

# Comparison of Cone-beam Computed Tomography and Periapical Radiography to Determine the Proximity of Periapical Lesions to Anatomical Structures in Premaxillary Area prior to Surgical Endodontics: A Clinical Study

Kesha Sheth<sup>1</sup>, Sonali Kapoor<sup>2</sup>, Shilpi Daveshwar<sup>3</sup>

## ABSTRACT

**Aim:** In the anterior maxillary region when periapical (PA) surgery is contemplated, knowledge of relation between root apices and lesion, spatial relationship of tooth root to adjacent anatomical structures is essential. The aim of this study was to compare cone-beam computed tomography (CBCT) and PA radiography to determine the proximity of PA lesions to anatomical structures in the premaxillary area for decision-making before apical surgery.

**Materials and methods:** Twenty subjects were selected. Three endodontists viewed PA radiographs and CBCT images. These observers (1) determined proximity of lesion to anatomical structures and (2) made decisions on treatment based on each imaging modality. Chi-square test was used to check the relationship between the treatment plans given by PA radiographs and CBCT images. Reliability of the observations was evaluated using intraclass correlation (ICC).

**Results:** Significant difference was noted in the treatment plan selected by the observers using the two modalities ( $p < 0.05$ ).

**Conclusion:** After the lesions were observed with CBCT, there was an increase in the number of teeth involved with the lesion. A change in the observer's treatment plan was recorded after viewing the CBCT scans.

**Keywords:** Anterior maxilla, Cone-beam computed tomography, Periapical lesion, Periapical radiography, Periapical surgery.

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## INTRODUCTION

Complete oral examination and high-resolution imaging are crucial diagnostic tools for treatment planning when periapical (PA) surgery is contemplated.<sup>1</sup> Clinical diagnosis is supported by accurate imaging and helps in determining the number of roots in the involved tooth, the number of affected roots in the involved tooth, the distance between the root apices, the extent of the PA lesion, and the proximity of the lesion to surrounding anatomical structures.<sup>2</sup> As PA radiographs are cost-effective and provide high-resolution imaging, they are still the most preferred imaging modalities. However, due to drawbacks, such as superimposition, distortion, and compression of anatomy of the area being radiographed, it is difficult to detect PA lesions. So, PA radiographs cannot consistently detect the site and the nature of a PA lesion.<sup>3-7</sup>

The ability to visualize the dentoalveolar structures in three dimensions has led cone-beam computed tomography (CBCT) to become an integral part of endodontics. The American Association of Endodontists (AAE) and the American Academy of Oral and Maxillofacial Radiology (AAOMR) guidelines recommend CBCT for the detection of pathosis, the assessment of previously treated teeth, the detection of vertical root fracture, the detection of traumatic injuries, the localization of resorptive defects, the presurgical treatment planning to locate root apex, the evaluation of proximity of the root apex and the lesion to anatomical structures, and the evaluation of healing following non-surgical and surgical endodontic treatment.<sup>8</sup>

Multiple studies have established the improved reliability in the diagnosis of PA lesions by CBCT over PA radiographs.<sup>9-11</sup>

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Velvart *et al.*,<sup>6</sup> Low *et al.*,<sup>12</sup> and Huuonen *et al.*<sup>13</sup> concluded from their studies that computed tomography helped correlate the relation of PA lesions to mandibular canal and maxillary sinus floor prior to PA surgery and also provided information for the retreatment cases.

Relationship of PA lesions in the maxillary anterior region to adjacent anatomical structures has not been evaluated yet. Knowledge of relation of PA lesion to the root apices, the nasopalatine canal, and the floor of nasal cavity can help in preventing complications, such as hypesthesia of anterior teeth and hard palate and damage to the nasal floor. Knowledge of proximity of the root apex to anterior nasal spine can help in deciding an alternative flap approach. Bone thickness and angulation of roots

are important to determine the osseous entry and the amount of bone removal required to reach the root apex and PA lesion.<sup>14</sup> Thus, the present study aimed to compare CBCT and PA radiographs to determine the proximity of PA lesion to anatomical structures in the premaxillary area for decision-making before PA surgery.

