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ROLE OF CBCT IN ORAL AND MAXILLOFACIAL SURGERY – A REVIEW

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ABSTRACT

The technological innovation have always been a boon to the mankind. Ever since the discovery of radiation in the year 1885 (Wilhelm Conroed Roentgen),there were enormous increase in diagnostic imaging technology. One such imaging which sweeped changes in field of dentistry is CBCT(Cone beam computer tomography).With no doubt it serves specific application in oral and maxillofacial surgery(OMFS).This article review the implications of CBCT in the diagnostic and operative procedure in OMFS by compiling the information from various databases such as articles and textbooks.

Keywords: *CBCT,OMFS, Diagnosis*

I. INTRODUCTION

Rapid developmental changes have taken place in dental imaging technology since years . CBCT is an excellent imaging option in field of maxillofacial surgery since it embrace the needs of the surgeon by reducing the amount of radiation compared to CT (computer tomography)[1] for evaluation of specific areas of interest.

HISTORY OF DEVELOPMENT OF CBCT

The understanding of radiation dates back to 1885 with the invention of ionizing radiation by Roentgen. It was followed by the phenomenonal discovery of Henry Becquerel but it was named after his doctoral student Marie curie as 'radioactivity'. She even contributed to the development of x- ray machines in the fields of world war I. [2]. In the year 1972 ,Sir. Godfrey N. Hounsefield invented

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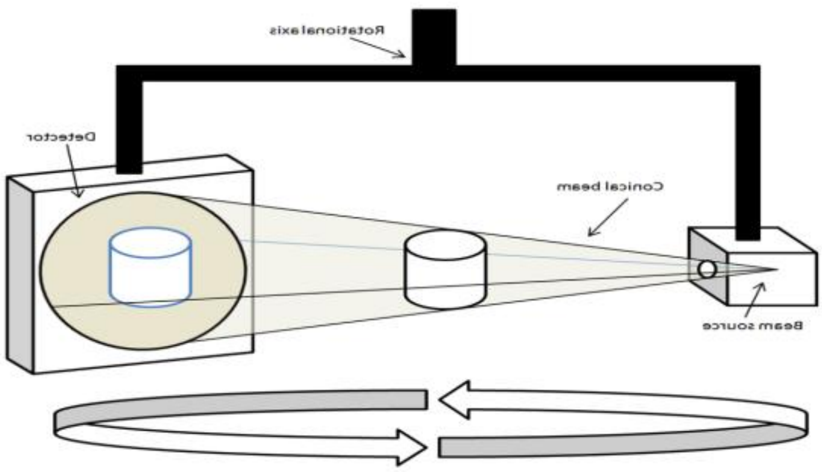
CT ,which brought a significant advance in diagnostic imagings. He was awarded noble prize along with Cormack for this discovery. Through the years 1980s and 1990s four generations of CT scanner evolved to latest the high acquisition MDCT with fast scan time. Four technological developments converged to facilitate construction of affordable CBCT units small enough to be used in the dental office for maxillofacial imaging [3].By the late part of 19th century first commercially successful maxillofacial CBCT was made in Italy in the year 1995 with Attilio Tacconi and Piero Mozzo as co-inventors and the system was designed and produced by QR, Inc. of Verona, now a Cefla company [4] .Numerous prototypes emerged through the years 1994- 2007 [5]. The most promising designs and models of CBCT are commercially available ranging from a full maxillofacial FOV to a hybrid unit panoramic unit with or without 2D digital cephalometric capabilities.

PRINCIPLE OF WORKING

CBCT works mainly by cone beam acquisition. beam geometry providing multiple transmission images that are integrated directly forming volumetric information[6].The unit consist of an x-ray source detector connected to a rotating gantry (360 degree) (fig 1)which is capable of rapid acquisition of images.The x-ray generators used in maxillofacial CBCT rotation performed within 5-20 seconds[7].The operating voltage is low in maxillofacial unit which is between 80kVp and 120kVp most of it work at the lower ranges.There are two important sequence in CBCT image formation acquisition and reconstruction. The beam and the x-ray receptor rotate simultaneously around the patient’s head during the time of acquisition. During this rotation, basis images are acquired in intervals as the radiation passes through the patient and is captured by the receptor.The resultant planar images from raw data are then reconstructed using computer algorithm[8].

