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Are we using Cone Beam Computed Tomography appropriately for our dental patients?

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Abstract
Radiology is an essential part of diagnosis, treatment planning, monitoring and evaluating treatment efficacy. Radiographs should always be supported with a thorough patient history and examination. CBCT prescription should be based on prevalence of the condition, the progression rates of the disease and the diagnostic accuracy (sensitivity and specificity) of CBCT, and should be compared with conventional 2D radiographs, for the specific problem. In this article I have discussed the indications of CBCT in each speciality in dentistry and appraised the literature with current evidence.

Keywords: Radiation risk, CBCT, Dental imaging, 3D imaging.

Introduction
Radiology is an essential part of diagnosis, treatment planning, and evaluating treatment efficacy. Radiographs should always be supported with a thorough patient history and clinical examination. Although, radiology provides us with additional information, it is important that dentists understand the risks of exposure to patients and, potentially, clinical staff. Dentists, unlike the medical speciality, prescribe radiographs more often for children and so, it is critical that their use has to be well justified.

Radiation Risk
Any radiograph, whether two-dimensional or three dimensional, carries risk to patient. It is important that the benefit obtained from the additional diagnostic information gained from the radiograph outweighs the radiation risk from a radiograph. In order to achieve this, it is essential that the selection of radiographs be based on the individual's history and clinical examination. Although this is vital for all patients, it is even more important when prescribing CBCT radiographs. A routine assessment without proper history is unacceptable and should not be carried out. CBCT prescription should be based on the progression rate of the disease and the diagnostic accuracy (sensitivity and specificity) of CBCT, and should be compared with conventional 2D radiographs, for the specific problem. In summary, CBCT should potentially add new information in the patient management.

Radiation detriment is the estimate of the severity of the harm experienced by an exposed group. This is age, sex and race dependent; the risk is always higher for females compared to males of the same age.[1]

The risk with the multiplication factor for age is given in Table 1.[2]

Table 1:

Age group (years)	Multiplication factor for risk
<10	x3
10-20	x2
20-30	x 1.5
30-50	x 0.5
50-80	x 0.3
80+	Negligible risk

Effective Dose
This is carried out to assess the long-term risks of radiation that might occur in the future. The risk of radiation also depends on the tissues involved. The radiosensitivity of tissues involved is taken into account using a special dose called effective dose. Many authors have attempted to evaluate the effective dosage.[1,3] The overall radiation dose is generally higher for CBCT when compared with two-dimensional radiography. The dose depends on several factors including equipment type field of view selected. A summary of the effective dose calculations is given below in Table 2.[4] However, the data is from an old review and it should be taken with caution, as the equipment can get out-dated quickly.

Table 2:

Type of radiograph	Effective dose (µS)
Intraoral radiograph	<1.5
Panoramic radiograph	2.7 – 24.3
Cephalometric radiograph	<6
MSCT Maxilla-mandibular	280 – 1410
Small FOV CBCT-maxilla	53 ± 38
Small FOV CBCT-maxilla	102 ± 88

In this article, we will briefly discuss different clinical scenarios in dentistry and the justification of CBCT for each of the clinical situation.

The developing Dentition

It is important to understand that the radiographic examination in children involves higher risk of radiation exposure and has to be clearly justified. The question that needs to be asked prior to taking any radiograph is "Does this add to my diagnostic information and will this change my treatment plan?"

Radiographs may be needed to identify abnormalities in eruption pattern, to determine the presence, absence, position and condition of teeth, to look for signs of crowding and to aid in treatment planning. Traditional radiographs for children include panoramic radiographs and lateral cephalometric radiographs. Other intra oral radiographs include, anterior occlusal and periapical radiographs according to patient-specific needs.

The most common application of CBCT in Orthodontics is for assessment of impacted tooth and its association with roots of adjacent teeth and to check for any signs of root resorption. In a previous clinical study assessing the efficacy of CBCT for impacted canines, the results showed that there were clear differences in the diagnosis made between CBCT and other 2D radiographs.[5] More importantly, the results showed a difference in the treatment plan between CBCT assisted assessment and 2D radiographic assessment. However, the treatment outcome was not evaluated in these cases. This finding was reinforced by several other studies, which stated that the diagnostic accuracy is improved and confidence on treatment plan is better with CBCT compared to 2D imaging.[6,7] While it is true that the CBCT is more likely to diagnose root resorption, it is important to assess if the risk of radiation exposure from CBCT can be overcome by the benefit obtained from this additional diagnostic information on the management of the patient. Orthodontists over many years have worked with conventional radiography and unless there is a substantial benefit for the patient on the treatment outcome, the necessity of increased radiation from CBCT has to be questioned.

Mini Implants

One of the reasons for CBCT in Orthodontics is to assess the bone thickness and volume prior to mini implant placement. Several authors have reported on the use of CBCT for mini implant placement. Some clinicians still routinely use CBCT for evaluating bone quantity before placing mini implants. This diagnostic information is carried out to avoid damage to the roots of the adjacent teeth. On the contrary, there are studies that report that any damage to the root cementum and dentin during placement, under favourable conditions, can heal and reform naturally post removal.[8] With the current evidence, it is accepted that the use of CBCT for mini-implants routinely is not advisable.

Complex Orthodontic-Surgical Treatment

Some of the complex malocclusions involving surgical and orthodontic treatment planning may require three-dimensional imaging. However, historically orthodontists and surgeons have planned this with two-dimensional imaging. There may be exceptional cases like mandibular asymmetry, complex bone morphology, etc., that may require CBCT, however, it is not advisable to take CBCT as a routine diagnostic method for these cases.