## MATERIALS AND METHODS

Institutional review board approval was obtained. Twenty patients reporting to the Department of Conservative Dentistry and Endodontics were considered for the study. The study group comprised of 14 male (70%) and 6 female (30%) patients, with a mean age of  $23.9 \pm 6.32$  years. History of present illness of all the patients was taken and they were examined clinically. After initial PA radiographs revealed the presence of PA lesion which required surgical intervention, they were considered for the study. Teeth included in the study were: single-rooted maxillary anterior teeth, teeth with previous root canal treatment, and teeth with previous restorations. Teeth that needed immediate therapy, teeth with radiographic evidence of fracture, unrestorable teeth, and pregnant women were excluded from the study.

### Image Acquisition

#### PA Radiographs

A paralleling axis technique was used to obtain the PA radiographs with Biodent-1070-D (BioMedicare Imaging Co., Badlapur, Maharashtra, India) machine. A round collimator of 2.89" diameter with variable kVp and mAs and focal spot size  $0.7 \times 0.7$  mm was used. Images were captured using Sopic 2 sensors (Acteon, France). Images were presented using SOPRO imaging software (Acteon, France) as 8-bit Tagged Image File Format (TIFF). All images were compared and those which were found to be of adequate quality were selected and standardized for the study.

#### CBCT

The procedure was explained to the patient and consent was obtained before commencement of the scan. i-CAT™ Next Generation CBCT scanner (Imaging Sciences International, Hatfield, Pennsylvania, USA) was used. Exposure factors used were 120 kVp, 5 mA with 7-second exposure time. Collimation suitable for the scan of maxilla was adjusted. The field of view (FOV) was  $8 \times 5$  cm. The radiation dose varied according to the patients. Images were examined using the i-CAT software.

### Image Viewing

Three endodontists with varying amounts of experience were selected. These observers determined proximity of PA lesions to anatomical structures for both PA radiographs and CBCT images (Figs 1 to 3) and selected treatment plan based on the two imaging modalities. All images were viewed on a HD LED Backlit Widescreen BrightView Display having a screen resolution of  $1366 \times 768$  pixels, brightness of  $250 \text{ cd/m}^2$  and contrast ratio 1000:1 installed with Microsoft Windows XP Service Pack 1 (Microsoft Corp, Redmond, Washington, USA). Patient information was anonymized and images were randomly presented. The observations were performed separately for PA radiographs and CBCT images. In the first evaluation, only the PA radiographs were presented. The same 20 cases with additional information of the CBCT scans were then reviewed by the examiners in the next evaluation. Evaluation for both the modalities was carried out after an interval of 10 days.

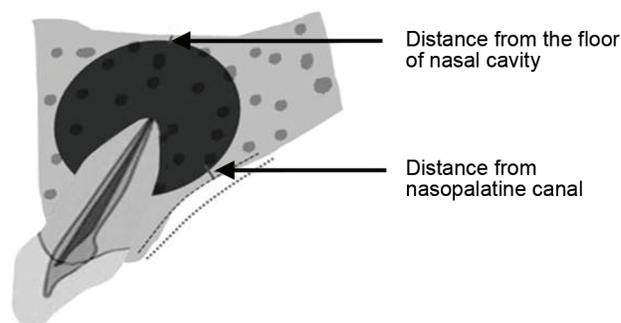


Fig. 1: Proximity of periapical lesion to anatomical structures in sagittal section

Each examiner was asked to analyze 10 randomly selected images again to check for consistency.

