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"Is Cone Beam Computed Tomography (CBCT) a Potential Imaging Tool in ENT Practice?: A Cross-Sectional Survey Among ENT Surgeons in the State of Odisha, India

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Abstract

This questioner survey aimed about awareness of the Cone Beam Computed Tomography (CBCT) machine and its various clinical applications in ENT, among the ENT surgeons in the state of Odisha. 150 questioner forms on CBCT were distributed to the all the participating ENT surgeons at a state level ENT conference, out of which the response rate was 110. The participants were asked to answer 30 multiple choice questions, which were divided into 3 parts; general information on CBCT, general approach to CBCT and practice related to CBCT. The statistical analysis of the data collected was carried out by a Chi square test to compare the means at a significance level of $P < 0.05$. The response rate for this study was 73%. The mean age of the participant ENT surgeons was 47.9 (±19.2). Of the study population, 71.2% (89) did not ever advice CBCT in their practice. Only 33.9% (38) of the population believed that CBCT is more beneficial in the field of ENT. Only 25% (28) knew that CBCT requires lower radiation dose than conventional CT. 28.1% (31) of population believed that the spatial orientation is better in CBCT than CT. 62.5% (69) of the population did not knew that CBCT can be used in imaging sinusitis of dental origins. 75% (83) of the population did not knew that CBCT can be used in diagnosis of obstructive sleep apnoea and visualizing airway space. Only 18.8% (21) of the study population agreed that the CBCT has the potential to replace conventional CT in ENT imaging in future. In the conclusion, this study clearly showed that the number of ENT surgeons advising CBCT imaging in their practice is very less. The knowledge about various advantages and clinical applications of CBCT had been very limited. However, through continuing medical education and conducting various seminars and workshops on CBCT, imparting chapters on CBCT, in the undergraduate and post graduate curriculum will definitely help increase the awareness on CBCT among ENT fraternity.

Electronic supplementary material

The online version of this article (doi:10.1007/s12070-017-1168-4) contains supplementary material, which is available to authorized users.

Keywords: CBCT in ENT, CT, 3D imaging, CBCT in dentistry

Introduction

Cone beam computed tomography (CBCT) is the most significant radiographic imaging method that allows accurate 3D imaging of hard tissues (Fig. 1). Currently CBCT has wide range of clinical application in the dental field like maxillofacial surgical treatment planning, assessing impacted teeth prior to surgical extractions, TMJ analysis, orthodontics, implantology, endodontic assessment, diagnosis and treatment planning, periodontics, bone level evaluation [1].

Fig. 1

The CBCT machine

CBCT is a volume acquisition method which was initially developed commercially for angiography in early 1980s [2]. Later in 1996, CBCT provided the 1st clinically and practically applicable technology demonstrating the application of 3D imaging not only in maxillofacial imaging but also for sinusitis of dental origins or other ENT aspects. In 1998, Mozzo et al. reported the 1st CBCT unit developed for dental use approved by FDA, *The New Tom 9000* [3]. In 2003, Hashimoto et al. reported that 3DX CBCT produced better image quality with a much lower radiation dose than the newest multi detector helical CT unit [4].

Traditionally imaging in the field of ENT area has been conducted with native 2D X ray imaging, medical computed CT or Magnetic imaging resonance MRI. Currently conventional medical CT has been the gold standard to diagnose many ENT problems. The rapid technological progress in terms of image quality, validity, reproducibility and less radiation exposure has made CBCT imaging an attractive alternative tradi-

tional imaging method in ENT. Because of these benefits cone beam CT is gaining more and more popularity and the technique is gradually replacing the native X ray method and conquering share from medical CT in ENT.

However the literature search revealed no survey study regarding the knowledge, attitude and perspective of CBCT in ENT practice.

So, this article is a cross sectional study report regarding knowledge, attitude and perspective of CBCT and its clinical applications, among ENT surgeons in the state of Odisha.