FIGURE 1: Figure showing the unit consist of an x-ray source detector connected to a rotating gantry (360 degree)



RADIATION DOSE AND CONCERNS

Since use of CBCT for maxillofacial imaging has substantially increased because of its low cost and remarkable utility. Its radiation exposure and inherent risk implications are of greater concern. Inspite radiation dose and exposure is low compared to MDCT , these rate may be primarily determined by the field of view (FOV) and exposure parameters [9,10]. I fact the use of a dentoalveolar FOV CBCT where indicated combined with a cephalometric radiograph also has a lower effective radiation exposure than a craniofacial FOV, although this difference in radiation exposure is much less marked than when comparing the traditional 2D radiographic series with a large or extended FOV CBCT also understanding the approach of background radiation exposure(3microsieverts per year) . It is also to be emphasized that young patients are more at risk than older patients because of their length of life span,the greater mitotic potential and low radiation resistence of tissue.It is advised to follow the ALARA (As low as reasonably achievable) principles and use of collimators to reduce the amount of radiation. Radiation exposure from CBCT is 10 times less than medical CT, which exposes patient to a dose of 400 to 1000 microsieverts. To get diagnostically acceptable and interpretable image, the National Commission on Radiation Protection and Measurements has introduced a modification of the as low as reasonably achievable concept of ALADA represents “as low as diagnostically acceptable” [11]. (Table 1)

Table 1: Types of radiography methods and effective dose ***(Sources of data include Loubele et al., 2005; Garcia Silva et al., 2008a, 2008b; Ludlow et al., 2008; Okano et al., 2009; Palomo et al., 2008; Theodorakou et al., 2012.)***

Type of radiography	Specific radiograph or methods	Effective dose (µSv)
2D radiography	Intraoral (PAs and bitewings)	27
	Panoramic	2.7–24.3
	Cephalometric	<6
Dentoalveolar FOV CBCT	10-year-old phantom	16–214 (43)
	Adolescent phantom	18–70 (32)
Craniofacial FOV CBCT	10-year-old phantom	114–282 (186)
	Adolescent phantom	81–216 (135)
Conventional CT	MSCT	280–1410
Background radiation		8

European Academy of Dental and Maxillofacial Radiology basic principles on the use of cone beam CT (CBCT)

1.Must not be carried out unless a history and clinical examination have been performed

2.Benefits outweigh the risks

3 Potentially add new information to aid the patient's management

4 Not be repeated ''routinely'' on a patient without a new risk/benefit

5 Supply sufficient clinical information on referral from other dentist

6 If cannot be answered adequately by lower dose conventional (traditional) radiography

7 Radiological report of the entire image data set

8 Evaluation of soft tissues conventional medical CT or MR, rather than CBCT

9. Should offer a choice of volume sizes and Choice of resolution

10. The resolution compatible with adequate diagnosis and the lowest achievable

11 Quality assurance programme

12. Aids to accurate positioning (light beam markers)

13. All new installations of CBCT equipment should undergo a critical examination

14 Equipment should undergo regular routine tests

15 Should follow Section 6 of the European Commission document Radiation Protection 136.

16 Need to Receive adequate theoretical and practical training

17 Continuing education and training required

18 Dentists should undergo a period of additional theoretical and practical training if not trained otherwise

19 For dentoalveolar CBCT images - (''radiological report'') should be made by a specially trained DMF Radiologist or ,where this is impracticable, an adequately trained general dental practitioner