### Statistical Analysis

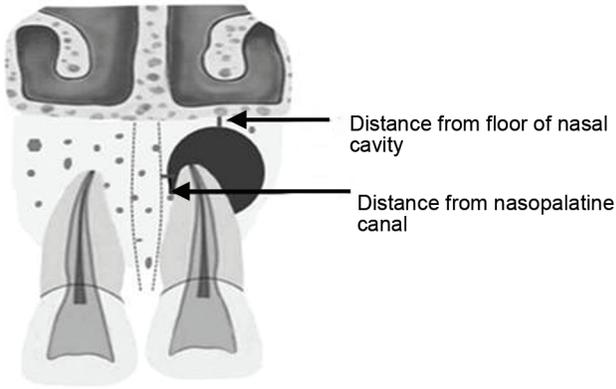
The IBM SPSS (Version 17.0; SPSS Inc., Chicago, Illinois, USA) software was used for statistical analysis. To check for statistical relationship between the treatment plan given by PA radiographs and CBCT images, chi-square test was used. Reliability of the observations was evaluated using intraclass correlation (ICC). Interexaminer reliability was assessed by Cohen's kappa. Validity of the results was assessed by face validity.

## RESULTS

Distribution of study participants on the basis of anatomical structures involved and treatment plan is shown in Tables 1 and 2, respectively. A significant difference in the treatment plan selected by observers between PA radiographs and CBCT images was revealed with the help of chi-square test [ $\chi^2 (3) = 44.45, p < 0.05$ ]. Anatomical structures could be easily identified by all the observers. The ICC among observers regarding treatment plan and anatomical structures involved for both PA radiographs and CBCT images was calculated. Intraclass correlation for anatomical structures involved showed a high value (0.958) which indicates a high similarity between the observations using PA radiographs and CBCT images (Table 3). Intraclass correlation for PA radiographs was 0.987 and for CBCT images was 0.968 which indicates a high similarity between the observations regarding the treatment plan using PA radiographs and CBCT images (Table 4). Measurement of agreement using PA radiographs was 0.844 and using CBCT images was 0.93 which indicates an almost perfect interexaminer reliability.

## DISCUSSION

The goal of PA surgery is to reinstate a tooth with an endodontic lesion by means of surgery. Periapical surgeries on maxillary anterior teeth generally involve fewer anatomical complications than posterior teeth. However, access to root apex in some patients may not be easy because of long roots, a shallow vestibule, or palatally inclined roots. The floor of nasal cavity can be encountered due to the presence of long roots or when PA lesion has extended superiorly and has eroded through the bony floor of the nose. The roots can also be close to bony anterior nasal spine which could complicate the route of entry to the root apex. Thus, for planning of PA surgery, extent of lesion, knowledge about the roots involved, relation between the lesion and adjacent anatomic

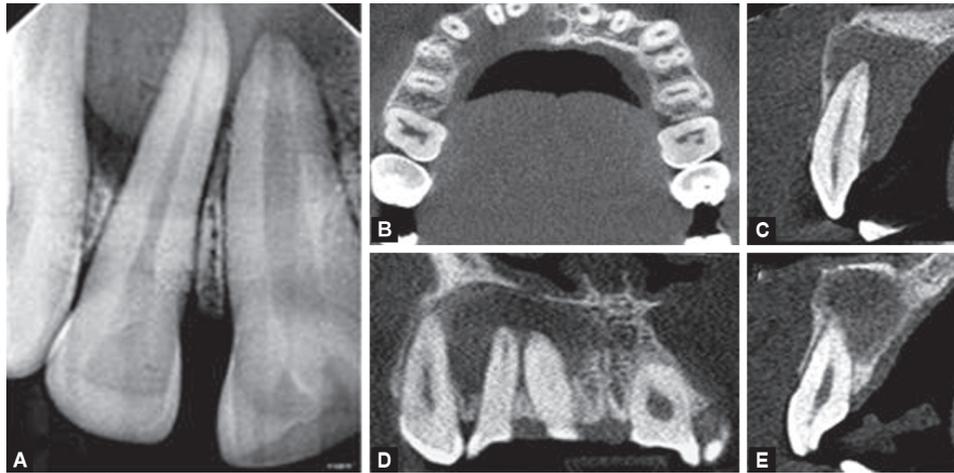


**Fig. 2:** Proximity of periapical lesion to anatomical structures in coronal section

structures and between root apices need to be known to prevent any complications.

