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Extra oral radiographic techniques in pediatric dentistry including CBCT- An Update

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Abstract

A combination of conventional x-ray and computerized volumetric reconstruction produces a 3-dimentional image which helps in accurate diagnosis and treatment planning and that's utmost important in pediatric dentistry. Though conventional radiography technique is being used since long time, it has limitations and that's the reason 3D imaging replacing it. Searches for dental literatures were carried out for clinical applications of CBCT in pediatric dentistry. Clinical applications of CBCT in children are assessment of impacted teeth and neighboring teeth root resorption, extraction or exposure of impacted teeth, defects like internal and external cervical resorption, airway analysis, virtual surgical planning of orthognathic surgery, auto-transplantation analogues, to define anatomical structures, to assess TMJ disorders. This innovative diagnostic tool has gained its popularity in all fields of dentistry, but its application in pediatric dentistry has been unexplored. In this article, we have discussed the clinical applications of CBCT among children in pediatric dentistry.

Keywords: 3D imaging, cone beam computed tomography, pediatric dentistry, diagnosis.

Introduction

Oral diagnosis and treatment planning is substantive in pediatric dentistry. For accurate diagnosis imaging along with clinical examination is necessary. Since many years intraoral radiography and panoramic radiographs are being used for diagnosis but it has limitations like superimposition of structures, images magnification, distortion of anatomical structures and misrepresentation of structures.[1] Extraoral radiographic techniques available are in both 2-Dimentional and 3-Dimentional modalities. It is nowadays attainable to obtain three-dimensional (3D) images of the oral and maxillofacial structures by cone beam computed tomography (CBCT) on a high resolution of 0.001 mm3 voxels, and these 3D images can indulge a better understanding.[2] 2D Extraoral imaging methods are OPG, lateral cephalograms, paranasal sinus view, posterio-anterior view, sub mento vertex view, waters view, oblique lateral view.3D imaging methods are conventional computed and cone-beam computerized tomography (CT/CBCT) , laser scanning (3D laser scanning) vision-based scanning techniques 3D orthognathic surgery planning, intraoral scanning, magnetic resonance imaging (MRI) and surface scanning, video camera (four-dimensional-4D imaging and video stereophotogrammetry).[3] Recently, however cone-beam volumetric tomography or cone beam computed tomography (CBCT) is preferred for the dental office with less scattering of radiation, cost effective, less capture time and easy data transfer as compared with conventional CT.[4-5] This is important in pediatric use because of the higher levels of risk associated with X-ray exposure in young age groups. This has stimulated efforts on justification and dose optimization of CBCT in the pediatric context.[6] There are comprehensive uses of CBCT in pediatric dentistry.

Different Extra Oral Radiographic Techniques

A. Two Dimensional(2D) radiographic techniques[7]

a) Panoramic Imaging (orthopantamographs)

In orthopantamographs (OPG) both hard and soft tissues can be recognized and will aid one to obtain diagnostic information from the radiographic image. Paramount is that one identifies what normal anatomy can be seen on a panoramic radiograph, so that understanding of pathology or unusual anatomy will be easier.

b) Panoramic or Extraoral Bitewings

Certain panoramic technologies allow for so-called extraoral bitewing radiographs, particularly if patients cannot cope with intraoral bitewings.

c) Cephalometric Imaging

The cephalometric radiograph is very frequently used for orthodontic as well as orthognathic surgery planning. The technique requires a specific X-ray machine which delivers a reproducible lateral skull view. That reproducibility is imperative as certain structures in the skull, and mainly the Sella turcica, have to be used as an indication to verify the progress or impact of disease or surgery.

d) Oblique Lateral Radiograph

This technique is ignored by many, but certainly has a place in pediatric dentistry imaging. It can be a very efficient source of diagnostic information in the hands of an skilled user. This being said, it is needs to be highlighted that there is a learning curve to generate good oblique lateral radiographs.

B. Three Dimensional(3D) radiographic technique[7]

a. Cone Beam Computed Tomography (CBCT)

As the name of the technique suggests, the shape of the X-ray beam is conical. The X-ray beam rotates only once around the patient's head (single rotation) while the image detector moves in synchronicity on the opposite side of the skull. The image that is acquired is therefore a cylinder and is taken as a whole and not in segments.

b. Conventional Computed Tomography

Technique, also called medical CT, uses a fan-shaped beam which rotates several times around the patient. For CBCT, one has to assume where the pivoting point or rotation axis is positioned, in order to capture the region of interest in the center of the scan volume. The latter is impracticable with MSCT.

c. MRI (Magnetic Resonance Imaging)

MRI stands for magnetic resonance imaging, is a medical imaging technique that uses a magnetic field and computer-generated radio waves to create detailed images of the organs and tissues in your body. A doctor may prescribe an MRI scan when they need more accurate, detailed images of the body.

