier in handicapped and young children.\[8\]

**Modification in Film Packets and Holder**

Film packets can be modified in patients to reduce the anxiety level or to minimize the local discomfort and gagging associated with the placement of the film. This modification includes the bending of the film (occlusal), using the smallest possible film or either bending of the corners of the film to decrease the irritation especially in the sublingual area of the oral cavity.\[7,9,10\] Lewis et al. suggested the use of cotton rolls, which are taped with the packet of the film for maintaining the plane of the film.\[11\]

For patients with gagging reflex, handicapped children or young children certain modifications of the film or film holder position are advocated. One technique includes the “reverse” bitewing in which the film is placed in the buccal vestibule, and the beam is directed through the jaws from the opposite side of patient’s head.\[8\]

**Alternative to Intraoral Periapical Radiographs**

Extraoral techniques may be a good and reliable alternative when it is not possible or practical due to many factors, e.g. handicapped children, young patients or patient with a gag reflex. The most common and frequently used substitute for intraoral radiography includes lateral jaw or lateral oblique and the panoramic films.\[8\]

**Management Techniques**

The different management techniques while taking a radiograph for a child <3 years of age includes “desensitization” i.e. the child is explained and made understand in simple language what the dentist wants to do. Tell, show and do technique is used to explain the child that a photograph of the tooth will be captured with the help of a camera. This not only reduces patient’s anxiety but also helps in achieving the confidence of the child. Initially in first dental visit of the child the least difﬁcult radiograph should be taken. Many patients face problem in stabilizing the film inside the oral cavity. In such patients, a positioning device (Snap-A-Ray) can be used for securing and stabilizing the film.\[12\]

In many cases, older children may also become uncooperative due to reasons such as exaggerated gag reflex, small jaw size unable to accommodate the radiograph and a fear of engulfing the film. Different techniques have been put forward for managing these difﬁculties.

Smallest size bitewing radiograph should be used or rolling the film so as to accommodate in the jaw and not irritate the soft tissues especially for the detection of proximal caries. The only
disadvantage associated with this technique is that it may lead to the image being distorted. Patient’s cooperation can be effectively achieved by using desensitization techniques. A child should slowly be exposed to a new stimulus. This can accurately be described by “Lollipop radiography: In this child is asked to lick a sugarless lollipop.” After few licks, the child is asked to return back the lollipop over which a radiographic film is attached with orthodontic rubber band and the film with lollipop is given back to the child and asked to lick it again. After this, the patient is asked to stabilize it in the mouth, and the radiograph is then taken.[12]

The film is placed on the buccal surface of the tooth, i.e., between the tooth and the cheek in the patient having an exaggerated gag reflex. Buccal surface of the teeth is made to contact the film side of the packet. Cone is placed under the angle of the ramus while the X-ray head placement is done on the opposite side. Radiation is made to pass through the tongue over the tooth structure and onto the film. A 2 times more exposure is required for the image formation as the beam has to travel more distance when compared with the conventional techniques.[12]

Specialized Radiographic Techniques

Computed tomography (CT)

CT scanner was first developed in the field of medicine by Hounsfield. It is also known as CAT scanning (computed axial tomography). The attenuation of an X-ray beam in the body is used in conventional radiography to project a shadow onto an image receptor. These shadowgraphs record a two-dimensional (2D) representation of a three-dimensional (3D) object. Small lesions are therefore not readily identified because of overlapping and underlying anatomy, image distortion occurs because of unequal magnification effects and low contrast masses are poorly delineated since scatter contributes substantially to the image data.[13]

It is a radiographic technique that blends the concept of thin layer radiography (tomography) with computer synthesis. CT is a digital and mathematical imaging technique that creates tomographic sections where the tomographic layer is not contaminated by blurred structures from adjacent anatomy. It enables differentiation and is a non-invasive procedure.[14]

CT examinations are quicker and more patient friendly. Tremendous research and development have been made to provide excellent image quality for diagnostic confidence at the lowest possible X-ray dose. It is mainly indicated for investigations of intracranial diseases, preoperative assessment of maxillary alveolar bone height and thickness before inserting implants, investigations of suspected intracranial and spinal cord damage investigation and assessment of fractures involving the orbits and nasoethmoidal complex, cranial base and cervical spine fractures, tumor staging-assessment of site, size and extent of benign and malignant tumors’ investigations of tumors and tumor-like discrete swelling intrinsic and extrinsic to the salivary glands and for the investigation of the temporomandibular joint (TMJ).[14]

It eliminates superimposition of images of structures outside the area of interest; normal hidden surfaces can be examined in detail. It has the ability to rotate images and to add or subtract structural components permits relationships to be studied. Structural relationships of hard and soft tissues can be observed directly.[13]

Though CT scan provides many above mentioned advantages, it offers certain limitations for its usage. In CT imaging the effect of blurring is much greater than in conventional radiographic systems. The detail of a computed tomographic image is not as fine as that obtainable on other radiographs. Furthermore, the metallic objects such as fillings produce marked streak artifacts across the CT image. The equipment is very expensive.[15]