In the present study, three endodontists viewed images of both modalities and determined the proximity of PA lesions to anatomical structures and made treatment decisions according to each modality.

In case of PA radiographs, anatomical structures were either not visible or only the intermaxillary suture was seen. However, with the help of CBCT, proximity of lesions to anatomical structures, such as nasopalatine canal, anterior nasal spine, and nasal floor, could also be assessed. In the present study, with the help of CBCT, 50% of the lesions were found to be close to nasal floor leading to discontinuity or thinning of the nasal floor. 43.3% of lesions were found to be away from nasopalatine canal, while 36.7% of lesions were found to be in contact with the canal and 3.3% of the lesions were found to be involving the canal. These findings could not be



**Figs 3A to E:** (A) Periapical radiograph of maxillary central and lateral incisor with large periapical lesion; (B) Axial section of CBCT showing the buccopalatal extent of the lesion and proximity to nasopalatine canal; (D) Coronal section of CBCT showing the mesiodistal extent of the lesion; (C and E) Sagittal section of CBCT showing the buccopalatal extent of the lesion and involvement of palatal cortical plate

**Table 1:** Distribution of study participants according to anatomical structures involved

Anatomical structures involved	Number of study participants					
	Observer 1		Observer 2		Observer 3	
	RVG	CBCT	RVG	CBCT	RVG	CBCT
Not visible	22	0	22	0	23	0
Intermaxillary suture	8	30	8	30	7	30
Nasopalatine canal	0	30	0	30	0	30
Anterior nasal spine	0	30	0	30	0	30
Nasal aperture	0	30	0	30	0	30

(RVG, radiovisugraphy; CBCT, cone-beam computed tomography)

**Table 2:** Distribution of study participants according to treatment plan

Treatment plan	Number of study participants					
	Observer 1		Observer 2		Observer 3	
	RVG	CBCT	RVG	CBCT	RVG	CBCT
No endodontic treatment	0	0	0	0	0	0
Root canal treatment	3	0	3	0	3	0
Periapical surgery	0	0	0	0	0	0
Apexification	0	0	0	0	0	0
Re-root canal treatment	3	0	3	0	2	0
Both root canal treatment and periapical surgery	9	14	9	15	11	15
Root canal treatment, periapical surgery, and apexification	15	16	15	15	14	15

**Table 3:** Intraclass correlation coefficient for anatomical structures involved

Modality	Average measures	95% Confidence interval		F test with true value 0			
		Lower bound	Upper bound	Value	df1	df2	Sig.
Periapical radiograph	0.958	0.898	0.986	24.077	13	26	0.000
CBCT	0.958	0.898	0.986	24.077	13	26	0.000

**Table 4:** Intraclass correlation coefficient for treatment plan

Modality	Average measures	95% Confidence interval		F test with true value 0			
		Lower bound	Upper bound	Value	df1	df2	Sig.
Periapical radiograph	0.987	0.967	0.995	74.143	13	26	0.000
CBCT	0.968	0.922	0.989	31.462	13	26	0.000

seen with the help of PA radiographs. This can be attributed to the fact that PA radiographs can produce acceptable images in only mesiodistal direction but information acquired in superio-inferior direction is limited thus, obscuring the visualization of anatomical structures that are located more superiorly. A similar problem in the detection of PA lesion and anatomical landmarks with PA radiographs was described by Velvart et al.<sup>6</sup> Thus, the finding that PA radiographs can lead to miscalculation of the dimension of the PA lesion holds true.<sup>15-18</sup>

In case of treatment plan, there was a statistically significant difference ( $p < 0.05$ ) between treatment plan given on the basis of PA radiographs and CBCT images. A change in examiner's treatment plan was recorded in 16% of the cases after viewing the CBCT scans. Similar observations were made in other studies which confirmed that preoperative CBCT imaging provides additional information which may lead to treatment plan modifications.<sup>19-21</sup> The results of present study contradict those obtained by Balasundaram et al.<sup>22</sup> who found that CBCT examination does not provide information that can change a therapy plan.