How it Works

The CBCT imaging is performed using a rotating platform or a gantry carrying an X ray source and a detector. A divergent cone shaped or a pyramidal source of radiation is directed through the region of interest (ROI) and a residual attenuated radiation beam onto an area X ray detector on the opposite side (Figs. 2, 3). X ray source and the detector rotates around a rotation centre fixed with in the centre of ROI. During the rotation, multiple sequential planar projection images are obtained while the x ray source and the detector moves 180–360 degrees. These single projection image constitute the raw primary data or basis of the image.

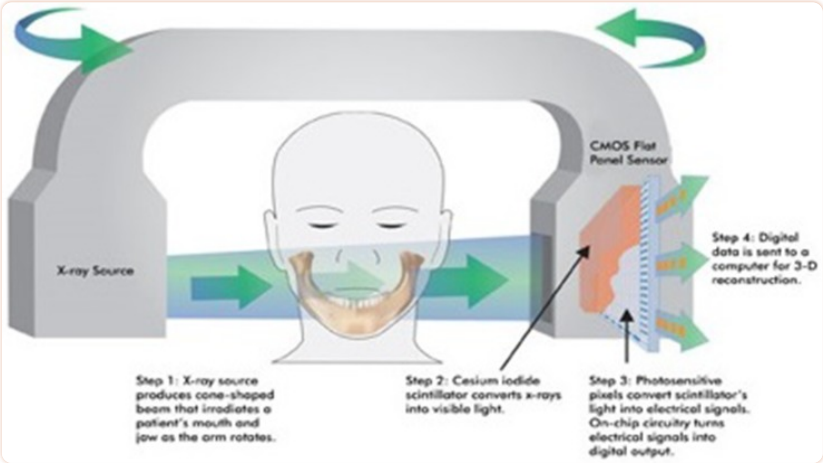

Fig. 2

The working principle of CBCT

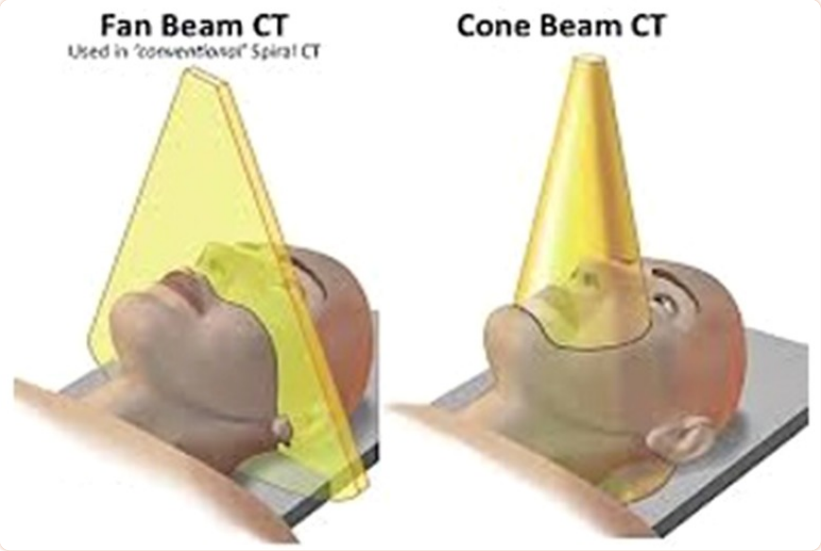

Fig. 3

Difference between CT and CBCT

There are usually several hundred 2D basis images from which the image volume is calculated and constructed. Software programmes incorporating sophisticated algorithms developed by Feldcamp et al. [5] in 1984 are applied to these projection data to generate a volumetric data set that can be used to provide primary reconstructed image in 3 orthogonal planes (axial, sagittal and coronal).