Cleft lip and Palate

Cleft lip and palate cases are complex and it is widely accepted that CBCT can be performed for diagnosis. They are increasingly done for assessing cleft area pre graft and measuring the volume of bone post alveolar bone graft. The use of CBCT is encouraged for clinical situations where multi-slice CT is undertaken.

Restorative

Dental Caries

Several systematic reviews have been performed evaluating the effect of CBCT on caries assessment and its comparison with 2D radiographs.[8-14] The results of five of the reviews showed that there was no difference between CBCT and conventional radiographs for assessment of caries. One of the studies showed higher sensitivity scores for CBCT but the overall result was not significant. The current evidence shows conventional radiography to be as good as CBCT imaging. There may be exceptional clinical circumstances like under fixed partial dentures or buccal surface caries etc. However, routine use of CBCT for dental caries assessment is not advisable.

Periodontal Assessment

Conventional radiographs are not ideal for periodontal assessment due to the nature of problems, like root fractures, external cervical root resorption, furcation involvement etc.[15-17] Two-dimensional images do not show attachment/bone loss in the buccal and lingual surfaces. The use of CBCT can therefore be considered. However, the scientific evidence for the use of CBCT for periodontal problems is weak. There are only a few systematic reviews.[18-21] The most recent review showed high accuracy of CBCT in visualising periodontal problems especially in degenerative periodontal diseases. However, the authors point out the additional diagnostic gain from CBCT may not lead to a better treatment outcome. Hence, the use of CBCT for periodontal problems should not be a routine method and should be restricted to more complex periodontal cases.

Endodontics

Endodontics is a speciality that requires high-resolution images of the root canal system at different stages of treatment and for different treatment procedures. Three-dimensional imaging offers a valuable tool for viewing the root canal system. Several systematic reviews and descriptive clinical studies have shown that CBCT is significantly better in identifying root canals especially in identifying second mesio-buccal canal in maxillary first molar.[22-28] However, none of the studies compared conventional radiographic method with CBCT. It has to be pointed out that CBCT image resolution (range 0.6 and 2.8 lp mm^{-1}) is inferior to that of conventional radiographs (approximately 3 Ip mm^{-1}) and additionally, it is not possible to reduce the field of view to a single tooth with CBCT. Hence, with the evidence available, it is not advisable to use CBCT as a routine diagnostic method for assessing root canal anatomy for endodontic purpose. The exceptions for this may include selected cases in multirooted teeth, where conventional radiograph does not provide adequate information to plan treatment.

Surgical Endodontic Cases

The evidence of additional value from CBCT for surgical endodontic cases are limited, however, the general clinical opinion is that CBCT can be justifiable for these complex clinical scenario. There are no systematic reviews in this area. However, the justification of CBCT depends on the complexity of the cases and its relation to anatomical structures.

Complex Endodontic Procedures

The use of CBCT for complex clinical situations like internal root resorption, perforations, perio/endo lesions can be justifiable, however, this is based entirely on clinical option with no clear evidence available in this field.

Dental Trauma

Dental trauma is a fairly common event. The incidence of trauma is high in younger age group and in children with protruding teeth. Often, the diagnosis of traumatic root injuries is difficult with conventional two dimensional radiography. This is even more complicated if the fracture/root damage happens on the buccal or lingual surfaces of the roots of teeth. The use of CBCT may be particularly helpful in diagnosing these injuries. There are several systematic reviews in this area and they collectively show CBCT to provide superior diagnostic information when compared with two-dimensional radiography.[29-36] Hence, CBCT is indicated in cases with dental trauma and where conventional two-dimensional radiography does not provide adequate information for planning treatment.

Implant Dentistry

Implant dentistry is a surgical field that requires careful assessment of bone quality and quantity prior to the surgical procedure. It is also imperative that the diagnostic method provides clear information on the adjacent anatomical structures like nasal floor, sinus cavities, nerves and vessels. This is one of the clinical areas in dentistry that uses three-dimensional imaging the most. The evidence shows CBCT provides sufficient information for image quality of important structures,[34] visualisation of peri-implant defects,[35] and details of cortical bone thickness.[36] More importantly, several studies have shown that CBCT is a valuable tool to evaluate the neurovascular structures in implant dentistry.[40-44] The CBCT is justifiable for this procedure and is recommended in place of multi slice CT imaging. The additional advantages over the MSCT are the possibility to adjust the field of view and the reduced exposure in CBCT. However, the use of CBCT for assessing bone density is questionable.

Bone Pathology

Many maxillary and mandibular bone pathologies like cysts, tumours etc., require careful assessment that may require more than two-dimensional radiographs. It is reasonable to accept that these bony pathologies can be better viewed by three-dimensional CBCT images. Many studies have shown that the CBCT provides better sensitivity and specificity for diagnosing bony pathologies of the jaws.[45-48] The CBCT imaging may be considered for other bony defects like cysts and granulomas: they have been shown to have high specificity in diagnosing these lesions,[48,49] however, they lack sensitivity in differentiating between both.

Conclusion

1. The role of CBCT in dentistry is vital, at the same time it must be used judiciously.
2. The clinicians should evaluate the need for CBCT with a question "Is this additional diagnostic tool (CBCT) going to have an effect on/ change my treatment plan". The justification is acceptable if the answer is "yes".
3. The clinicians have a duty of care for the patients and should take into account the radiation risk involved with the CBCT and clearly demonstrate the net benefit to the patient on the overall treatment outcome.

Conflict of Interest: None.

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