Advantages of Cone Beam Computed Tomography (CBCT)

There are a lot of advantages associated with use of CBCT which has made this technique very popular for imaging of the craniofacial region.

Some of these advantages are as follows:

A. Accurate Imaging

- CBCT units allow voxel resolutions that are isotropic, i.e., similar in all 3 dimensions.
- This generates sub-millimeter resolution ranging from 0.4 mm to as low as 0.125 mm.[8]

B. Fast scan time-

- CBCT attains all images in a single rotation which makes scan time less.
- Artifacts due to subject movement are less because of single rotation and fast capturing**.**[8]

C. Reduced image artifact

- Artifact reduction algorithms have been integrated within reconstruction process such as Scanora 3D.
- These have been supported to palliate image noise, metal, and motion artifacts. Additionally, these are recognized to lower the acquisition dose by reducing the number of projection images.

D. Reduced radiation dosage

- CBCT machines can be used for scan of even a small region if needed for diagnostic purpose.
- According to the 2007 recommendations of the International Commission on Radiological Protection recommended dose is 52 -1025 µSv, which is revised after 1990.[9]
- Dose can be reduced by collinizing the primary x-ray beam, to reduce the size of the radiated area.

E. X-ray beam limitation

- As child patients are more vulnerable to radiation dose therefore use of CBCT should be justified.
- As children are greatly susceptible to ionizing radiations, exposure should be done as low as reasonably achievable.

Limitations of CBCT[7]

- There is no clear demarcation present between the different soft tissues. Due to poor soft-tissue contrast, all soft tissue appears homogenously gray. That way one can't differentiate between lymph nodes and salivary glands and muscle for example. This makes CBCT impractical for soft-tissue pathology, but very valuable for assessing bone and teeth. Nevertheless, the gingiva can be better visualized when cotton rolls are placed in the buccal folds or if the patient is requested to blow up the cheeks throughout the scan. Both the latter cause the cheeks to be forced away from the gingiva, which permits one to measure gingival thickness in CBCT.
- Radiopaque materials, like gutta-percha or metals, will produce streaking artifacts in the axial plane, which is significant to recognize when assessing possible root fractures in endodontically obturated teeth. The black streaks in the axial view can imitate a fracture line.
- Also, radiopaque objects out from the field of view (e.g., earrings, stainless steel crown), but in the radiation beam, can produce axial streaking artifacts. This means that patients should remove all metallic jewelry in the head and neck region, including tongue piercings, lip and nose piercings, as well as hair clips. Also, removable

dentures or orthodontic appliances have to be take out, except if they don't comprise metal.

➢ It is nearly impossible to compare radiation doses from various CBCT machines, as there is no standardization concerning field of view and exposure parameters. Publications regarding radiation dose and CBCT should always be analyzed cautiously as the type of machines used in different studies influences greatly the outcome of the study. E Choi and N L Ford et al when the imaging protocols were held constant, the highest absorbed dose was measured in all locations in the small child phantom and the lowest absorbed dose was measured in the adult phantom. This study illustrates the necessity of optimizing the imaging protocols to ensure that child and adolescent patients are not receiving a higher radiation dose than that required for diagnosis.[10]

Indications for CBCT

A. Impacted teeth or supernumerary teeth

It is difficult to depict accurate location and anatomy of the impacted teeth in 2D extraoral radiographic techniques rather it is possible with CBCT images.[11]Katheria BC et al found out in their study that 2D techniques are helpful only for initial diagnosis but detailed information about the impacted teeth position, any root resorption and accurate treatment planning are achieved with CBCT images.[11] Liu et al also confirmed these findings.[12] Liu et al suggested that CBCT be used routinely for the treatment of supernumerary teeth, especially for those cases with multiple supernumeraries, those with local malocclusions, or with high-situated supernumeraries, but Tumen et al emphasize that before requesting a CBCT, the necessities of this scan and risk/advantage analysis need to be determined.[13-14]

B. Orthodontic Treatment

CBCT has been used in several studies for assessment of dental and skeletal effects of maxillary expansion and comparison of the periodontal, dentoalveolar, and skeletal effects of tooth-borne and tooth-bone-borne expansion devices, determining how expansion forces affect different regions of the maxilla. [15]

After orthodontic treatment, root parallelism and angulations can be determined by using CBCT to aid post-treatment stability. [16]

C. Airway analysis

CBCT examination is advised for assessment of airway volume[17]. CBCT was also suggested in airway evaluation studies to examine the nose and sinuses as well as volumes of airway spaces at different levels; however, these studies had no high-quality scores, and that is the reason, actual indication could not be stated according to Kujipers et al.[18]

