Original Research Article

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20213188

Use of the cone-beam computed tomography-endodontic radiolucency index for determination of lesion extension in periapical periodontitis

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Received: 16 June 2021 Accepted: 02 August 2021

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ABSTRACT

Background: Periapical periodontitis is caused by extension of necrotic pulp tissue into the periodontal ligament area. cone-beam computed tomography (CBCT) facilitates better diagnosis for periapical periodontitis, especially in the absence of clinical symptoms. This study aims to use cone-beam computed tomography-endodontic radiolucency index (CBCT-ERI) to determine the extension of periapical periodontitis in post-graduate clinics of Riyadh Elm university (REU) and to record the extension of periapical periodontitis in the coronal direction along the root surface and evaluate the degree of cortical bone involvement associated with periapical radiolucency.

Methods: CBCT images for patients treated at the endodontic clinics of REU were selected for this retrospective observational study. Images were examined after inter-examiner calibrations under the same magnification, slice thickness, and resolution and the measurements were analyzed statistically.

Results: The first permanent molars were the most frequently affected by periapical periodontitis, followed by the second molars. The majority of lesions were graded with a score of 6 in length and width according to CBCT-ERI.

Conclusions: The use of CBCT-ERI revealed extensive involvement of periodontal tissues around the apices of the roots of the examined teeth. Coronal extension of periapical periodontitis was observed along the root surface. The axial view accurately detected cortical bone involvement, including thinning of the cortical bone, which was the most common manifestation (11.76%). Apical radiolucency was observed most commonly in the first molars.

Keywords: CBCT, Apical periodontitis, Periapical index, Endodontic radiolucency index, Endodontics

INTRODUCTION

Periapical periodontitis is considered a source of infection in the periodontal ligament area. It is an inflammatory response to microbial infection that originates in the pulp as a result of extensive caries. Infections in the root canal trigger an inflammatory response of the periodontal tissue, causing calcified periodontal lesions in relation to the infected tooth in response to irritation. Infection around the root apices leads to alveolar bone destruction, which can be subsequently detected radiographically. The periapical index (PAI) scoring system was introduced in

1967 to facilitate specific radiographic diagnosis of periapical periodontitis. This index has been proven to be reliable, reproducible, and discriminatory. However the PAI scoring system is highly subjective, compared to the CBCT-ERI scoring system, which is highly sensitive tool. In a study conducted by Ridoa-Sacie PAI was evaluated using periapical and panoramic X-rays. The results revealed that PAI facilitated better interpretation of panoramic X-rays only in the second and third molar region. Moreover in a previous study clinical examination, periapical X- rays, and histological sections were used to verify the reliability of PAI. Their results supported the role of histological findings that

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corresponded with both clinical and radiographic interpretations.⁷ Periapical periodontitis may asymptomatic in the early stages. Hence, the use of PAI may lead to misdiagnosis. Delayed diagnosis may result in more invasive treatment.8 CBCT images can help in distinguishing between a cyst and periapical periodontitis by providing a clear image of the different densities of its contents.9 In his study, Pinsky proved that CBCT is a more reliable and highly sensitive tool for detecting oral lesions and making maxillofacial diagnoses compared to CT.10 Therefore, Torabinejad recommended a new periapical index, termed the CBCT-ERI.¹¹ It is considered to be a modification of Estrela et al index CBCT-PAI.¹² CBCT-ERI is able to distinguish radiolucent lesions less than 0.5 mm. Therefore it was reviewed as a highly accurate tool compared to CBCT-PAI.11

This study aims to examine the extent of periapical periodontitis observed on CBCT images in patients treated at the post-graduate clinics at REU, based on the CBCT-ERI and to record the extent of periapical periodontitis along the root surface in the coronal direction and to examine cortical bone involvement associated with periapical radiolucency.