20. For non-dentoalveolar small fields of view (e.g.temporal bone) and

all craniofacial CBCT images - radiological report should be made

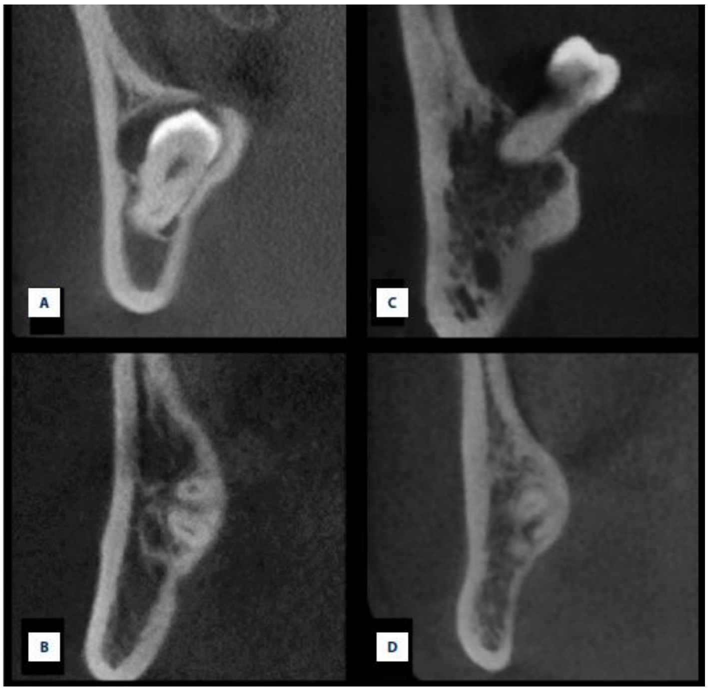
by a specially trained DMF Radiologist or by a Clinical Radiologist.

APPLICATIONS IN ORAL &MAXILLOFACIAL SURGERY

a)IMPACTION OF TEETH

Surgical removal of impacted teeth is one of the most common dentoalveolar surgical procedures. For a good surgical planning visualization of the vital structures like inferior alveolar canal , sinus boundaries and nasal floor is required . Position of inferior alveolar canal and its relation to the root apices of mandibular third molar can be identified using appearances in CBCT(fig2).This has potential advantage of identifying the operative risk and reduce the nerve damage[12] .Also helps to assess the angle of impaction , path of exit and nature of osseous structure surrounding the tooth.

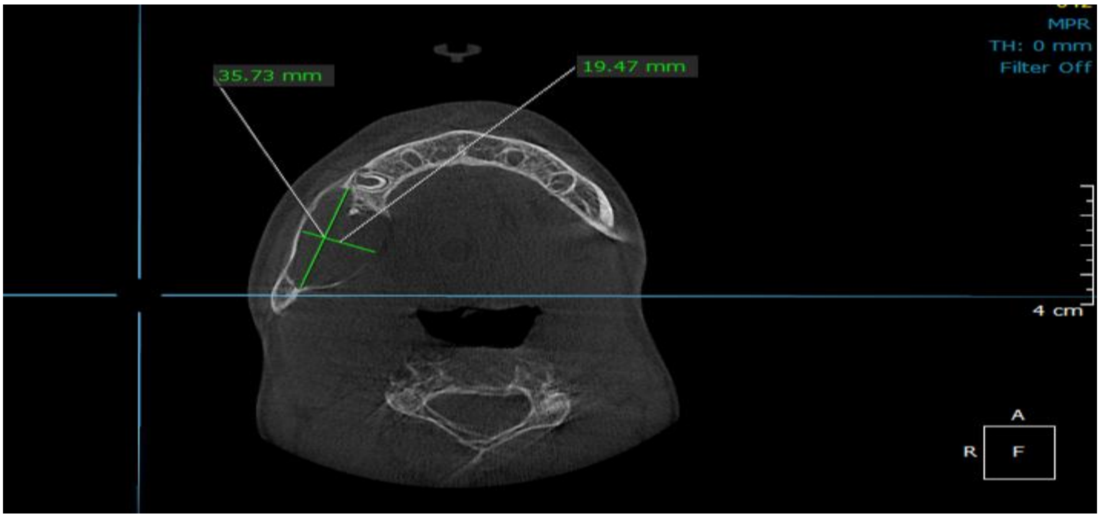
FIGURE 2: Ghaeminia classification in CBCT: (A) root located buccal of the canal; (B) root located lingual of the canal; (C) root located inferior of the canal; (D) MC located interradicular of the MTM.



b) CYSTIC AND BENIGN LESIONS OF MAXILLA AND MANDIBLE

Studies reveal that CBCT play a significant role in diagnosis of cystic and lytic lesions of jaws beacause of its superior grey scale properties[13].Radiolucent ,radioopaque and mixed lesions of jaw can occur due to odontogenic and non odontogenic pathology.To facilitate optimum image presentation of osseous structures it is necessary to adjust parameters like window (window level and width)and contrast . Images are set to different elements and tissue ranges from -1000 to 3000 (air versus bone) which makes it possible to evaluate as either benign or malignant characteristics.Although histopathology is the definitive diagnosis on kind of lytic lesion ,CBCT findigs helps in pre operative surgical planning by delineating the borders and epicenter of the lesion(figure 3).

