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ACCURACY OF CONE BEAM COMPUTED TOMOGRAPHY (CBCT) IN ENDODONTICS: A STUDY OF COMPARISON OF CBCT VS. DIGITAL INTRA-ORAL PERI-APICAL RADIOGRAPHS IN THE EVALUATION OF PERIAPICAL RADIOLUCENCY IN ENDODONTICS

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ABSTRACT

CBCT is a newer technology, that utilizes a cone-shaped beam of ionizing radiation and advanced reconstruction algorithms to generate a 3-D reconstruction of the maxillofacial region, has superior imaging capabilities over traditional 2-D Digital Intra-oral Peri-Apical Radiographs (IOPAR). CBCT represents an accurate evaluation of root canal morphology, peri-apical pathology, and dental anomalies. However, CBCT carries the drawback of increased radiation exposure and high cost. Our study compares the diagnostic accuracy of Cone Beam Computed Tomography (CBCT) vs. Digital Intra-oral Peri-Apical Radiographs (IOPAR) in the assessment of periapical radiolucency in post endodontic cases, while contributing to the existing literature on CBCT's role in endodontics.

A sample of 105 teeth from 60 patients were included in the study, with endodontic treatment within the past six months. The detection of periapical radiolucency was evaluated, using CBCT as the gold standard. Statistical analysis, including the Chi-Square test and odds ratio analysis, were conducted to compare the diagnostic performance of CBCT and IOPAR.

CBCT exhibited a higher sensitivity (100%) and specificity (57.14%) compared to IOPAR in detecting periapical radiolucency. However, the observed difference between the two imaging modalities was not statistically significant ($p > 0.05$). The odds ratio analysis indicated a 1.7 times greater chances of detecting periapical lesions when employing CBCT as the diagnostic modality.

CBCT has better accuracy than IOPAR in detecting periapical radiolucency in post-endodontic cases. However, further research is required for evidence-based recommendations for routine use of CBCT in endodontics.

Keywords: *Cone beam computed tomography, Endodontics, Intraoral periapical radiograph, Periapical lesion.*

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INTRODUCTION

Cone beam computed tomography, CBCT is a relatively advanced technology using ionizing radiation in shape of cone beam and a reciprocating detector, which rotates 360 degrees around the patient [1], and acquired data is used for 3D reconstruction using a conical beam [2]. Using an algorithm, the data is analyzed and reconstructed to generate a data volume, which is viewed in 3 dimensional planes, i.e. sagittal, axial and coronal or multiple desired planes at the manipulation of the acquired data [3]. CBCT enables precise details of maxilla-facial bony structures in multiple planes [4]. Its advantages over 2D imaging and benefits in endodontic practice have been well accepted in literature [5]. In Endodontics, the application of CBCT has enhanced the diagnostic task and pre-operative assess-

ment of root canal morphology, dental anomalies and peri-apical pathology, procedural errors and outcome success. Periapical radiolucency are regularly seen in Endodontic cases. The radiographic diagnosis of peri-apical radiolucent lesions are very important during root canal treatment. An inflammation in periapical tissues occurs against irritants, due to an inflammation that developed in the pulp tissue [6]. Intra Oral periapical radiograph, IOPAR is primarily indicated in endodontics, but provides only 2D representation of 3D structures. CBCT has overcome some limitations of 2D radiography, however; there is high radiation exposure to the patient [7]. Digital IOPAR has now been chosen over conventional intra oral film radiography by dentists' due to well documented advantages, because it does not require film processing [8].

In Post Endodontic treatment follow-up: when CBCT is compared to IOPAR, 3D imaging reveals earlier signs of healing. However; CBCT scans, like traditional radiography, cannot distinguish between pathologic or scar tissue in periapical radiolucency, in previously endodontic treated teeth [9]. CBCT has a higher accuracy in detecting peri-apical radiolucency compared to IOPAR. The indications for limited FOV CBCT should follow American association of Endodontics, AAE guidelines for its use in endodontics [10]. The guidelines of ALARA principle for the use of CBCT in dentistry should be followed [11], because the radiation dose of CBCT is much higher than that of digital intraoral periapical radiography. CBCT scans can significantly improve the provision of endodontic care, beyond diagnosis and treatment planning. CBCT provides a plan before an access is made, locating previously less accessible canals and managing difficult calcification, e.g. MB2 canal in a maxillary molar [12]. Additionally, CBCT allows to monitor the healing process more effectively. CBCT has a shown a significant impact in endodontics, since it has changed the approach, the endodontic success outcomes are assessed [13].