Clinical application of CT in children includes diagnosis of neonatal maxilla and disorders involving the auditory ossicles and TMJ. It also provides a detailed view of the dental arches and positioning of the supernumerary teeth. The extent of the cyst and tumors can be identified. In orthodontic cases, both skeletal as well as a dental relationship can be assessed. Proper evaluation of the trauma involving the face can be made with the use CT.[16]

Xero radiography

Xeroradiography is a highly accurate electrostatic imaging technique that uses a modified xerographic copying process to record images produced by diagnostic X-rays. The xerographic process was invented and first used in 1937.[17] The most common application of xeroradiography in medical field is mammography, but it has also been successfully applied to imaging other body parts such as the skull, larynx, respiratory tract, TMJ, mandible, paranasal soft tissues, and dental structures. In 1955, the first recorded use of xeroradiography for alveolar structures took place. It was a lateral oblique view of the mandible.[18]

The main advantage of xeroradiography includes simultaneous evaluation of multiple tissues i.e. tissues with different thickness and densities can be easily viewed under one film. Accidental film exposure is impossible. It has excellent characteristics of the forces around the electrostatic charges, which form the latent image i.e. it provides a high-resolution images. So far as no special skills are required for office copying machine, even more so is the xeroradiographic process. Furthermore, dark room requirements are unnecessary, and the entire xeroradiographic process may be completed within 60 sec. The process also allows multiple copies simultaneously. It is the most cost effective method compared to either automatic processing or manual processing.[19]

Periapical xeroradiographs were made using a smaller plate when compared with the plate size of conventional X-ray film.[20] Xeroradiograph shows a well-defined and a sharp delineated bone details as well as soft tissue imaging on the same picture. These features offer advantage orthognathic surgery and in cephalometrics tracing especially in children.[21]
Cone beam CT (CBCT)

CBCT also called as dental volumetric tomography, cone-beam volumetric tomography, dental CT, and cone beam imaging is a recent technology initially developed for angiography in 1982 and subsequently applied to maxillofacial imaging. It is only since the late 1980s that it has become possible to produce clinical systems that are both inexpensive and small enough to be used in the dental office. The principal feature of CBCT is that multiple planar projections are acquired by rational scan to produce a volumetric dataset from which inter-relational images can be generated.[22]

Cone-beam scanners use a 2D digital array providing an area detector rather than a linear detector as CT does. This is combined with a 3D X-ray beam with circular collimation so that the resultant beam is in the shape of a cone, hence the name “cone beam.” Because the exposure incorporates the entire region of interest (ROI), only one rotational scan of the gantry is necessary to acquire enough data for image reconstruction.[22]

As CBCT requires only a single scan for capturing the necessary data the time required for CBCT scanning is substantially less (<30 sec) as compared to conventional CT. CBCT data reconstruction and viewing is performed on a personal computer. Also, some manufacturers provide software with extended functionality mainly requires for orthodontic analysis and for implant placement.[22]

CBCT can be used in pediatric patients having malocclusions and craniofacial anomalies, including cleft lip and palate. It is also proven to be helpful for the proper assessment and correct determination of the position of the unerupted teeth especially for the canines in upper arch and to determine the extent of root resorption. CBCT also provide a proper relationship between the dentition and for assessment of treatment planning and its outcome.[22]

This technology has limitations related to the cone beam projection geometry, detector sensitivity, and contrast resolution that produce images that lack the clarity and utility of conventional CT images.[23]

Magnetic Resonance Imaging (MRI)

An MRI scan is a radiology technique that uses magnetism, radio waves, and a computer to produce images of body structures. The MRI uses non-ionizing radiation from radio frequency band of electromagnetic spectrum (10 9-10 11 nm of wavelength). It is a non-invasive imaging modality that uses electrical signals generated from response of hydrogen nuclei to strong magnetic field and radio wave/radiofrequency pulses to produce an image to allow specialists to explore inner working of human body, to detect and define the difference between healing and diseased tissue without the use of X-ray.[26]

MRI scan can be used as an extremely accurate method of disease detection throughout the body. It is mainly indicated for assessing intracranial lesions, especially those involving posterior cranial fossa, the pituitary, and the spinal cord. In the head, trauma to the brain can be seen as bleeding or swelling. It is also used for staging the tumor i.e. evaluating the size, site and extent of all soft tissue tumors and tumor like lesion involving all areas, including salivary gland, pharynx, larynx, and orbit. Also used for imaging the tongue mainly for lingual tumor for the definition of boundaries and degree of vascularity. To study the extent of soft tissue tumors and tumor like lesions involving, salivary gland, the pharynx, and the larynx.[26]

Being a non-invasive technique, MRI successfully helps in 3D visualization of the curious lesion and determining its extent and its relationship with the adjacent surrounding tooth structures.[27]

Conclusion

The use of proper and innovative radiographic techniques can help the dentist to obtain diagnostic radiographs with minimum harm and maximum comfort for the pediatric patient. There are many modifications available for both intraoral and extraoral techniques. It depends on the type of patient and the situation for the use of these modifications. All these modifications can act as a substitute for the conventional radiographic method.

References