Methodology

The current study was conducted at all Odisha ENT surgeons meet held in KIMS and Pradyumna Bal Memorial Hospital, Bhubaneswar, Odisha on 19th and 20th Dec 2015. 150 registrations were received during the conference. So the sample size for the present study was set to be 150. A total of 150 questionnaires were distributed. Participants involved PG students, faculties associated with different medical colleges, consultants in various corporate hospitals, district hospitals and private practitioners from various parts of Odisha. The questionnaire was developed with the guidance of previous studies. Ethical clearance and informed consent for the study was obtained. A close ended questionnaire form were distributed to the participants and were asked to answer 30 multiple choice questions. A brief discussion regarding the questionnaire and any clarification regarding any question was also done. The questions in the questionnaire were focused on participant's awareness, attitude and his perspective towards the use of CBCT in ENT field. The questionnaires were subdivided into 3 main topics (Demographic data, General approach to CBCT, Various applications of CBCT in ENT). Many questions used a 3 point answer scale, YES, NO, DON T KNOW and few questions used AGREE, DISAGREE, CAN'T SAY. A total of 110 questioners (The response rate) were available for analysis. The data collected were statistically analysed.

Statistical Analysis

The collected data was entered into a personal computer and analysed in SPSS software version 20 windows. Data was evaluated according to the descriptive statistics, which are presented as frequencies (n) and percentages (%). A Chi square test was used to determine the test of significance. Difference between the level of significance was set at 5%. Unanswered questions were treated as missing values.

Results

1. *The Response Rate* The response rate for this study was 73%. From the 150 questioners distributed, 110 deemed usable.
2. *Demographic Data* The mean age of participants in the study was 47.9(±19.2) with range 27–68 years. Most of the ENT surgeons in the study were having mean of 17.5(±14.7) service experience. It was observed that 18.7% (21) participants were purely into clinical practice, where as 40.6% (45) and 40.3% (44) were into purely academic and both academic and clinical practice respectively.
3. *Whether Knowledge of CBCT received during UG/PG/Clinical practice* All the participants in the study group, agreed that they had not received any knowledge or training regarding CBCT in their UG curriculum, only 29% (7) had acquired knowledge in their PG curriculum and 71% (17) of the population in their clinical practice.
4. *Knowledge Regarding the Location of CBCT machine in Odisha* 85.9% of the participants did not know that CBCT machine is present in Bhubaneswar, 81.5% of the participants did not know CBCT machine is present in Kalinga Institute of Dental Sciences, KIIT university Bhubaneswar.

The results of Comparison between conventional CT and CBCT, knowledge about various clinical application of CBCT in ENT, knowledge about CBCT being advantageous and future prospectus of CBCT are mentioned in the Tables 1, 2, 3, 4 respectively.

Table 1

CBCT when compared to conventional CT

Description	Yes (%)	No (%)	Don't know (%)	Chi square test	Yes (N)	No (N)	Don't know (N)
CBCT radiation is higher	17 (15.6%)	28 (25%)	65 (59.4%)	0.08	17	28	65
CBCT takes Longer time	21 (18.8%)	17 (15%)	34 (31.2%)	0.03	21	17	34
CBCT requires less exposure	24 (21.9%)	34 (31.2%)	52 (46.9%)	0.00	24	34	52
CBCT takes more space	34 (31.2%)	45 (40.6%)	24 (28.2%)	0.00	34	45	24
CBCT need high maintenance	41 (37.5%)	39 (35.3%)	31 (28.2%)	0.36	41	39	31
CBCT needs complex software	55 (50%)	10 (9.3%)	45 (40.7%)	0.01	55	10	45
CBCT same spatial relationship	38 (34.3%)	31 (28.1%)	41 (37.6%)	0.00	38	31	41