The rationale for this study is to compare the diagnostic accuracy of CBCT and IOPAR in the detection of periapical radiolucency in post–endodontic cases. This study aims for evidence based recommendations regarding the use of CBCT in periapical lesion detection, considering its advantages over 2D imaging and the potential drawbacks associated with increased radiation exposure and cost. The study's findings can provide valuable insights for clinicians in selecting the appropriate imaging modality for detection of periapical lesion, incorporating CBCT technology in routine endodontic diagnostics in Pakistan, therefore; improving the quality of endodontic diagnosis and endodontic treatment planning.

Objective

Comparing the diagnostic accuracy of CBCT and digital intraoral peri-apical radiographs, determining the sensitivity and specificity of both imaging modalities in detecting and characterizing periapical lesions, evaluating their ability to provide complete diagnostic information, comparing their clinical utility in endodontic evaluation, and contributing to the existing literature on the role of CBCT in endodontics.

MATERIALS AND METHODS

Study design

This study is a comparative cross sectional study.

Case selection

Sample size: 105 teeth in patients.

Duration: 6 months, 1st-Nov 2022 to 30th-April 2023.

Setting: Department of Endodontics at Bakhtawar Amin Dental College Multan.

Inclusion criteria

- Patients with Root canal treated tooth within 6 months of study.

- IOPAR for post Endodontic follow-up.

- CBCT imaging performed for treatment Case planning.

Data collection

105 teeth in 60 patients have satisfied these criteria. Informed consent was taken from each patient. The sample size of n = 105 patients was determined using a power analysis with a 95% confidence interval and a power of 80%. The effect size was estimated based on a previous study with similar objectives. The Digital intra-oral radiographs were acquired by intraoral CMOS HDR sensor and viewed on imaging software. CBCT images were acquired by Carestream Kodak 9300 3D come Beam and interpreted on CS 3D imaging software. Each image was evaluated by the operator.

Data Analysis

In this study, the accuracy CBCT and digital IOPAR were compared, to evaluate the presence or absence of peri-apical radiolucency in post-treatment endodontic cases, while CBCT being considered as the gold standard imaging modality. The data were analyzed using statistical software SPSS-26. The Chi-Square test was used to compare the diagnostic performance of CBCT and IOPAR with a significance level of 0.05. The diagnostic accuracy of both modalities was determined by calculating the accuracy, specificity, sensitivity, positive predictive value and negative predictive value, by taking CBCT as Gold standard.

RESULTS

Out of the 105 total samples, 69 lesions were detected by CBCT, while only 41 lesions were detected by digital peri-apical radiographs. Additionally, 36 lesions were not detected by CBCT, while 64 lesions were not detected by IOPAR. Statistically there is no difference between the two diagnostic modalities. The results showed that CBCT had a higher sensitivity of 100% and specificity of 57.14% compared to IOPAR. Based on given data and considering CBCT as Gold standard, we have following values:

- True Positive = 69
- False Positive = 27
- False Negative = 0
- True Negative = 36

Using these values, we can calculate the following statistical measures:

- Sensitivity = TP / (TP + FN) = 1.0 or 100%
- Specificity = TN / (TN + FP) = 0.5714 or 57.14%
- PPV = TP / (TP + FP) = 0.7183 or 71.83%
- NPV = TN / (TN + FN) = N/A (no FN)

The results of this study show that peri-apical lesion detection on CBCT is 65.7% and, on IOPAR is 39% (table 1). The Chi-square test is applied and p-value is 0.198. The P-value of < 0.05 is taken as statistically significant, therefore; the assumption of rejecting the null hypothesis is violated, and we will accept the null hypothesis. According to odd ratio analysis (table 2), there are 1.7 times higher chances of detecting a PA lesion when CBCT is used as a diagnostic modality.

