A comparative analysis of periapical status by using cone beam computed tomography and periapical radiography

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Abstract. – OBJECTIVE: The aim of this study was to compare the periapical status of different teeth by using the Periapical (Pa) and the cone beam computed tomography (CBCT) radiographs.

PATIENTS AND METHODS: Pa and CBCT radiographs were obtained from the patients who required Endodontic treatment. The absence and presence of periapical lesions were investigated using both Pa and CBCT radiographs. Periodontal conditions other than periapical lesions were also observed by using both radiographs and recorded. Cohen's Kappa analysis was performed to observe the inter-rater and intra-rater reliability. Descriptive statistics including frequency and percentages of presence and absence of periapical lesions were analyzed. Independent t-test was conducted to compare the Pa and CBCT for the detection of periapical lesions. Chi-square test was used to investigate the distribution of gender and periapical lesions by both radiographs.

RESULTS: A total of 204 teeth from 72 patients (29 female and 43 male) were assessed *via* CBCT and Pa radiographs. Inter-observer and intra-observer reliability showed the absolute level of agreement. T-test showed there is significant difference between Pa and CBCT radiographs regarding detecting periapical lesions. Chi-square test showed no significant differences between the gender and apical pathosis.

CONCLUSIONS: CBCT is more reliable to detect periapical lesions compared to the Pa radiographs.

Key Words:
CBCT, Endodontic lesions, Periapical, Radiographs.

Abbreviations

CBCT: Cone beam computed tomography, FOV: Field of views, Pa: Periapical radiograph, 2D: two-dimensional, 3D: three dimensional.

Introduction

The periapical disease is an inflammatory condition which affects the tissues surrounding to the apex of the tooth due to multiple reasons, such as pulp infection and necrosis[1]. A periapical (Pa) radiograph is an intra-oral, two-dimensional (2D) radiograph (Mesio-distal), which is used to detect periapical diseases. It provides useful information regarding the existence and the extent of peri-radicular lesions[2,3]. Since the information given by Pa radiographs is limited, it might direct the dentists to misidentify or misdiagnose a potential pathology[4,5]. The application of a Pa radiograph is imperative in every step of the procedure to achieve the best possible treatment outcome. It gives us an overview of details of the tooth and bone pathology and anatomical information, canal length, and quality of obturation[6]. The conventional radiographic techniques (including digital and film radiography), have certain limitations while viewing the anatomical structures that could hinder the periapical lesion diagnosis. It was observed that the Pa radiograph does not recognize 30%-45% of periapical lesions[7].

While taking a Pa radiograph, specific technique, such as parallel technique should apply carefully otherwise the peri-radicular lesions might mis-detect[8]. However, this technique might be challenging with a compromised patient with limited mouth opening or gag reflex[9]. Moreover, the diameter of periapical radiolucency on Pa radiograph could be altered through positioning tube head and the film. Previous studies showed that detecting periapical lesions has the greatest disagreement between examiners when using conventional radiographs. Therefore, additional radiographs might be

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required to detect anatomical noise and visualized endodontic lesions with accuracy. Taking serial radiographs by paralleling techniques might increase the image quality; however, they are not always consistently reproducible. Additionally, this leads to increase radiation exposure[10].

2D radiographs exhibit certain limitations in the diagnosis of periapical lesion which confirmed by different *in-vivo* and *ex-vivo* studies[11,12]. Over the past few decades, various new diagnostic approaches have been developed such as cone beam computed tomography (CBCT), ultrasound, densitometry methods of digital radiography, magnetic resonance imaging and nuclear techniques[13,14]. Among them CBCT is widely using since it introduced in the 1990s which is a three-dimensional (3D) extra oral imaging system with an insignificant radiation dosage[15].

