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Original Research Article

The Effect of Two Different Voxel Sizes on the Diagnosis of External Root Resorption by Planmeca Cone Beam Computed Tomography System: an in vitro study

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Abstract: Early diagnosis of root resorption lesions may result in the arrest of these lesions with therapeutic protocols; this early diagnosis can only be achieved with CBCT. However, CBCT involves higher radiation doses compared to conventional radiography. A greater radiation dose is required when using different voxel sizes of CBCT system. Therefore, it is important to determine the voxel size, which creates an image with high diagnostic potential with minimum possible radiation dose. This study evaluated the effect of changes in voxel size on the diagnostic results of external root resorption using the Planmeca CBCT system. Single-rooted anterior teeth were collected and cavities measuring 0.25 and 0.5 mm in depth were created on their cervical, middle and apical surfaces. CBCT scans of the lesions were obtained using two voxel sizes: 0.2 and 0.4 mm. Two observers determined the presence of simulated external resorptions on CBCT images. Diagnostic indices of specificity, accuracy, sensitivity, and positive and negative predictive values were calculated for all the images .Diagnostic capacities of CBCT images obtained at the above voxel sizes were almost similar on the middle, apical and cervical surfaces and with large and small lesions. Good, agreements were observed between the two observers examining the images prepared using two voxel sizes. Similar diagnostic abilities were noted for two voxel sizes of CBCT system to diagnose external root resorption lesions; therefore, voxel size 0.4 can be used to detect root resorption lesions with adequate accuracy and the least patient exposure dose.
Keywords: External Root Resorption, Voxel Size, Cone-beam Computed Tomography, Dental Radiography

INTRODUCTION:

External root resorption is characterized by the loss of cementum or dentin that occasionally extends to the pulp; the condition in most cases has an unknown etiology, except in cases where inflammatory lesions, tumors, and high mechanical and occlusal forces are known to affect it [1]. The most common areas for the occurrence of external root resorption are the apical and cervical regions where the periodontium and root surface are repaired spontaneously in approximately two weeks; in these cases no, therapeutic protocol is indicated. In severe injuries such as intrusion or avulsion, in particular when implantation process is suspended for more than 60–90 minutes, external inflammation can remain active, leading to osteoclastic resorption of the root dentin by multinucleated cells [2].

The radiographic appearance of external root resorption depends on the severity of the lesion. Primary lesions are observed as radiolucent had owes in the marginal areas of the tooth. External root resorption may be confirmed by dental radiography using the paralleling technique[3,4]. This technique may be helpful in identifying and determining the position of external root resorption; however, intraoral radiography fails to show the actual dimensions of lesions; in particular, when the external root resorption extends to all parts of the root, diagnosis will be more difficult [5].

It is well known that lesions with a diameter under 0.6 mm and a depth under 0.3 mm cannot be identified by conventional periapical radiography and

thus external root resorptionre mains undiagnosed and is allowed to progress[6,7]. Lesions that occur on the buccal or lingual surfaces of the tooth pose a major diagnostic problem in conventional radiology[8]. Furthermore, the diagnostic efficacy and the accurate estimatation of the position and size of root resorption on the root surface play a decisive role in selecting an appropriate and successful therapy[7].Therefore, the use of three-dimensional (3D) images could be a valuable diagnostic tool in dental treatments. Images obtained by cone-beam computed tomography (CBCT) can be extremely helpful as they reconstruct dental structures with a quality similar to the original one, have high-speed performance (between 10 and 70 seconds), and allow exposure dose which is almost one-sixtieth of the radiation produced by multi-slice computed tomography[9-11].

Cone-beam computed tomography (CBCT) is an efficient imaging technology that provides images of the oral and maxillofacial regions. It is a cost-effective technique compared to other commonly used CT imaging systems and has much potential. CBCT imaging technique seems to improve both the early diagnosis of internal and external root resorption lesions and the prognosis in patients undergoing treatment.

The present study aimed to determine the effect of voxel size changes on the diagnosis of external root resorption by Planmeca cone-beam computed tomography system.