TABLE 1: VARIABLES: PERIAPICAL LESION ON CBCT VS IOPAR

Variables	Pearson's Chi Sq Test n=105		
	On CBCT	On IOPAR	p-value*
Periapical Lesions	69 (65.7%)	41 (39%)	0.198

*p-value < 0.05 are taken as statistically significant

TABLE 2: RISK ESTIMATE WITH 95% CONFIDENCE INTERVAL

	Value	Lower	Upper
Odds Ratio for PA Lesion Detected on CBCT (NO / YES)	1.748	.744	4.107
For cohort PA Lesion Detected on IOPAR = NO	1.229	.911	1.658
For cohort PA Lesion Detected on IOPAR = YES	.703	.401	1.232
N of Valid Cases	105		

DISCUSSION

Several Studies have shown that CBCT has the higher accuracy in detecting peri-apical radiolucency as compared to IOPARs, demonstrating the advantage of CBCT on decision making and treatment planning [14]. CBCT can be used to evaluate anatomical variations in the root canals [15]. The diagnostic efficacy of IOPAR and CBCT for identifying simulated apical periodontitis in extracted teeth was evaluated in a research, the authors concluded that CBCT is the gold standard method for identifying apical periodontitis [16]. One study concluded that, the CBCT imaging has a plays a significant role in diagnosing the etiology of endodontic pathology and prescribing treatment [17]. Compared to two-dimensional imaging methods, the sensitivity of CBCT in detection of periapical radiolucency was much higher [18]. Periapical digital radiography has a shown less sensitivity in detection of periapical radiolucent lesions, as compared to CBCT [19]. A study found out that, the iatrogenic errors and periapical lesions present in post- endodontic cases on CBCT were noted; prevalence of post-operative periapical radiolucencies were 81% in the presence of iatrogenic errors [20]. CBCT can be used successfully to determine root canal configurations. Several studies have been conducted in Pakistan on root canal morphology using CBCT; In one study, 26.2% mandibular incisors had two canals in Pakistani population [21]; in another study, the frequency of 2nd MB2 canal in maxillary molars was found to be 56% [22]; while in another study, out of 189 mandibular molars, middle mesial canals were found in 9 and isthmus in 62 teeth [23]. In a study of CBCT based assessment in a Pakistani population, the proximity of roots to the maxillary sinus floor were evaluated. The mesio-buccal root of the maxillary 2nd molar was the most common tooth root protruding in the sinus, followed by palatal roots of the maxillary first molar [24]. CBCT should be judiciously used, when the history and clinical examination of a patient shows its benefits, more than its potential risks. Thus, CBCT is not recommended in the absence of clinical signs and symptoms, [25]. Indications for CBCT during endodontic treatment includes assessment of root morphology, clinical diagnosis, evaluation of root resorption, traumatic dental injury, root perforations, vertical root fractures, and 3D endodontic tooth guides [26]. CBCT along with the 3D printed tooth models can be used for an educational perspective and training purpose in endodontic treatment [27]. Small FOV is indicated in endodontics, improving the spatial resolution and minimizing the

effective radiation dose and, small FOV CBCT with higher resolution, may allow detection of cracks [28]. Reporting on the CBCT data requires that entire volume of acquired CBCT data should be analyzed and reported systemically [29]. CBCT provides a distinct technological advantage in endodontic practice, as it significantly improves the detection of endodontic pathology [30].

However, it is important to consider the limitations and potential drawbacks of CBCT, such as increased radiation exposure, beam hardening effects, and higher cost. Further research and evidence are needed to provide more definitive recommendations regarding the appropriate imaging modality for periapical lesion detection in endodontics, when deciding on its use in routine endodontic diagnostics.

