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Case Study

CBCT AUDIT: AN EVALUATION OF REFERRAL PATTERN TREND

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A B S T R A C T

Aim: To analyse the trends of scans referred to the department of radiology.
Materials and Methods: Retrospective CBCT data was retrieved for the study over a period of 3 years. All included scans were analysed for referral department, reasons for referral, optimum diagnostic value, exposure parameters used and CBCT artifacts. Stitched and partially reconstructed scans were excluded.
Results: Analysis revealed that a majority of scans were indeed justified, however discrepancies in calculating a risk/benefit ratio led to few avoidable exposures.
Conclusion: This paper will enhance the knowledge of CBCT indications possessed by the clinician. It may also aid professionals in adopting discretion while advising radiographs and thereby help optimise patient care in tandem with the principle of ALADA (as low as diagnostically achievable).

INTRODUCTION

An audit is the process of evaluation or analysis of a particular methodology to determine its accuracy or safety; it can also be a document which declares the result of such an analysis. Audits were first employed in dentistry by Forte and Richardson (1990), Flood et al (1990), Beruard (1994) [1] to improve the quality effectiveness and efficiency of patient care. When it comes to dental imaging, Cone beam Computed Tomography (CBCT) has paved a significant path into dental diagnosis and treatment due to the advantages it offers over two dimensional radiographs; namely better image quality, three dimensional visualisation and accurate measurements. However the relatively higher use of ionizing radiation compared to conventional imaging modalities increases the potential impact on public health. The risk to public health from unwarranted exposure, probable inappropriate application of the technology, lack of adoption of measures to minimalize patient exposure, and the ineffectiveness of radiation protection has been perceived by the ICRP.[2] SEDENTEXCT (Safety and Efficacy of a New and Emerging Dental X-Ray Modality) have developed 20 basic principles on evidence-based guidelines dealing with justification, optimisation and referral criteria for users of CBCT. Regular clinical audits should be carried out by establishments conducting CBCT examinations have been emphasized by the same.[3.]

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Periodic audits of patient imaging studies are also recommended by ICRP to ensure optimal use of the imaging system[4]. It may be possible that most guidelines are not always put in to practice. We therefore hypothesised that there could be a probability of inappropriate use of CBCT. The aim of this study was to conduct an audit of CBCT scans done in an oral radiology unit of a dental school associated with a tertiary hospital. The audit would evaluate the justification of CBCT scans and assess the diagnostic value of each scan emphasising on various artifacts and their effects on the diagnostic value.

MATERIAL AND METHODS

This audit was designed as a retrospective study. A total of 549 CBCT scans taken by the oral radiology unit over the last three years were chosen. Stich CBCT images and partial reconstructed images were excluded from the study. All CBCT scans were taken on Carestream KODAK 9000 3D machine with a field of view (FOV) size of 50X37 mm, voxel size of 76.5X76.5X76.5µm and X-ray pulse time of 30ms. The kVp was set at 60-90kV and current at 2-15mA with exposure time between 9 to 10.8 seconds. Stitched CBCT images and partially reconstructed images were excluded. All included scans were analysed for referral department, reasons for referral, optimum diagnostic value, exposure parameters used and CBCT artifacts. Optimal diagnostic value was determined on the basis of quality of scans, diagnostically acceptability of scans. The obtained data was analysed and segregated into respective categories.

RESULTS

Biometric value

Of the 549 scans, 278 belonged to males and 271 to females with age ranging from 8 to 60 years. The highest percentage of scans (24.4%, 134) belonged to the 20-30 years group and the least belong to under 10 years of age (18 scans, 3.2%) (Table 1)

Table 1 Distribution of number and percentage of various scans for different age groups.

Age Group	Number of Scans (Percentage)
< 10 YEARS	18 (3.2%)
10 – 20	78 (14.2%)
20- 30	134 (24.40%)
30- 40	107 (19.4%)
40- 50	99 (18.03%)
50- 60	57 (10.3%)
>60	56 (10.2%)

Referral

The highest referrals for CBCT scans were for assessment of periapical pathologies among both adults and paediatric population accounting for 28.96 %of the scans followed by implant site assessment constituting about 23.86 % of the scans. Over-retained root stumps (0.18%), Medicolegal cases (0.36%), root resorptions and bony lesions involving maxillary sinus (0.55% each) andoro-antral fistula (0.73%) were the least scoring concern for referrals. (Table 2)

Table 2 The number, percentage and reasons of different CBCT scans referred.