MATERIALS AND METHODS:

This experimental invitro study was performed on 30 single-rooted anterior teeth with no visible defects or root fractures as confirmed by direct observation. To meet the principles of infection control, the teeth were left in sodium hypochlorite diluted in water (1:5) for 24 hours and later stored in 70% ethanol. Simulated external root resorption lesions were randomly created on three cervical, middle and apical surfaces of each tooth, measuring 0.25 and 0.5 mmin depthusing a round-end bur(0.5 mm diameter, Dia Dent, CITY Italy). To create and simulate external root resorption, the drill shank lightly touched the tooth root to create cavities with a more accurate size. After that a digital caliper (absolute 500-196-20, Mitutoyo, Japan) was used to measure the size of each cavity and excluding samples with greater depth. Finally, 60 small and60large lesions on the root surfaces with desired depth included in the study. Periodontal ligament (PDL) simulation was achieved through dipping the root surface into melted waxup to the cervical region, creating approximately a 0.2-mm-thick layer of wax. The teeth were randomly mounted in cast blocks containing a mixture of chalk and sawdust (1:1)(figure 1) and CBCT scans were obtained by Planmeca system (Planmeca Promax 3D, Finland) at voxel sizes of 0.2 and 0.4 mm(Figure 2).All the images obtained by CBCT technique were evaluated by two radiologists. The results of evaluation of images were recorded in related tables as positive (+) for the teeth with external root resorption by their size and negative (-) for healthy teeth. Following the observation of CBCT images of external root resorption in the cervical, middle and apical thirds the values for diagnostic parameters, including accuracy, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV), were reported in large and small lesions. Data were analyzed with SPSS 18.0.

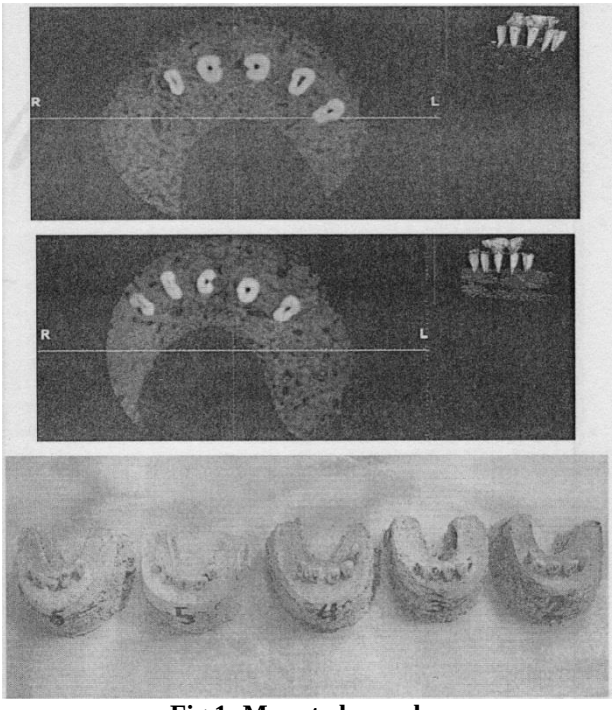

Fig 1: Mounted samples

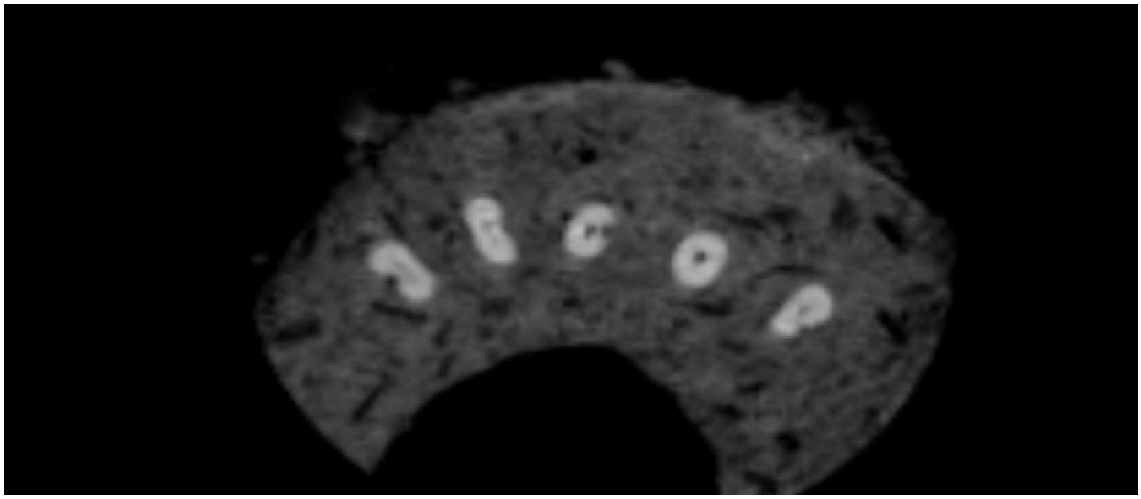

Fig 2: The samples were scanned in CBCT and demonstrated in axial view

RESULTS:

The diagnostic accuracy, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV)were calculated for each voxel size on three surfaces of the teeth: cervical, middle and apical. The values obtained by observers 1 and 2 and the inter-observer kappa results for these values were calculated. The values obtained for diagnostic accuracy, sensitivity, specificity for apical, middle and cervical surfaces for large and small lesions in both voxel sizes are presented in Tables 1and 2.As seen in the Tables, there were no significant differences between the samples.

Table 1: Values of accuracy, sensitivity, specifity for large lesions on root surfaces with voxel sizes of 0.2 and 0.4 mm

INDICATOR	VOXEL SIZE EXAMINED SURFACE	VOXEL SIZE 0.2	VOXEL SIZE 0.4	p-value
ACCURACY	CERVICAL	**90**	**76.66**	0.804
	MIDDLE	**84.98**	**71.67**	0.912
	APICAL	**86.66**	**74.83**	0.851
SPECIFICITY	CERVICAL	**91.65**	**62.5**	0.682
	MIDDLE	**80.93**	**64.37**	0.569
	APICAL	**88.23**	**79.8**	0.612
SENSITIVITY	CERVICAL	**100**	**90.38**	0.287
	MIDDLE	**93.17**	**85.43**	0.341
	APICAL	**84.67**	**67.44**	0.290

Table 2: Values of accuracy, sensitivity, specifity for small lesions on root surfaces with voxel sizes of 0.2 and 0.4 mm

INDICATOR	VOXEL SIZE EXAMINED SURFACE	VOXEL SIZE 0.2	VOXEL SIZE 0.4	p-value
ACCURACY	CERVICAL	**76.66**	**68.33**	0.302
	MIDDLE	**78.33**	**75.0**	0.221
	APICAL	**61.66**	**53.33**	0.283
SPECIFICITY	CERVICAL	**50.0**	**38.46**	0.302
	MIDDLE	**70.85**	**61.36**	0.212
	APICAL	**55.81**	**46.87**	0.223
SENSITIVITY	CERVICAL	**89.32**	**82.35**	0.104
	MIDDLE	**81.38**	**82.23**	0.066
	APICAL	**66.67**	**67.44**	0.072

The degree of correlation between the observers to examine the images created by CBCT system at 0.2- and 0.4-mm voxel sizes was calculated by Kendall's correlation coefficient by which the total agreement, considering the category of interest, was found to be within the proper limit. Interobserver kappa findings in values for accuracy, sensitivity, specificity, PPV and NV between the two observers represented in Table 3.

Table 3: Interobserver kappa findings in values for for accuracy, sensitivity, specificity, PPV, and NV between the two observers

	p-value in small lesion voxel size=0.2	p-value in large lesion voxel size=0.2	p-value in small lesion voxel size=0.4	p-value in large lesion voxel size=0.4
Cervical	0.526	0.935	0.439	0.48
Middle	0.494	0.804	0.444	0.553
Apical	0.223	0.912	0.526	0.57

The correlation coefficients of clinical diagnoses achieved through images produced at 0.2- and 0.4-mm voxel sizes for small lesions were 0.638 and 0.649 for the first and second observers, respectively. Furthermore, the correlation coefficients calculated for large lesions were 0.712 and 0.731 for the first and second observers, respectively.

DISCUSSION:

In the dental literature, the insufficient accuracy of conventional radiography methods in detecting root lesions such as small resorptive lesions on the buccal and lingual surfaces is well-documented [6-8, 12]. This has led investigators to look for other techniques that will diagnose external root resorption lesions.

In teeth with invasive cervical [13] or inflammatory lesions [14], which induce root resorption, early treatment to prevent the progression of lesions is recommended to increase the success rate. The prognosis of root resorption lesions depends on the position, size and the root surface. As conventional radiographic images do not have adequate accuracy in detecting these cases, the application of digital diagnostic systems is recommended for endodontic treatments [15].