In the present study, CBCT images also provided additional important information which was not observed on PA radiographs. After the lesions were observed with CBCT, there was an increase by 40% in the number of teeth found to be involved with the lesion. In a similar study, Lofthag-Hansen et al.<sup>9</sup> could gather more information with the help of CBCT.

Low et al.<sup>12</sup> and Patel et al.<sup>23</sup> concluded in their respective studies that CBCT helped in the identification of lesions which were undetected on PA radiographs and this is possible as CBCT removes the anatomical noise and irradiation geometry which hamper the PA radiographs. Thus, the observation that detection of lesions limited to the cancellous bone by PA radiographs can be difficult hold true.<sup>24-26</sup>

In the present study, CBCT also provided the advantage of helping in diagnosis of additional pathologies like the presence of external root resorption which was not observed on the PA radiographs. This finding was similar to the one obtained by Patel et al.<sup>27</sup> who found that overall sensitivity of intraoral radiography in detecting external root resorption was lower than CBCT which in turn influenced the treatment decision.

During PA surgery, additional information like the thickness and shape of the bone and angulation of the roots can be useful in determining the osseous entry.<sup>6</sup> These findings could be obtained with the help of CBCT by selecting relevant views. In the present study, thinning of both the buccal and palatal cortical plates was found in around 40% of the cases. This information can be beneficial

in determining the amount of bone needed to be removed to gain access to the PA lesion and the root apex.<sup>6</sup> In a study Nakata et al.<sup>28</sup> concluded that by selecting relevant views and slices of data of CBCT, thickness of cortical plate, pattern of cancellous bone, and angulation of roots of teeth could be viewed. Yoshioka et al.<sup>29</sup> concluded that in cases with persistent PA lesions, CBCT helped in correct identification of the type of PA bone defect. Rigolone et al.<sup>30</sup> found that CBCT helped in measuring the distance between cortical plates and palatal root of maxillary first molar. Velvart et al.<sup>6</sup> demonstrated that CT scans could accurately determine the thickness of bone and the extent of PA lesion.

In the present study, with regards to the number of tooth surfaces involved, there was change in the findings after lesions were assessed with CBCT as it facilitated a complete three-dimensional viewing of the tooth involved with the lesion.

These findings highlight the fact that preoperative CBCT images are able to provide more diagnostically relevant information as compared to PA radiographs. In case of treatment planning for PA surgery, CBCT provided clinically relevant additional information which could not be obtained from PA radiographs.

## CONCLUSION

The present study showed that CBCT images revealed an increase in the number of teeth involved with the lesion. A change in the treatment plan was observed after viewing additional information with CBCT. Thus, CBCT helps in accurate treatment planning and providing safer treatment by presenting the clinician with relevant information, such as thickness of bone, angulation of the root, and position of anatomical structures.

## CLINICAL SIGNIFICANCE

- High standard radiographs play an important role in preoperative diagnosis and treatment planning of teeth scheduled for PA surgery.
- In case of maxillary anterior teeth, knowledge of relation of root apices to lesion, nasopalatine canal, and floor of nasal cavity will help in preventing complications to anterior teeth and prevent damage to hard palate and nasal floor.
- Knowledge of proximity of root apex to anterior nasal spine will help in deciding an alternative osseous approach.
- Bone thickness and angulation of roots help to ascertain the osseous entry and amount of bone removal required to reach the root apex and PA lesion.

- Comparison between the findings obtained through PA radiographs and CBCT images revealed that CBCT provided a three-dimensional view which gave additional information which helped in deciding the flap approach and also helped in determining if any additional treatment was required.

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