Reasons for referral	Number of scans	Percentage of Scans
Periapical Abscess/ Granuloma	61+24	15.48
Variation in root canal anatomy	34	6.19
Periapical cyst	30	5.46
Missed canals	10	1.82
Post RCT non healing lesions	10	1.82
Instrument breakage	10	1.82
Malignancy	18	3.27
Medicolegal Cases	2	0.36
Benign /malignant/cystic lesion	25	4.55
Maxillofacial trauma	13	2.36
Impacted teeth	11	2.00
TMJ pain	6	1.09
OAF	4	0.72
Over retained root stump	1	0.18
Bone quantity assessment	32	5.82
Soft tissue lesions	2	0.36
Impacted canine positions	41	7.46
Implant site assessment	89+42	23.86
Periapical lesions (pediatric)	34	6.19
Cystic lesion	21	3.82
TMJ fracture / inflammatory lesion of TMJ	12	2.18
Root resorptions	3	0.54
Mandibular canal relation with 3rd molar	5	0.91
Lesions with impacted teeth	4	0.72
Bony lesions extending into maxillary sinus	3	0.56
Others	2	0.36

Optimal diagnostic value

From 549 scans taken, 513 were diagnostically acceptable while 36 scans needed to be repeated. 24 of the scans were repeated because of patient movement and 12 because of radiographic artifacts like beam hardening, metal and motion artifacts which had hampered the diagnostic information.

Exposure parameters

The various exposure parameters for different body sizes is explained in the below table (Table no 3)

Table 3 Various exposure parameters for different body sizes.

SIZE	NO.	Kilo Voltage (KV)	Current (MA)	Exposure (SEC)	Absorbed Dose (mGycm2)
Pedo	28	68	6.3	10.8	131
Small	100	70	8	10.8	174
Medium	150	70	10	10.8	218
Large	222	70	10	10.8	227

DISCUSSION

Imaging using cone beam technology has swiftly become a widespread and regularly used imaging modality to aid dentists and other health care professionals in a multitude of diagnostic tasks to improve patient care.[5]

Implementing the ALARA principle in CBCT technology may not be getting done because very few dentists in private practice have advanced training in Oral and Maxillofacial Radiology. The possibility of CBCT units being used with the default settings set for the of images requiring wide field of view, needlessly exposing many patients, to excess radiation also cannot be exempted.

It is not surprising that the most exposed section belonged to the age group of 20-40 years of age, accounting for 39% of total patients scanned. CBCT scanning of this age group may be acceptable with appropriate justification, however optimal protection needs to be provided. Data obtained from ICRP 1990, representing relative attributable lifetime risk based upon a relative risk of 1 at age 30 showed that multiplicative risk for age groups 20-30 was 1.5 times higher than usual.

Women comprised almost 50% of the scanned group, inspite of the risk of stochastic effects due to radiation exposure in women being higher for all age groups. The least exposed group was below 10 years of age, however it still accounted for 3.2% of all scans, which is of concern since multiplicative risk was highest (x 3) in this age group. That women and children are more susceptible to radiation-induced cancer than men is a well-known fact1and therefore caution needs to be exercised during referrals made for the same.

Though studies suggest higher sensitivity of CBCT for detection of periapical lesions, in practice, clinical signs and symptoms aid significantly in diagnosing these lesions and radiological evidence obtained from intraoral radiographs can sufficiently aid in diagnosis, without the need of CBCT being the standard of care in all such cases.

In a study conducted on 24 patients it was found that lesion size and choice of treatment of periapical lesions based on CBCT radiographs do not change significantly from those made on the basis of 2 D radiographs[6]. However, limited volume, high resolution CBCT may be indicated for periapical assessment, in selected cases, when conventional radiographs give a negative finding when there are contradictory positive clinical signs and symptoms.

With 34 cases referred for variations in root canal anatomy, and 10 for missed canals, it is imperative to know that

endodontics requires a high level of image detail, which current CBCT systems fail to deliver, thereby defeating the purpose of the scan. Also, the field of view required is very less, and systems unable to reduce the FOV will cause unnecessary exposure to other parts. Thus, CBCT scanning should be mandated only in those cases where inadequate treatment planning information is provided by conventional intraoral radiographs and not as a standard to determine the root canal anatomy. However, when surgical endodontic procedures are planned, CBCT scans may be justified to analyse potential complicating factors such as proximity to anatomical structures.

25 cases from Oral Surgery and 21 cystic lesions plus 3 bony lesions from Oral Medicine and Pathology were referred for assessment of benign/malignant/cystic lesions. CBCT scans are justified in these cases if initial imaging modalities failed to provide adequate information to distinguish between benign and malignant tumors or lesions of oral carcinoma.

In cases of maxillofacial trauma, where soft tissue detail is not required, use of CBCT is justified to provide cross sectional imaging and provide information on degree of communication, displacement, etc.

11 cases were referred for impacted third molars from Oral Surgery department and 5 cases from Oral Medicine and Radiology to assess the mandibular third molar relation to mandibular canal. This can be justified only if conventional radiographs in these cases suggested proximity of the impacted tooth to vital structures and should not be routinely used for diagnosis of all impacted teeth. CBCT gave a better bucco-lingual appreciation of the nerve canal and aided in planning the surgical approach, when the nerve was lingually placed.