In a study by da Silveira *et al.;* on the benefits of multislice CT in detecting external root lesions, the authors reported that this technology provides high sensitivity and specificity in identifying external root lesions on buccal surfaces[16]. Based on the results of their study, the presence of small lesions inthe apical third significantly decreased the rate of diagnostic sensitivity. Furthermore, the sensitivity and specificity of CBCT technique was shown to be very high in diagnosing external root resorptions with no significant differences noticed in relation to cavity size, location and cross-section[17]. Case reports have also validated the use of CBCT and CT imaging modalities in the diagnosis and treatment planning of external root resorptive lesions[9, 18]. In CBCT technology, the observation of root surfaces from different locations such as axial and coronalangles allows accurate determination of the stage and extent of resorptive lesions, leading to earlier detection and improved prognosis.

Consistent with previous papers[18,19], our study demonstrated that images obtained at both 0.2- and 0.4-mm voxel sizes with Planmeca CBCT system are similar in terms of diagnostic parameters, i.e. accuracy, sensitivity, specificity, PPV and NPV in all the regions of the root (apical, middle and cervical surfaces). Moreover, this technique was equally successful in detecting small and large external root resorption lesions throughout the root. Therefore we can safely conclude that the voxel sizes used in the current study for CBCT images had no significant effect on the diagnostic accuracy of images for different sizes and locations of resorptive lesions. It is noteworthy to mention that in several cases the diagnostic criteria used to evaluate images at a voxel size of 0.2 mm were slightly higher than those obtained at 0.4-mm voxel size. Similar results were reported in a study by Liedk *et al.;* [17].It can be assumed that the results of this study are accurate as good agreement was obtained between the two obsevers at both 0.2- and 0.4-mm voxel sizes.

Based on the results of the present study, the highest values for diagnostic sensitivity for images obtained at 0.2-mm voxel size was observed on cervical surfaces by the first and the second observers [10]. The first and the second observers' examinations also yielded a value of 100 for both PPV and NPV (highest value). The lowest diagnostic value for the images was at a voxel size of 0.4mm on the cervical surface. In a study by Esterla *et al.;* all the cases of root resorption lesions were identified by CBCT; in particular, when the terminal regions of the lesions had a size greater than 1–4 mm,95.8% of cases were discovered with a voxel size of 0.2 mm[19].

However, it is worth mentioning that the difference in exposure factors at different voxel sizes

could, with voxel size itself, influence the quality of the images obtained.

Although the values obtained for diagnostic sensitivity were higher in the middle and cervical regions than those in the apical third were when two 0.2- and 0.4-mm voxel sizes were used, the difference was not significant. Other studies have shown this pattern of sensitivity [16, 20].

The results of application of two CBCT systems at different voxel resolutions for detecting small cavities of internal resorption were evaluated in a study by Kamburoglu & Kursan, in which the high resolutions of both systems yielded similar results in identifying internal resorption lesions, although one of the two systems somehow produced better results at low resolution[21,22,23].

A brief review of findings of 0.2- and 0.4-mm voxel sizes for small and large resorption lesions showed that as the size of cavities grew, the diagnostic accuracy of root resorption by CBCT increased in some cases, although not significantly so. Goldberg *et al.;* examined the ability of CBCT in detecting simulated external root resorption in the incisor teeth of upper jaw and concluded that the detection of small cavities, compared to cavities of intermediate and large sizes, is laborious and difficult[7,24].

In another study by da Silveira *et al.;* small, medium and large apical resorptions were discovered in 28.6%, 86.66% and 100% of cases and an increase in cavity size improved the ability of CT technique to detect such lesions[16]. Finally, the diagnostic accuracy of CBCT for external root resorption at different voxel sizes was also examined by Neves *et al.;* in which an increase in cavity size yielded higher values for diagnostic accuracy, PPV and NPV[22,24,25]. This study, however, showed that overall the voxel size used in the current study for CBCT images had no statistically significant effect on the diagnostic accuracy of large and small images at the different levels of the root.

CONCLUSION:

Overall, both voxel sizes used in CBCT yielded relatively similar results in relation to the diagnostic accuracy for both large and small external root resorption lesions. We can conclude that the 0.4-mm voxel size, due to its lower radiation dose and equivalent accuracy, can be recommended for diagnosing root resrption lesions.

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