Many previous studies confirmed the enhanced diagnostic precision of CBCT over conventional radiographs for the diagnosis of periapical periodontitis. There are two types of CBCT available: comprehensive volume CBCT scanners and the narrow CBCT scanners. While comprehensive scanners consist of wide field of view (FOV) for scanning the whole maxilla and mandible, narrow scanners comprise the less area of view. Less the FOV, lesser the radiation requires while the other factors are still present. However, CBCT scans promote an easier overall evaluation of each case before the treatment[6]. The optimal radiation dosage from CBCT is more significant than a conventional radiograph. Hence, using a CBCT scan should not cause any hazard to the patients. Previous studies have shown that the sensitivity of intra-oral radiographs is mainly 0.248 (24.8%). On the other hand, the CBCT sensitivity is greater than the periapical radiograph by about 31%. Therefore, we can consider CBCT as a “gold standard” in recognizing the appearance of periapical lesions[4].

Periodontal lesions are small and enclosed to the cancellous bone at the early stage where overlying cortical plate is masking the periapical lesion which known as anatomical noise. Hence, this anatomical noise makes it difficult to identify periapical lesions *via* Pa radiographs[16,17]. Moreover, the complex 3D anatomy of human body became flattened in the area being radio graphed. Due to these limitations, a 2D radiograph could not reliably reveal the location and nature of the periapical periodontitis[18].

The CBCT radiographs provide the suitable resolution of images which reflects the details of tooth and surrounding alveolar anatomy. Therefore, endodontics diagnosis and treatment planning became more precise with this powerful 3D CBCT. However, risk/benefit ratio of exposing a patient to CBCT need to assess based on the treatment demand[19]. Therefore, the aim of this study was to determine the extent of using CBCT for daily Endodontic practice and diagnosis. Furthermore, to analytically compare the periapical status of different teeth by using the Pa and the CBCT radiographs.

Patients and Methods

Study Design, Sampling, and Ethical Considerations

This cross-sectional observational study compared periapical pathosis diagnosed by Periapical radiograph and CBCT. Institutional Review Board (IRB) at Riyadh Elm University approved this study with the approval number (IRB No.mF-UGRP/2021/230/416/409).

Inclusion and Exclusion Criteria for PA and CBCT

All the inclusion and exclusion criteria of this study were listed in Table I.

Table I. Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
• 16 years and above	• Individuals under 16 years old
• Female and male	• Unrestorable teeth
• Saudi and non-Saudi	• Pregnant women
• Normal apical tissue	
• Endodontically treated teeth	
• Irreversible pulpitis	
• Necrotic pulpitis	
• Reversible pulpitis	
• Symptomatic apical periodontitis	
• Asymptomatic apical periodontitis	

Table II. Number of teeth examined by Pa and CBCT radiographs between genders.

Gender	Mean	SD	Total
Female	22.07	5.32	115
Male	22.65	6.34	89

SD; Standard deviation.

Diagnostic Criteria for Periapical Lesions

Data collection

Pa and CBCT radiographs were obtained from the patients referred to the department of Endodontics or who attended the outpatient clinics of the college of dentistry in Saudi Arabian universities (governmental and private) from 2015 to 2021. The radiographs were organized randomly and adjudged using 'Sirona - Galileo' in every session. The investigators noted the absence and presence of periapical lesions using the Microsoft Excel version 16.47.1(21032301).

There was 1-2 days intervening time between each session and to establish the accuracy of the result, the radiographs were reviewed again by another investigator. The radiographs were reviewed in 2 weeks within 6 sessions. For each session, periapical lesion was identified as a radiolucent area in periapical area which appears twice the width of the periodontal ligament. In CBCT radiographs, axial, coronal and sagittal axis was used to assess the periapical lesion. On the other hand, parallel technique with a beam aiming machine was used to obtain Pa radiographs. Both radiographs were taken using a dental x-ray machine Sirona and Galileo system.

Statistical Analysis

Reliability analysis was performed using the Cohen's Kappa statistics. Descriptive statistics of the frequency distribution of various conditions diagnosed on the CBCT and Pa radiographs were conducted. Mean and standard deviations (SD) were calculated for the number of teeth identified with periapical pathosis based on Pa radiographs and CBCT evaluations between genders. Independent t-test was conducted to compare the Pa and CBCT for the detection of periapical lesions. Chi-square test was used to investigate the distribution of gender and periapical lesions by both radiographs. p-value <0.05 was considered as a significant different. All the analyses were performed in the spreadsheets from Microsoft Excel version 16.47.1(21032301) and SPSS (version 25) software (SPSS Corp., Armonk, NY, USA).