METHODS

Study design

This is a retrospective observational study utilizing existing CBCT images of patients. The study population consisted of 30 CBCT images of 20 women and 10 men with an average age of 41 years. The images were selected from the records of patients treated at the postgraduate endodontic clinics of REU, Riyadh, Saudi Arabia. These images had been used for diagnosis and treatment planning. Teeth were recorded according to the Fédération dentaire internationale system. CBCT examination was performed for 112 teeth. Image selection was based on teeth showing clear evidence of periapical radiolucencies, with or without root canal treatment (the exact date of endodontic treatment was not available). A slice thickness of 2-3 mm was used with a magnification of 5 cm. A higher magnification was used (10 cm) for the detection of cortical bone involvement. The same resolution was used throughout the measurement process. Periapical status of the width and length scores were recorded using CBCT-ERI. CBCT images were inter-calibrated by 6 dental students and 1 periodontist, under continuous guidance of a radiologist. The differences between the readings of the researchers were less than 0.5 mm. Inclusion criteria was: 1) participants over 14 years of age, 2) CBCT images obtained between 2014 and 2018, and 3) presence of a periapical radiolucency. The exclusion criteria Included: 1) patients who were confirmed or thought to have focal osteoporotic bone defect and 2) presence of CBCT artifacts.

Ethical consideration

The proposal was registered at the research center, REU, college of dentistry. Ethical approval RCI/IRB/2019/134 was obtained from the institutional board of university. Consent forms declaring patients' examination records belonged to the university and that it could be used for research studies were signed by patients during their first visit to REU dental clinics. We ensured that all patients' data were secure, and confidentiality was preserved.

Acquisition of CBCT images

Images were acquired using the Galileos CBCT 3D digital imaging system (Sirona, Germany) using the following parameters: 85 kV, 5-7 mA, and 14 s, with a voxel size of 0.3 mm, and a field-of-view of 15x15x15. The Galaxis 3D imaging software was used to aid image assessment in the form of CBCT panoramic reformatting, and tangential and cross-sectional views with the (CBCT-ERI) as following: ERI score 1=widest dimension of PDL: 0.5 mm <x≤1.0 mm, ERI score 3=widest dimension of PDL: 1.0 mm<x≤1.5 mm, ERI score 4=widest dimension of PDL: 1.5 mm<x≤2.0 mm, ERI score 5=widest dimension of PDL: 2.0 mm<x≤2.5 mm and ERI score 6=widest dimension of PDL: >2.5 mm

RESULTS

Table 1 shows the distribution of the CBCT-ERI scores of the roots including the frequency and percentage of increase in periodontal widening. A CBCT-ERI score of 6 was found in 25 roots (49.01%), while 9 roots (17.65%) had a CBCT-ERI score of 5 (2.0<x\le 2.5 mm), 11 roots (21.57%) had a CBCT-ERI score of 4 $(1.5 < x \le 2.0 \text{ mm})$, 9.80% had a CBCT-ERI score of 3 (1.0 \leq x \leq 1.5 mm), and 2 roots had a CBCT-ERI score of 2 (0.5<x≤1.0 mm). None of the roots had a CBCT-ERI score of 1 (\leq 0.5 mm). Table 2 shows the distribution of the CBCT-ERI scores of the roots including the frequency and percent of length. A CBCT-ERI score of 6 was found in 21 roots (41.18%), while 6 roots (11.76%) had a CBCT-ERI score of 5 (2.0<x≤2.5 mm), 6 roots (11.76%) had a CBCT-ERI score of 4 (1.5<x≤2.0 mm), 27.45% had a CBCT-ERI score of 3 (1.0<x≤1.5 mm), and 4 roots had a CBCT-ERI score of 2 (0.5<x≤1.0 mm). None of the roots had a CBCT-ERI score of 1 (≤0.5 mm) (Figure 1).

Table 1: Distribution of CBCT-ERI scores of the roots and percentage of increase in periodontal widening.

Maximum diameter (wid	th)	
Score index	Frequency (%)	
1	0 (0)	
2	1 (1.96)	
3	5 (9.80)	
4	11 (21.57)	
5	9 (17.65)	
6	25 (49.01)	
Maximum (width)=16.01 mm, minimum (width)=0.56 mm and mean (width)=4.755 mm		

Table 2: The distribution of the CBCT-ERI scores of the roots including the frequency and percent of length.