CONCLUSION

This study has compared the diagnostic accuracy of CBCT and IOPAR in the detection of periapical radiolucency in post-endodontic cases. CBCT has a higher sensitivity and PPV than IOPAR, indicating that CBCT is better at detecting periapical lesions and identifying true positives. However, IOPAR has a lower specificity, meaning it may produce more false alarms or false positives than CBCT. Therefore; it can be concluded that CBCT is more accurate than IOPAR in detecting periapical lesions. Nevertheless, CBCT has limitations and potential drawbacks. Dental Practitioners should adopt a balanced approach that considers both the advantages and limitations of CBCT and IOPAR, ensuring accurate diagnosis while minimizing unnecessary risks.

REFERENCES

1 Nasseh I, Al-Rawi W. Cone Beam Computed Tomography. Dent Clin North Am. 2018;62(3):361-391. doi:10.1016/j.cden.2018.03.002

2 Mena Álvarez J, Zubizarreta Macho Á. Applications of CBCT in Endodontics [Internet]. Oral Diseases. IntechOpen; 2020. Available from: http://dx.doi.org/10.5772/intechopen.89956

3 Patel S, Brown J, Pimentel T, Kelly RD, Abella F, Durack C. Cone beam computed tomography in Endodontics – a review of the literature. Int Endod J. 2019;52:1138–1152. doi:10.1111/iej.131151138.

4 Kaasalainen T, Ekholm M, Siiskonen T, Kortesniemi M. Dental cone beam CT: An updated review. Phys Med. 2021;88:193-217.

5 Patel S, Dawood A, Mannocci F, Wilson R, Pitt Ford T. Detection of periapical bone defects in human jaws using cone beam computed tomography and intraoral radiography. *Int Endod J*. 2009;42(6):507-515.

6 Keser G, Namdar Pekiner F. Periapical Bone Lesions and Radiographic Features. Clin Exp Health Sci 2017; 7: 166-70.

7 Khanna, A.B. Applications of cone beam computed tomography in endodontics. Evid.-based Endod. 2020;5(1):1. https://doi.org/10.1186/s41121-020-00020-4.

8 Campello AF, Gonçalves LS, Guedes FR, Marques FV. Cone-beam computed tomography versus digital periapical radiography in the detection of artificially created periapical lesions: A pilot study of the diagnostic accuracy of endodontists using both techniques. Imaging Sci Dent. 2017;47:25-31.

9 Torabinejad M, Rice DD, Maktabi O, Oyoyo U, Abramovitch K. Prevalence and size of periapical radiolucencies using cone-beam computed tomography in teeth without apparent intraoral radiographic lesions: a new periapical index with a clinical recommendation. J Endod. 2018;44:389–394. https://doi.org/10.1016/j.joen.2017.11.015.

10 American Association of Endodontists, American Academy of Oral and Maxillofacial Radiology. Use of cone-beam computed tomography in endodontics Joint Position Statement of the American Association of Endodontists and the American Academy of Oral and Maxillofacial Radiology, Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2, 2011;111: 234-237.

11 Bueno MR, Estrela C, Azevedo BC, Diogenes A. Development of a New Cone Beam Computed Tomography. Braz Dent J. 2018;29(6):517-529.

12 Blicher B, Pryles RL. Uses for Cone Beam Computed Tomography In Endodontic Care. Decisions Dent. 2020;6(1):10, 12-14, 17.

13 Estrela C, Pécora JD, Estrela CRA, et al. Common operative procedural errors and clinical factors associated with root canal treatment. Braz Dent J 2017;28:1-12.

14 Patel S, Brown J, Semper M, Abella F, Mannocci F. European Society of Endodontology position statement: Use of cone beam computed tomography in Endodontics: European Society of Endodontology (ESE) developed by. Int Endod J. 2019;52(12):1675-1678. doi:10.1111/iej.13187.

15 Almeida JC, Candemil AP, Bertolini GR, et al. Cone-beam computed tomographic evaluation of the root canal anatomy of the lower premolars and molars in a Brazilian sub-population. Imaging Sci Dent. 2023;53(1):77-82. doi:10.5624/isd.20220204

16 Ludlow JB, Laster WS, See M, Bailey LJ, Hershey HG. Comparison of periapical radiography and cone-beam computed tomography for detecting simulate apical periodontitis: an in vitro study. J Endod. 2008 Aug; 34(8):959-962.