Table 2

Various applications of CBCT in ENT

Description	Yes (%)	No (%)	Don't know (%)	Chi square test	Yes (N)	No (N)	Don't know (N)
CBCT in tooth and sinus relation	28 (25%)	69 (62.5%)	14 (12.5%)	0.008	28	69	14
CBCT in endoscopic sinus surgery	38 (34.4%)	10 (9.3%)	38 (34.4%)	0.048	38	10	38
CBCT in bony pathology of TMJ	21 (18.8%)	79 (71.9%)	10 (9.3%)	0.14	21	79	10
CBCT in nasal floor fractures	21 (18.8%)	79 (71.9%)	10 (9.3%)	0.63	21	79	10
CBCT in temporal bone fractures	24 (21.9%)	76 (68.7%)	10 (9.4%)	0.201	24	76	10
CBCT in middle ear malformation	24 (21.9%)	72 (65.7%)	14 (12.6%)	0.586	24	72	14
CBCT in cochlear implants visualisations	28 (25%)	69 (62.5%)	14 (12.5%)	0.2	28	69	14
CBCT in ossicular chain malformations	28 (25%)	55 (50%)	28 (25%)	0.569	28	55	28
CBCT in obstructive sleep apnoea	17 (15.7%)	83 (75%)	10 (9.3%)	0.37	17	83	10
CBCT in3D analysis of airway	51 (46.8%)	45 (40.6%)	14 (12.5%)	0.972	51	45	14
CBCT in visualisation of air way space	24 (21.8%)	41 (37.5%)	38 (34.3%)	0.05	24	41	38
CBCT in blockade in nasolacrymal duct	21 (18.7%)	69 (62.5%)	21 (18.7%)	0.6	21	69	21

Table 3

Knowledge about CBCT being advantageous

How often do you advice CBCT	
(1) Yes	21 (18.8%)
(2) No	89 (71.2%)
Is CBCT beneficial in ENT	
(1) Yes	38 (33.9%)
(2) No	30 (30.1%)
(3)Don t know	40 (36%)
Accuracy of CBCT	
(1) Same as CT	58 (53.1%)
(2) Less than CT	27 (25%)
(3) More than CT	25 (21.9%)
Beneficial to have CBCT in practice	
(1) Yes	28 (25%)
(2) No	14 (12.5%)
(3) Don t know	68 (62.5%)

Table 4

Future prospects of CBCT

Can CBCT replace CT	
(1) Agree	21(18.8%)
(2) Disagree	10(9.3%)
(3) Cant say	79(71.9%)
CBCT should be imparted in UG curriculum	
(1) Yes	24(21.9%)
(2) No	14(12.5%)
(3) Cant say	72(65.6%)

Discussion

Though relatively new into ENT imaging system, CBCT has established itself as a potential diagnostic imaging tool in a vast range of ENT disorders. But the present day ENT practice mainly relies on CT or other imaging tools for its diagnosis. So the present study aims at assessing the knowledge of the ENT surgeons about the CBCT machine and its various clinical utility. It is found, no studies have been reported in the literature regarding the knowledge, attitude and perspective of the present day ENT fraternity towards CBCT imaging in the state of Odisha.

Numerous positive features of the CBCT have made it suitable for imaging in many dental as well as ENT applications, but it has also a number of limitations. The difference between CBCT and CT [6] is briefed in Table 5.

Table 5

Difference between CBCT and conventional CT

CBCT	CT
Single rotation	Multiple rotation
Isotropic voxels	Anisotropic voxels
Lower radiation dose	Higher radiation dose
Lower cost	Higher cost
Smaller space requirement	Larger devices
Spatial resolution	Better contrast resolution
Deficiency to display soft tissues	Clear evaluation of soft tissue
Higher scatter radiation	Lower scatter radiation

As each question in the questioner pertains to certain aspects of CBCT, thus in this discussion each aspect of CBCT is being explained under separate headings.

Strength of CBCT

1. *Size and Cost* CBCT has greatly reduced size, approximately 1/4th and 1/5 th of the cost of CT.
2. *Fast Acquisition* More advanced CBCT scanning is performed in less than 30 s.
3. *Submillimeter Resolution* Which provide submillimeter voxel resolution in all orthogonal planes.
4. *Relatively Low Patient Dose* Effective dose for various CBCT device ranges from 25 to 1025μ Sv depending on the type and model of CBCT equipment and imaging protocol used. The different effective dose between various forms of radiographic imaging systems are compared in Table 6.