FIGURE 3 : KERATOCYST IN 10 YEAR OLD BOY



C) MAXILLOFACIAL INFECTIONS

Diagnostic validity of CBCT stands superior compared to conventional radiograph in the evaluation of inflammatory lesions of maxillofacial region.Eventhough Irregular ragged margins are the characteristic feature of malignant lesions of jaw ,some chronic infections of jaw like osteomyelitis show destructive bone findings. Soft tissue changes could not be appreciated in CBCT,so its of least diagnostic importance in acute infections.It has been used to assess the spread of odontogenic temporal and infratemporal space infections based on its intraosseous course.[14]

D)INVOLVEMENT OF PARANASAL SINUSES

Sinonasal anatomy because of its complexity is extensively studied [15].Anatomical variations of sinus stuctures and osteometal unit are common findings. CBCT is of less invasive and low radiations than conventional radiographs for the diagnosis of sinus pathology.Incidental findings like sinus opacification and mucosal thickening are well quoted in several literatures.A study by Pazera et al they examined 46.8% incidental maxillary sinus pathologies in CBCT taken for orthodontic patients in north india population[15,22].

E) TMJ ANATOMY AND PATHOLOGY

Literature stating diagnostic performance of CBCT in TMJ evaluation have been reviewed.The first accuracy study was done in the dry human skull which measured their dimensions[16].With comparable diagnostic accuracy with CT ,it is used for visualizing osteophytic changes,erosive changes and degenrative joint diseases

F)FRACTURES OF MAXILLOFACIAL FRACTURES

CBCT can be a good alternative to MDCT for detecting fractures. Mutiplanar reformatted images are of high accuracy in zygomatico complex and condylar head fractures. In case of frontal bone fractures it should be combined with MRI to differentiation of soft tissue and in case CSF leaks[17].

G)ORTHOGNATHIC SURGERY

CBCT is found a useful tool for the orthognathic surgical planning , guidance and creating stereolithographic models. Despite the shortcomings compared to MDCT ,CBCT can also be used for manufacturing 3D surgical models of adequate quality.The DICOM data (Digital Imaging and Communications in Medicine) is converted to assess the spatial changes of jaw position by calculating 3 dimentional movement of surgical landmarks[18].

H) IMPLANT SURGERY

A number of studies have shown that CBCT can be used for planning and placement of implants combining with guided system [19].Latest software updation has also enabled the clinician to eliminate the need of radiographic stent.

Combination of virtual surgical planning and CBCT scan the implant can be placed in correct axial inclination virtually. It is also efficacious for the visualizing the surrounding anatomy and subjacent ossoeus stuctures which is in proximity to implant site.

I) SALIVARY GLAND PATHOLOGY

CBCT plays a significant role in the assessment of salivary gland lesions.CBCT sialography is a new modality which is superior to convention sialographic methods.Obstructive disorders of salivary gland accounts for one- half of benign salivary gland disease ,more than 80% in submandibular glands.Several studies have demonstrated the application of CBCT sialography for determination of ductal anatomy.strictures ,dilatations and salivary calculi formation[21]

ADVANTAGES OF CBCT: Faster and less invasive, Accurate diagnosis, 3D information , Lower radiation dose than MDCT(98%), Low cost, Lower distortion and magnification(0.1 precision)

DISADVANTAGES OF CBCT: Poor contrast resolution, Practical training required for dentist, Routine adjustement of unit is required

ARTIFACTS:[20]Patient motion artifacts, Scatter artifacts, Step artifact, Zebra artifacts, Scanner related artifact, Ring artifact, Beam hardening

II. CONCLUSION:

Despite many limitation CBCT is being used extensively in various fields of dentistry especially OMFS .It must be emphasized that diagnostic information we obtain are of superior quality than conventional radiographic techniques and have adequate accuracy. Practioner must also keep in mind the CBCT findings should always be correlated with clinical examination while diagnosing osseous pathology. In future,as technology it iterative CBCT can be combined with robotic technology for optimum surgical plan and performance.

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