17 Chogle S, Zuaitar M, Sarkis R, Saadoun M, Mecham A. The Recommendation of Cone-beam Computed Tomography and Its Effect on Endodontic Diagnosis and Treatment Planning. J Endod. 2020;46(2):162-168.

18 **Ramis-Alario A, Tarazona-Alvarez B, Cervera-Ballester J, Soto-Peñaloza D, Peñarrocha-Diago M, Peñarrocha-Oltra D, Peñarrocha-Diago M. Comparison of diagnostic accuracy between periapical and panoramic radiographs and cone beam computed tomography in measuring the periapical area of teeth scheduled for periapical surgery. A cross-sectional study. J Clin Exp Dent. 2019 Aug 1;11(8):e732-e738.**

19 Asa I, Nasutianto H, Okano T. Diagnostic accuracy of periapical radiolucency using periapical radiography and cone-beam computed tomography. Jurnal Radiologi Dentomaksilofasial Indonesia (JRDI). 2023;7(1):10.32793/jrdi.v7i1.934.

20 Al Yahya RS, Al Attas MH, Javed MQ, et al. Root Canal Configuration and Its Relationship with Endodontic Technical Errors and Periapical Status in Premolar Teeth of a Saudi Sub-Population: A Cross-Sectional Observational CBCT Study. Int J Environ Res Public Health. 2023;20(2):1142. Published 2023 Jan 9. doi:10.3390/ijerph20021142.

21 Hassam Anjum Mir, Asad-ur-Rahman, Mussab Irfan, Inamullah Jan Khattak, Akhla Nadeem Ahmed, Fawad Ali Shah. Root Canal Morphology Of Mandibular Incisors In Pakistani Population Using CBCT. J Khyber Coll Dent [Internet]. 2020 Sep. 30 [cited 2023 Jun. 1];10(03):7-10

22 Shirazi UR, Yasir F, Shehzad H, Chaudry A. Frequency of second mesiobuccal canal in maxillary first molar detected through cone beam computed tomography. Pak Oral Dent J

2022; 42(1):36-38.

23 Rehman UA, Siddique SN, Rehman S, Munawar M, Ginai HA. Prevalence of middle mesial canals and isthmi in mandibular molars using cone beam computed tomography. J Pak Dent Assoc 2020;29(3):114-119.

24 Motiwala MA, Arif A, Ghafoor R. A CBCT based evaluation of root proximity of maxillary posterior teeth to sinus floor in a subset of Pakistani population. J Pak Med Assoc. 2021;71(8):1992-1995. doi:10.47391/JPMA.462.

25 AAE, AAOMR. AAE and AAOMR joint position statement: use of cone-beam computed tomography in endodontics 2015 update. J Endod. 2015;41(9): 1393-1396.

26 Mazzi-Chaves, J.F., Camargo, R.V., Borges, A.F. et al. Cone-Beam Computed Tomography in Endodontics—State of the Art. Curr Oral Health Rep 8, 9–22 (2021).

27 Ludwig J, Reymus M, Winkler A, Soliman S, Krug R, Krastl G. Root Maturation of an Immature Dens Invaginatus Despite Unsuccessful Revitalization Procedure: A Case Report and Recommendations for Educational Purposes. Dent J (Basel). 2023;11(2):47.

28 Pinto JC, de Faria Vasconcelos K, Leite AF, et al. Image quality for visualization of cracks and fine endodontic structures using 10 CBCT devices with various scanning protocols and artefact conditions. Sci Rep. 2023;13(1):4001.

29 Patel S, Harvey S. Guidelines for reporting on CBCT scans. Int Endod J. 2021;54(4):628-633. doi:10.1111/iej.13443

30 Aminoshariae A, Kulild JC, Syed A. Cone-beam computed tomography compared with intraoral radiographic lesions in endodontic outcome Studies: a systematic review. J Endod. 2018;44:1626–1631.

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