Table 6

Radiation exposure of different imaging methods [7]

Imaging method	Effective dose [µSv]
Intraoral radiograph	<1.5
Panoramic	2.7–24.3
Cephalometric radiograph	<6
Dentoalveolar CBCT (FOV height <10 cm	11–674
Craniofacial CBCT (FOV height >10 cm)	30–1073
MSCT maxillo-mandibular	280–1410

In the present study, only 25% (28) agreed that CBCT requires less radiation dose, only 15% (17) of the study group agreed that CBCT requires less exposure time. 50% (5) of the population believed wrongly that CBCT requires high maintenance. 28.1% (31) responded that the spatial resolution of CBCT is more than that of conventional CT. All the results obtained here indicates that, when CBCT compared with Conventional CT, very few participants actually knew the advantages of CBCT over CT and rest participants did not have any knowledge regarding the advantages.

Limitations

1. *Contrast Resolution* Contrast resolution of CBCT is bad and consequently the soft tissue cannot be evaluated, so CBCT should be avoided in patients with a lesion or proven malignancy.
2. *Density Resolution* Low radiation intensity comes at the cost of a much narrower density scale than on CT thus less fine discrimination of soft tissue density. Study of soft tissue extension of pathological process (tumour, infection or facial blood effusion) cannot be done, which is better visualised in CT or MRI.
3. *Noise* Noise degrades image quality. In clinical application, the scattered to primary radiation ratio may be 0.4–2 in CBCT imaging. For these reasons, it is always desirable to use the smallest FOV possible when making a CBCT image.
4. *Poor Soft Tissue Contrast* Contrast resolution is the ability of an image to reveal subtle difference in image quality. CBCT has a poor soft tissue contrast.

Various applications of CBCT in ENT

Sino-Nasal Pathology

Paranasal Sinus Imaging and Sinus and Tooth Relations The relatively low radiation dose, high quality bone definition, and compact design of CBCT have made it attractive for scanning paranasal sinuses [8]. For the diagnosis of chronic rhinosinusitis, inflammatory sinusitis, CBCT can be used. Low dose imaging

is crucial as inflammatory sinus disease is often recurring and results in repetitive imaging requests, in such cases CBCT provides good spatial resolution with reduced FOV [9].

The present study, the response rate (yes) for population knowing the application of CBCT in tooth sinus relation was only 25% (28),which indicates many ENT surgeons (75%) did not knew about CBCT in sinus nasal imaging.

Endoscopic sinus surgery Evidence supporting sinus CBCT has emerged from exploration of intra operative CBCT imaging to endoscopic sinus surgery (ESS) [10]. Rafferty et al. established that both spatial and soft tissue contrast was sufficient to aid surgical navigation in the frontal process [11]. CBCT is has also been used recently to evaluate contrast delivery during sinus irrigation after ESS.

The response rate (yes) of the study population knowing about the use of CBCT on Endodscopic sinus surgery was only 34.4%(38).

CBCT in TMJ

Because of superimposition of different structure in the TMJ area, condylar fractures were missed out in native 2D images. They were diagnosed by the CT or MRI but at the cost of heavy radiation dose. CBCT is an alternative to these in the study of bony pathology of TMJ of CBCT. Osteoarthritis, inflammatory arthritis, synovial chondromatosis, ankylosis are frequent indications of CBCT, but TMJ pain and internal disc derangement should be studied by MRI [12].

71.9% (79) of the study population did not know (response rate NO) about the application of CBCT in TMJ pathosis.

Maxillofacial and Nose Trauma

Good spatial resolution and volume rendering quality of CBCT enable excellent study of small maxillo mandibular fractures involving the nasal bones, sinus or orbital walls or mandibular condyles. Zygomatico maxillary complex fractures at the level of cribriform plate, which are easily detected on coronal and sagittal CBCT [13, 14].

18.8% (21), of the study population actually knew (response rate YES) the role of CBCT in identifying the nasal bone fractures.

Temporal Bone

Temporal Bone Pathology Today temporal bone imaging is one of the highest radiation burden and is the most challenging. CBCT is less sensitive to metal artefacts from metal containing pistons and middle ear implants, implants. CBCT had the potential to acquire images with a better spatial resolution of 75–I50 micron at lower radiation dose [15].

21.9% (24) of the study population agreed that CBCT can be used for imaging temporal bone pathology.