Results

A total of 204 teeth from 72 patients (29 female and 43 male) were assessed *via* CBCT and Pa radiographs. Among 204 teeth, 89 teeth were measured from female subjects and 115 teeth were measured from male subjects. Inter-observer and intra observer reliability showed the absolute level of agreement. Table II shows the mean and SD for the number of teeth examined by PA and CBCT among both genders. Table III shows the frequency of presence and absence of periapical lesions in Pa and CBCT radiograph. Figure 1 shows the comparison of the mean number of apical lesions between Pa and CBCT. There is significant difference observed (p=0.008) between the Pa and CBCT radiographs. Figure 2 shows the comparison of apical pathosis between genders, which exhibited not statistically significant. Table IV presented the frequencies of different conditions disclosed by Pa and CBCT.

Discussion

Radiographic examination is an essential component of any diagnosis, treatment planning and assessment of any disease outcome[4]. In this study, we focused on defining the frequency of misidentified or misdiagnosed cases with PA radiographs compared to CBCT. For preoperative diagnosis, a good quality Pa radiograph is necessary. However, Pa radiographs show only in two dimensions,

Table III. Comparison of presence and absence of periapical lesions between Pa and CBCT radiographs

Radiographs	Lesion absent n (%)	Lesion present n (%)
Pa	74 (36.27)	130 (63.73)
CBCT	10 (4.90)	194 (95.10)

n, total number; %, percentage; Pa, periapical radiograph; CBCT, cone beam computed tomography; P, p-value (<0.05); *, Statistically significant.

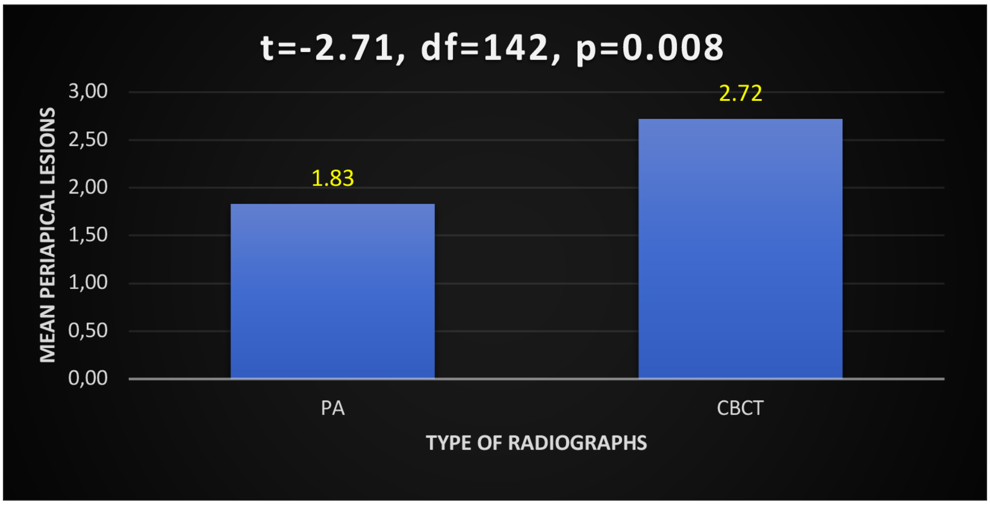

Figure 1. Comparison of mean number of apical lesions between PA and CBCT.

thus making it more difficult to achieve an accurate diagnosis.

CBCT imaging helps in early recognizing of the inflammatory lesions, and this diagnosis seldom appears when using conventional 2D radiographs. CBCT not only can define lesion but also can identify the extent of the lesion accurately, as well as the internal, external, and cervical resorption. Moreover, it defines the morphology and number of the tooth roots along with correlated canals (main and accessory), helps to find the accurate working lengths and locate the type and degree of root angulation. Additionally, in post-trauma emergency cases, where tooth evaluation is required, CBCT imaging can guide dentists to the most suitable treatment approach.