Maximum diameter (length))		
Score index	Frequency (%)		
1	0 (0)		
2	4 (7.84)		
3	14 (27.45)		
4	6 (11.76)		
5	6 (11.76)		
6	21 (41.18)		
Maximum (length)=9.64 mm, minimum (length)=0.59			
mm and mean (length)=3.456 mm			



Figure 1: Examples of the cross-sectional periapical CBCT of the mandible (A) A periapical radiolucency is observed with a root-canal treated lower left molar, (B) Periapical radiolucency is observed with a root-canal treated lower right premolar, (C) Periapical radiolucency is observed with the distal root of a root-canal treated lower right first molar.

Extent of periapical periodontitis lesions

The highest proportion of the extension of lesions was observed with a score of 6 (41.18%) and the maximum length was 9.64 mm. Moreover, maximum extension in width was recorded with a score of 6 (49.01%), which was equivalent to 16.01 mm. Table 3 shows that the lesions extended in a coronal direction along the lateral aspects of the root to the apical third in 92.16%, to the middle third in 5.88%, and to the furcation in 1.96% of affected teeth. The frequency of coronal extension of the lesions in the maxillary teeth was almost twice that in the mandibular teeth. Lesions reaching the furcation area were easily identified on the cross-sectional view (Figure 2 and 3).

Table 3: The Frequency of coronal extension among different aspects.

Extend	Frequency (%)
Middle	3 (5.88)
Apical	47 (92.16)

Furcation 1 (1.96)

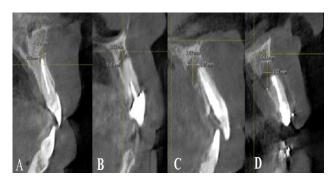


Figure 2: Examples of cross-sectional CBCT views of upper anterior incisors with periapical radiolucency (A, B and C) Root-canal treated upper right central incisor with periapical radiolucency, (D) Root-canal treated upper right lateral incisor with periapical radiolucency.

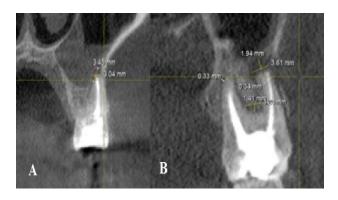


Figure 3: Examples of teeth with periapical radiolucencies cross-section view on the CBCT of the upper molars (A) Root-canal treated upper left first molar with periapical radiolucency related to the mesiobuccal root, (B) Root-canal treated upper left third molar showing periapical radiolucency with the mesial root furcation involvement, and cemental tears.

Thinning of cortical bone, destruction, and furcation involvement were observed in 6 (11.76%), 5 (9.80%), and 1 (1.96%) lesion, respectively. Figure 4 B shows thinning of the cortical bone from the axial view, which was the most common manifestation (Table 4).

Table 4: Cortical bone involvement.

Cortical bone involving	Frequency (%)
Destruction	5 (9.80)
Furcation	1 (1.96)
Thinning	6 (11.76)

Frequency and percentage of teeth showing pulpal pathology and periapical radiolucencies

Periapical radiolucency was observed most commonly in the first molars, followed by the second premolars. The lateral incisor was associated with the largest extension in height (9.64 mm), while lesions were the widest in central incisors (16.01 mm). The 3rd molar was least commonly affected tooth as shown in the Table 5. Distribution and frequency of lesions in relation to site of occurrence in this study maxillary molars scored 17, while affected mandibular anterior tooth was scored 3 (Table 6) (Figure 4).

Table 5: Periapical radiolucency.

Variables	N
Third molars	1
Second molars	6
First molars	13
Second premolars	8
First premolars	5
Canines	3
Lateral incisors	6
Central incisors	5
Total	47

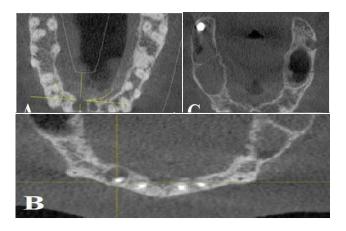


Figure 4: Axial CBCT view of teeth with cortical bone involvement (A) Upper right central incisor with periapical and palatal bone destruction, (B) Upper right lateral incisor with periapical periodontitis and thinning of cortical bone, (C) Upper left third molar with periapical periodontitis and destruction of buccal cortical bone.