Middle/Inner Ear Malformation CBCT is useful in selected imaging tasks, including evaluation of inner and middle ear malpositioning. In patients with chronic otitis media, the lysis of lenticular process or long process of incus, inflammatory changes between incus and mallius, subtle tympanosclerosis, incudostapedial luxation CBCT is very useful.

21.9% (24) of the study population agreed that CBCT can be used for imaging inner ear and middle ear malformation.

Cochlear Implant Visualization High quality CBCT helps in post operative, middle and inner ear cochlear implant visualization implant evaluation, visualisation of reuniting duct in the inner ear, intraoperative temporal bone surgical guidance [16].

25% (28) of the study population agreed that CBCT can be used for visualization and evaluation of cochlear implant.

Ossicular Chain Malformation- CBCT can also be used in progressive hearing loss in predicting continuity of ossicular chain malformation and in detecting ossicular erosions [17] Excellent spatial resolution of CBCT, leads to diagnosis of anatomic ossicular chain malformation or fixation bone dysplasia.

25% (28) of the study population agreed that CBCT can be used for imaging of ossicular chain malformation.

Obstructive Sleep Apnoea

CBCT can be used to assess 3D evaluation of the cephalometric changes in the craniofacial region and volumetric changes in the oropharyngeal region of patients diagnosed with obstructive sleep apnoea syndrome after maxillomandibular advancement and genial tubercle advancement surgeries. [18].

Only 15.7% (17) of the study population agreed (YES) that CBCT can be used for diagnosis of obstructive sleep apnoea.

Airway Imaging

CBCT is the choice of investigation in3D analysis and visualization of upper airway, [19]. Lateral cephalometry and CBCT when compared for nasopharyngeal space airway area and volume, concluded that CBCT is an accurate method of analysing the nasopharyngeal space [20]. The drawback is thoracic and oesophageal region is not well visualised. CBCT helped in 3D analysis of airway with cleft lip and palate [21].

46.8% (51) of the study population responded YES in the role of CBCT in 3D analysis of airway and 21.8% (24) of the study population responded YES for visualization and imaging of airway.

Naso Lacrimal Gland and Salivary Glands

CBCT with Dacryocystography with some iodine contrast media for lachrymal canaliculi and sac is used to check blockade in nasolacrimal duct. Few salivary gland calculi and duct canaliculi which can be missed in normal US scan and sialography can be well detected in CBCT [22, 23].

Only 18.7% (21) of the study population knew about the role of CBCT in identifying blockade in naso lacrymal duct.

It is found from the study that there was low or limited awareness amongst the ENT surgeons regarding applications of CBCT. The responses to the above questions emphasized the absence of complete and accurate information regarding CBCT. However, if there is a lack of awareness among the ENT practitioners, its potential can never be explored to the fullest.

All of the participants felt that there is a lack of the standardized training program in CBCT in the state of Odisha. It is suggested that there is a general need felt by the ENT specialists to have a structured, detailed and formal training in CBCT. It is suggested that efforts should be made to improve students' knowledge base regarding CBCT and that the medical school curriculum should devote more curriculum time to this promising new technology like CBCT.

Conclusion

Cone beam computed tomography is a relatively advanced imaging technique with a profound potential in the field of ENT. The study results indicated that there is a definite gap in knowledge of CBCT and its various applications amongst the ENT specialists. All the participating ENT specialists felt that there is a lack of awareness as well as training in this field. Introduction of training in CBCT at undergraduate as well as Post graduate level shall ensure that ENT specialists use this technique in an efficient way to improve the accuracy and reliability of ENT diagnosis, treatment planning and outcomes.

Because of various advantages of CBCT over conventional CT, in near future CBCT might eventually become the gold standard in imaging of many ENT disorders but at the same time due to its poor density resolution and soft tissue contrast, in certain cases CT and MRI are still the choice of imaging in ENT.

Electronic supplementary material

Below is the link to the electronic supplementary material.

Supplementary material 1 (DOCX 14 kb)(15K, docx)

Footnotes

Electronic supplementary material

The online version of this article (doi:10.1007/s12070-017-1168-4) contains supplementary material, which is available to authorized users.

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