It has been reported that periapical lesions are frequently diagnosed while erosion or perforation cover the cortical plate. Alternatively, the anatomical noise enhances the low contrast appearance among the periapical lesions in the cancellous bone and cortical bone[8]. Likewise, anatomical noise, the cortical plate is one of the reasons to under evaluate the actual size of periapical lesion in 2D radiographs. This could motivate geometric deformation that might lead to maximize or minimize the size of periapical lesion[4].

The outcome of this study proves that CBCT detects the PDL space more accurately than Pa radiograph, which past studies have proved as well. The comparison statistics for the CBCT and Pa are presented in Figure 1. Both CBCT and Pa radiographs assessed the presence and absence of periapical lesion.

A comparison of the radiograph showed that 63.73% and 36.27% periapical lesions were present and absent, respectively while assessed with the Pa radiographs. On the other hand, same teeth showed 95.10% and 4.90% of periapical lesions present and absent, respectively while evaluated with CBCT (Table III). The accuracy of CBCT is significantly higher (p=0.008) than the Pa radiographs. On the contrary, CBCT radiograph is an effective tool for recognizing periapical lesions. Some studies recommended using the CBCT radiograph which enhances the contrast distinguishing between the apical granulomas and apical cysts. Alamri et al[20] state that apical periodontitis could observe on CBCT, which was not the case with Pa radiographs. This study proved that the CBCT radiographs are not only highly precise at recognizing periapical lesions but also had more clarity on contrast with Pa radiographs.

In a comparison of the presence and the absence of periapical lesions in the CBCT and Pa radiographs, a previous clinical study classified the patient's chief complaint, and they found that the most commonly reported symptoms included localized swelling followed by biting/chewing sensitivity[21]. However, the current study did not focus on patients' complaints.

Another study[10] looked for the sensitivity of the two radiographs, which was 1.0 and 0.248 for CBCT, and Pa radiographs, respectively. Pa radiographs tends to be more affected by the external factors, such as irradiation geometry and the anatomical noise, which is uncontrollable by the clinicians and leading unable to detect the periapical lesions. CBCT could eliminate these types

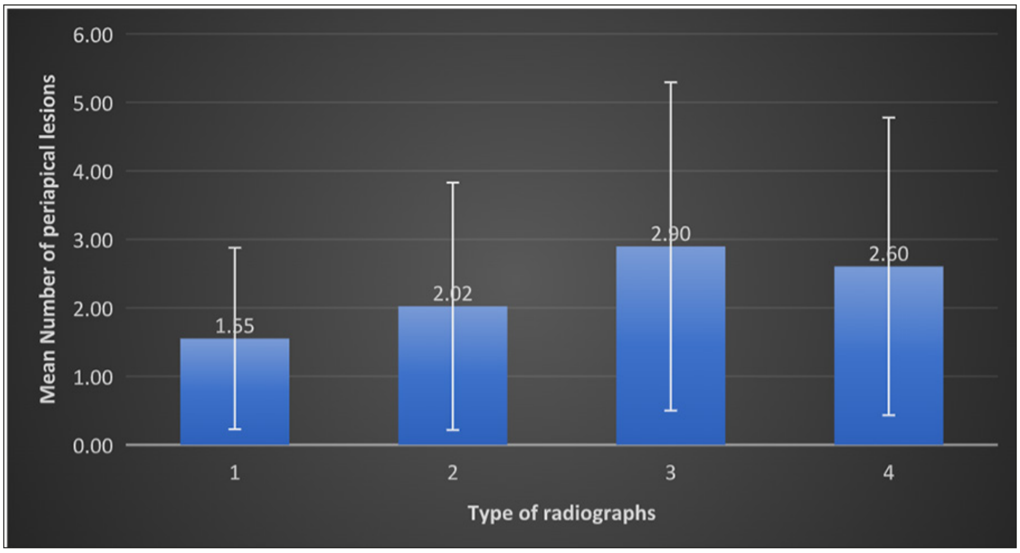

Figure 2. Comparison of apical pathosis between male and females.

of external factors. The detection rate of apical radiolucency is higher in CBCT radiography.