Table 6: Distribution and frequency of lesions in relation to site of occurrence.

Variables	Anterior	Premolar	Molar	Total	Percent (%)
Maxillary	11	7	17	35	68.63
Mandibular	3	6	7	16	31.37
				Lesion=51	

DISCUSSION

Selection of the CBCT-ERI for scoring in this research was based on its higher ability to detect periapical pathology than that of the periapical radiolucency index (PRI). Extension of periapical periodontitis was measured in width and length using the CBCT-ERI. Moreover, cortical bone involvement in relation to the lesions was detected using the axial view of the CBCT. The highest recorded score with the CBCT-ERI was 6 (more than 2.5 in diameter, both in length and width); a score of 6 was observed in 90.19% of the examined teeth.

Meanwhile, study published by Torabinejad et al reported that the highest score was 1, which accounted for 53% of reported cases, while only 2.5% of their participants had a score of 6.¹¹ This marked difference remarked between the two studies can be attributed to the clinical variation between the respective study populations, i.e., the earlier study included patients with asymptomatic pulpal infections and had longer follow-up periods (greater than 2 years). While in the present search, the examined CBCT images were captured either before endodontic treatment or shortly after therapy.

In the present study, extension of periapical radiolucency to the apical third of the root was seen in 92.16% of the images examined. Extension to the middle third of the

root was seen in 5.88% of the lesions and the prevalence of furcation involvement was the lowest (1.96%). Highest frequency of lesions around root apices could be due to the fact that it is the most common root for transmission of necrotic pulp tissues to periapical periodontal tissues is vascularity passed through apical foramen.¹⁴ This indicates the increased liability for the risk of orofacial infection.¹⁵ The most commonly affected tooth with periapical periodontitis was the first molar (27.65%), followed by second premolars (17.02%). Similar findings were found in a study performed in Saudi Arabia and Sweden. 16,17 While a study done by Vengerfeldt et al reported higher incidence of root canal treatment in lower molars than upper molars. 18 Results also showed that periapical infections were detected mostly in teeth of upper arch. Maxillary central incisor had the largest extension of the lesion (length: 8.17 mm and width: 16.01 mm) with the destruction of cortical bone and resorption of the palatal plate of the alveolar bone. However, cortical bone involvement was not a constant feature in all lesions scored 6. Furthermore a study published in 2011 confirms significant difference between Maxillary Mandibular bone involvement, and the rationale behind it is due to the thick cortical bone surrounding mandibular posterior teeth which reduce the risk of bone defects caused by periapical lesions.¹⁹

This study highlighted the utility of CBCT-ERI in depicting the actual extent of periapical periodontitis and

can help in identifying the amount of cortical bone involvement, which can further help in the selection of an appropriate treatment modality and in the evaluation of the response to treatment. However, this study had some limitations with respect to the participants' medical records, such as, small study population and the retrospective identity of the study.

CONCLUSION

The use of CBCT-ERI revealed extensive involvement of periodontal tissues around the root apices of the examined teeth. Furthermore, the coronal extension of periapical periodontitis was observed along the root surface, which was detected accurately using the axial view. Thinning of the cortical bone demonstrated the highest score of involvement (11.76%) and apical radiolucency was observed most frequently in the first molars.

ACKNOWLEDGEMENTS

Authors would like to thanks Dr. Cristalle Soman for her constant guidance in ensuring perfect protocol during the acquisition of CBCT images and measurement processes.