D. Cleft lip and Cleft palate

3D imaging is mostly used prior to treatment for evaluating the patients with craniofacial deformities for example as patients with CLP, orthognathic surgery, any syndromes, and facial asymmetries.[19] De Moraes et al. emphasized that in CBCT can achieve better evaluation of craniofacial morphology than 2D images.[20] Nur et al. evaluated that CBCT is an appropriate diagnostic method in facial asymmetry to compare the right and left facial hard and also limits soft tissue measurements. Current studies assessed that CBCT provides valuable information in patients with CLP for determining the volume of the alveolar defect, location, proximity, eruption status, and paths of the teeth near the cleft site.[21]

E. TMJ disorders

The sensitivity of CBCT for assessing bone defects is dependent on the size of the defects, as evaluated by Marques et al[22] and confirmed by Patel et al. in their studies of simulated condylar lesions. Extremely small defects (2mm), demonstrated to be difficult to detect, although the sensitivity for detecting condylar osseous defects overall was fairly high: 72.9–87.5%.[22-23]

F. Dental trauma

In CBCT, this problem could be diagnosed and the extraction of deciduous canine can be planned well in time. In case of oblique fractures, which are not viewed properly on 2D radiographs, CBCT provides an enhanced view with inner details. Another advantage of CBCT is that it can be acquired easily after trauma also, when periapical radiographs cannot be simply done because of swelling, bleeding and discomfort experienced by patients. The ability to view the cut of a single tooth of interest in the three planes of space makes determining if the involved tooth displays fracture much easier.[24]

G. Temporary anchorage device (TAD) (mini-implant) in orthodontics

To evaluate the amount of root resorption that might occur after intrusion of teeth achieved using TADs and to assess the amount of skeletal expansion achieved using TADs.[25]

There are some golden rules to take into account, when considering radiation dose and CBCT

A. Basic principles of radiation protection

Radiation exposure always should be considered first while using CBCT in children because there is possibility of deoxyribonucleic acid damage and rapid tissue growth and this may cause harmful effect later in life. [26]

That is the reason three basic principles of radiation protection should be followed [26]

The three basic and fundamental principles of radiation protection are:

a) Justification principle

- It indicates that radiographs are only advised if there is no means of obtaining the necessary information.
- If the patient cannot cope with the procedure, then radiographs should not be advised.

b) Limitation principle

- It states that the practitioner should always try to keep the radiation dose as low as reasonably achievable (ALARA) as supported by American Dental Association.[10]
- The appropriate FOV, kVp and mAs settings and high resolution /high definition parameters depending upon the indication of the scan should be advised to achieve a diagnostically acceptable and interpretable image. Now it is time to move from ALARA to ALADA (as low as diagnostically accepted).[27]

c) Optimization principle

- It suggests that any doctor should always try to attain the best possible diagnostic image.

B. Radiation Dose in CBCT

- There is a proportional linear correlation among radiation dose and mA setting of the machine. The absorbed radiation dose at 5 mA is half the dose absorbed at 10 mA.[7]
- A proportional linear relationship is there, between the radiation dose and exposure time. If the exposure time is doubled, then the radiation dose also doubles.[7]
- There is also a proportional linear relationship among the radiation dose and the image resolution. The latter goes hand in hand with exposure time and thus an image taken at 400 μm will result in half the radiation dose as the image captured at 200 μm.[7]
- The effect of kV on the radiation dose is exponential, which means that changing the kV does not certainly result in a vast alteration in radiation dose. One should, however, keep in mind the ALADA (as low as diagnostically acceptable) [27]principle and thus reducing

the radiation dose beyond the diagnostic acceptable level is not required.

Conclusion

Cone beam computed tomography (CBCT) is nowadays being overused by several clinicians as many forget about the radiation dose aspect and potential impact and only see the aesthetic aspects of the pictures, which are an excellent selling point towards patients and their parents. The attractiveness of the image must not be the reason why one advises a young child to CBCT. As always, the three basic principles of radiation protection hold: justification, limitation, and optimization. Only if the three-dimensional information would have an effect on the diagnosis and/or the treatment plan, CBCT is justifiable. Confirmation of what's known from clinical examination and two-dimensional imaging information isn't a legitimate reason for CBCT. An additional fact that one should know is that there is currently absolutely no intention among manufacturers and/or regulatory agencies to standardize the exposure parameters and the field of view of CBCT units. The latter makes it very difficult to recognize the CBCT machine that is appropriate for pediatric dentistry. The size of the field of view is probably the most significant aspect when attempting to keep the radiation dose as low as possible. In the second place, there is the alternative to lower the rotation arc, which then decreases the radiation dose. At the same time, one needs to keep the principle of optimization in mind as well, because if high-detailed images are requisite, the radiation dose will be higher as well, because of the higher mA and longer exposure time settings. In other words, the justification principle will decide if there is a require for a CBCT and then the individual case will determine what resolution is necessary. Basically there is no difference with any other exposure to ionizing radiation: justification, limitation, and optimization.

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