Three percent of the scans were for Oral Malignancy. Often the clinical appearances in such cases are diagnostic enough; if not, biopsies are confirmatory. Such patients routinely undergo a CT scan. In addition, they are exposed to 60 to 70 Gy of radiotherapy. The response is often checked by CBCT and post treatment too, the patient is subjected to follow up PET-CT scans amounting to a lot of cumulative exposure. Adding the burden of CBCT scan for the sole purpose of diagnosis is not really justified.

In cases of TMJ pathology, 6 cases were referred from Oral Surgery and 12 from Oral Medicine and Radiology, when bony abnormalities or fractures were suspected. CBCT scans may alter the management of the patient over conventional radiographs, and are thus justified in these cases.

32 cases were referred for assessment of bone quantity. However 2 cases were referred for gingival soft tissue assessment after graft placement. Where it is likely that evaluation of soft tissues will be required as part of the patient's radiological assessment, the appropriate imaging should be conventional medical CT or MR, rather than CBCT, since it offers no diagnostic value in such cases.

41 cases were referred for impacted canine position from Orthodontia department. This should sound a warning of caution since it is not justified as the first modality of diagnosis and needs to be used only when external resorption of other teeth is suspected or management modality may change after CBCT scan.

131 cases were referred for implant site assessment, 89 from the department of prosthodontics and 42 externally referred. . This is justifiable as cross sectional imaging is required prior to implant placement and CBCT offers a better alternative compared to other existing cross sectional modalities like MSCT (Multi Slice Computed Tomography) where radiation dose is higher. Also, with its adjustable FOVs, CBCT scan offers advantage over MSCT, since only a localized part of the jaws need to be exposed. Also, scans provided accurate geometric measurements of the bone height, width and length, along with its proximity to important structures such as nerves, vessels, roots, nasal floor, and sinus cavity.

34 cases were referred for diagnosis of periapical pathoses in paediatric patients, an alarming statistic. As mentioned above, children in the age group of 1-10 years had the highest multiplicative risk (3 times the normal) to stochastic effects like cancer from radiation exposure and high dose radiation exposure should be reserved only for special cases where clinical findings and routine radiographic aids did not suffice to aid in diagnosis.

Radiation Dose and Exposure Parameters

Absorbed dose is the basic physical dose quantity and is the energy deposited to tissue per unit mass. It is a measurable quantity but is not a good indicator of the biological damage. The radio sensitivity of tissues is taken into account by using a special dose quantity known as effective dose which is a more relevant quantity to estimate the stochastic effects.

Exposure parameters varied for paediatric patients and adult patients based on their size as mentioned above. With increasing patient size, increased radiation dose was required thereby causing net increase in absorption. The table below shows the risk in relation to age. The data was derived from ICRP (1990) and represent relative attributable lifetime risk based upon a relative risk of 1 at age 30 (population average risk). (Table 4)

Table 4 Multiplication factor for risk according to Age groups

Age group (years)	Multiplication factor for risk
<10	x3
10-20	x2
20-30	x1.5
30-50	x0.5
50-80	x0.3
Above 80	Negligible risk

According to the data collected during the audit, out of the 34 pediatric patients scanned, 6 scans were taken without altering any of the parameters which is totally unacceptable keeping in mind the huge risk it endows on the patient.

Artifacts

Artifacts in radiographic imaging are discrepancies between the reconstructed visual image and the actual content of the subject being studied. Artifacts can seriously degrade the quality of computed tomographic (CBCT) images, sometimes to the point of making them diagnostically unusable. The various artifacts included beam hardening, metal artifacts, motion artifacts, aliasing and ring artifacts, exponential edge gradients and noise artifacts.

As mentioned above, from the 36 scans which were repeated and caused unnecessary patient exposure, 10 were due to

artifacts while the rest were due to patient movement. This double exposure could have been avoided by careful patient positioning and optimal selection of scan parameters.

CONCLUSION

This was one of the first comprehensive CBCT audits conducted in an OMR department. It reiterates the basic principles laid down by SEDENTEXCT. CBCT should only be used when the question for which imaging is required cannot be answered adequately by lower dose conventional (traditional) radiography. Where CBCT equipment offers a choice of resolution, the resolution compatible with adequate diagnosis and the lowest achievable dose should be used. The justification process is a highly important part of this audit and it can't be stressed enough that all CBCT examinations must be justified for each patient to demonstrate that the benefits do outweigh the risks to the patient. CBCT has a great range of clinical applications. The 3D information from a CBCT scan gives the potential for an improved diagnosis for the patient and must do so to justify the higher dose than that used in conventional radiology. The dose can be optimised by using a lower resolution and as small a volume as possible.

Based on the above results and discussion, this CBCT audit could help in improving diagnostic accuracy, encouraging the need for justifying a scan, minimizing radiation exposure and identifying and avoiding various artifacts and their effect on the diagnostic value.

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