Funding: No funding sources Conflict of interest: None declared

Ethical approval: The study was approved by the

Institutional Ethics Committee

REFERENCES

- Lia RC, Garcia JM, Sousa-Neto MD, Saquy PC, Marins RH, Zucollotto WG. Clinical, radiographic and histological evaluation of chronic periapical inflammatory lesions. J Appl Oral Sci. 2004;12(2):117-20.
- Huumonen S, Ørstavik D. Radiological aspects of apical periodontitis. Endodontic Topics. 2002;1(1):3-25.
- 3. Persoon IF, Özok AR. Definitions and epidemiology of endodontic infections. Curr oral health rep. 2017;4(4):278-85.
- 4. Brynolf I. A histological and roentgenological study of the periapical region of human upper incisors. Almqvist and Wiksell. 1967;11.
- 5. Reit C, GrÖNdahl HG. Application of statistical decision theory to radiographic diagnosis of endodontically treated teeth. Eur J Oral Sci. 1983;91(3):213-8.
- Ridao-Sacie C, Segura-Egea JJ, Fernández-Palacín A, Bullón-Fernández P, Ríos-Santos JV. Radiological assessment of periapical status using the periapical index: comparison of periapical radiography and digital panoramic radiography. Int endodontic j. 2007;40(6):433-40.
- Croitoru IC, CrăiŢoiu Ş, Petcu CM. Clinical, imagistic and histopathological study of chronic apical periodontitis. Romanian journal of

- morphology and embryology Revue roumaine de morphologie et embryologie. 2016;57(2):719-28.
- 8. Mota de Almeida FJ, Knutsson K, Flygare L. The impact of cone beam computed tomography on the choice of endodontic diagnosis. Int Endodontic J. 2015;48(6):564-72.
- 9. Laux M, Abbott PV, Pajarola G, Nair PNR. Apical inflammatory root resorption: a correlative radiographic and histological assessment. Int endodontic j. 2000;33(6):483-93.
- 10. Pinsky HM, Dyda S, Pinsky RW, Misch KA, Sarment DP. Accuracy of three-dimensional measurements using cone-beam CT. Dentomaxillofacial Radiol. 2006;35(6):410-6.
- 11. 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 endodontics. 2018;44(3):389-94.
- 12. Estrela C, Bueno MR, Azevedo BC, Azevedo JR, Pécora JD. A new periapical index based on cone beam computed tomography. J endodontics. 2008;34(11):1325-31.
- 13. Wu MK, Shemesh H, Wesselink PR. Limitations of previously published systematic reviews evaluating the outcome of endodontic treatment. Int endodontic j. 2009;42(8):656-66.
- 14. Bjørndal L, Kirkevang L-L, Whitworth J. Textbook of endodontology. John Wiley and Sons. 2018.
- 15. Riggio MP, Aga H, Murray CA. Identification of bacteria associated with spreading odontogenic infections by 16S rRNA gene sequencing. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007;103(5):610-17.
- 16. Khan SQ, Khabeer A, Al Harbi F. Frequency of root canal treatment among patients attending a teaching dental hospital in Dammam, Saudi Arabia. Saudi J Med Med Sci. 2017;5(2):145.
- 17. Lofthag-Hansen S, Huumonen S, Gröndahl K, Gröndahl H-G. Limited cone-beam CT and intraoral radiography for the diagnosis of periapical pathology. Oral Surg Oral Med Oral Pathol Oral Radiol Endodontol. 2007;103(1):114-9.
- 18. Vengerfeldt V, Mändar R, Nguyen MS, Saukas S, Saag M. Apical periodontitis in southern Estonian population: prevalence and associations with quality of root canal fillings and coronal restorations. BMC oral health. 2017;17(1):147.
- 19. Yoshioka T, Kikuchi I, Adorno CG, Suda H. Periapical bone defects of root filled teeth with persistent lesions evaluated by cone-beam computed tomography. Int Endodontic J. 2011;44(3):245-52.

Cite this article as: Shafshak S, Alsubaie F, Alzamil F, Alzughaibi L, Alhaqbani M, Al Yamany R et al. Use of the cone-beam computed tomography-endodontic radiolucency index for determination of lesion extension in periapical periodontitis. Int J Community Med Public Health 2021;8:4268-72.