Previous *in-vivo* studies[5] of detecting the early formation of periapical lesions *via* CBCT and Pa radiographs showed that CBCT images were more accurate compared to the Pa images. A total of 273 paired roots were assessed and CBCT radiographs exhibited periapical lesions were present in 48% of teeth and absent in 52% of teeth. On the other hand, periapical lesion was observed in only 20% of teeth *via* Pa radiographs. However, the percentage is slightly higher in this study where CBCT detected 95.10% periapical lesions whereas Pa radiographs detected 63.73% lesions.

Table IV. Different conditions disclosed by Pa and CBCT.

Periodontal conditions		N (%)
Caries reaching Pulp	Absent	61 (84.7)
	Present	11 (15.3)
Resto reaching pulp	Absent	58 (80.6)
	Present	14 (19.4)
Normal pulp	Absent	67 (93.1)
	Present	5 (6.9)
Asymptomatic AP	Absent	66 (91.7)
	Present	6 (8.3)
Symptomatic AP	Absent	70 (97.2)
	Present	2 (2.8)
Reversible Pulpitis	Absent	72 (100)
	Present	0 (0)
Defect prosthesis	Absent	68 (94.4)
	Present	4 (5.6)

N, total number; %, percentage.

A 3D radiographic technique is a valuable tool for diagnosing the periapical problems. Another study[22] assessed a total of 46 teeth and found 42 out of 46 teeth had periapical lesion observed by CBCT, while Pa radiograph identified the periapical lesions in 32 teeth only. Individual roots were also evaluated and found that CBCT identified periapical lesions in additional 33 roots than the Pa radiographs. CBCT images persists the artifacts sometimes; however, more clinical information could be obtained through the 3D CBCT images. Likewise, CBCT radiograph found 13.7% periapical lesions whereas, Pa radiograph found only 3.3% lesions out of the 307 pairs of roots[6]. Not only periapical lesions, other anatomical structure of maxilla and mandible also compromised when diagnosing with Pa radiograph only. A previous study stated that periapical lesion on 15 teeth were missed using the pa radiograph out of 58 teeth. Moreover, the distance between mandibular canal and the apices was assessable in only 24 Pa radiographs out of 68 radiographs[2].

In this study we discovered that additional periodontal conditions could show periapical lesion on the radiograph, however no conditions along with periapical lesion were noticeable on Pa radiograph alone; 31.37% of the samples that were involved in this study showed periapical lesion on 3D CBCT radiographs that was not shown on Pa radiograph. A consent panel has been used in this study for estimating the periapical lesion to reduce the inter-examiner errors. Investigators in the consent panel could examine CBCT radiographs and respecting the impediments of these radiographs even if in its lower resolution as well as the limitation of using this technology in everyday clinical practice. Because of infrequent reporting of most complaints by the patients, this could be considered as a limitation of the study affecting the sample size.

Future studies with larger sample sizes will evaluate patients' chief complaint categories and produce more accurate inferences from the data. Moreover, it would be better to focus subsequent studies on one specific condition of the periapical lesion.

Conclusions

In comparing the presence and absence of periapical lesion in CBCT and Pa radiography, this study showed that CBCT is more reliable in detecting the periapical lesions. Therefore, it may be incorporated in everyday clinical practice to get accurate diagnosis and treatment planning.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical Approval

The study was approved by Institutional Review Board (IRB) at Riyadh Elm University with the approval number (IRB No. FUGRP/2021/230/416/409) dated 08-03-2021.

Data Availability

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Authors' Contribution

L.S. Alsaikhan, R.A. Algarni, M.A. Alzahrani contributed to study design, clinical data collection, and conducting the study; M. Altammami, I. Mansy, A.M. Alqahtani, contributed to designing & supervising the study; A.M. Alqahtani contributed to the manuscript writing and editing; K. Gufran contributed to the manuscript editing and correspondence to the journal. All authors approved the final manuscript.

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Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

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