The Evaluation of Computed Tomography Scans and Ultrasounds in the Differential Diagnosis of Periapical Lesions

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Abstract

Traditionally, the definitive diagnosis of periapical lesion depends on histopathological examination of the tissues, which is impractical in cases planned for nonsurgical treatment. Recently, some authors have used ultrasound with power Doppler and computed tomography in differential diagnosis between a cyst and a granuloma. The aim of this study was to evaluate and compare the use of computed tomography (CT) scan and ultrasound with power Doppler flowmetry in differential diagnosis of periapical lesions. Twelve periapical lesions were imaged with the help of CT scans and ultrasound with color-power Doppler flowmetry. A provisional preoperative diagnosis was made based on history, clinical presentation, and radiographic features. The cases were treated by surgical endodontics. In all 12 cases, the diagnosis with CT scan and ultrasound coincided with the histopathological diagnosis of the lesions. It is proposed that CT scans and ultrasound with power Doppler flowmetry can provide an additional dignostic tool without invasive surgery, where treatment option is nonsurgical. *(J Endod 2008;34:1312–1315)*

Key Words

Color-power Doppler flowmetry, computed tomography, periapical lesions, ultrasound

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Traditionally, the diagnosis of periapical lesion is based on clinical and radiographic presentations, which are only empiric methods. The final confirmatory diagnosis is performed by histopathological examination of the tissues, which is impractical in nonsurgical treatment cases. Once a biopsy is taken, the treatment is no longer a nonsurgical procedure (1, 2). The most commonly used diagnostic adjunct is radiograph. The radiographic image is a shadow and has the elusive qualities of all shadows. Also, it is a two-dimensional representation of a three-dimensional object. Traditional radiographs could only determine the mesiodistal extent of the pathology and not the buccolingual extent (3). In late 1980s, radiographs were digitized to provide a control over the quality of the film and also to reduce the radiation dosage. These digitized radiographs have an advantage that the contrast and brightness could be controlled by the operator (4). But even these provided a two-dimensional picture of the lesion. Hence, other diagnostic methods like CT scan and ultrasound with power Doppler flowmetry were introduced.

CT scans use x-rays and computers for cross-sectional slices of the body part. Each picture is like a slice from a loaf of bread, showing both the outline and internal structure (5). Trope et al. in 1989 (6), for the first time, used CT scans in the differentiation of radicular cyst and granulomas. A CT scan was performed on the root tips and the periapical lesions of eight teeth. Seven of the periapical lesions had a cloudy appearance with a density similar to each other and to the surrounding soft tissue. In the eighth lesion, a homogeneous dark area with a distinctly lower density could be distinguished from the surrounding cloudy areas. Histologically, the dark area was shown to be an epithelialized cystic cavity. The other seven lesions were granulomas. Thus, a cyst could be differentiated from periapical granulomas by CT scans because of a marked difference in density between the content of the cyst cavity and granulomatous tissue.

Cotti et al. in 2003 (7) proposed that ultrasound may help to make a differential diagnosis between cysts and granulomas by revealing the nature of the content of a bony lesion. Ultrasound is based on the evaluation of the reflected echoes from the interface between two different tissues having different acoustic properties. Hypoechoic area has a low echo intensity; anechoic is an area in which no reflection occurs (ie, any area filled with fluids), and hyperechoic is an area that has high echo intensity. In addition, power Doppler flowmetry provides information regarding the presence, direction, and velocity of blood flow within the lesion (8). Ultrasound has an advantage over CT scans because no ionizing radiations are used. But the major disadvantage of ultrasound is that it can be used only if there is a bony defect over the lesion, through which ultrasonic waves can traverse (7). To date, very few studies are available to validate the use of CT scan and ultrasound in the diagnosis of periapical lesions. The purpose of this study was to compare the diagnostic validity of CT scans and ultrasound with power Doppler flowmetry in the diagnosis of large periapical lesions and compare the findings with a surgical biopsy report.

Materials and Methods

Twelve patients between the ages of 12 and 45 years having periapical lesions in anterior maxillary teeth diagnosed by their clinical signs and symptoms and radiographic findings were selected for the study. Informed consent was taken from all the patients before their inclusion in the study. A patient record sheet was tabulated to

TABLE 1. Results of 12 Periapical Lesions Scanned by a Computed Tomography Scan, Ultrasound with Power Doppler Flowmetry, and Biopsy Report

Case #	Tooth #	HUs Obtained by CT Scan					Ultrasound Features			Biopsy
		Center	Min	Max	Lips	Cortical Bone	Echography	Margins	PDF Vascularity	
1	7, 8	−13	−56	24	42	1,078	Anech	WD	Absent	Cyst
2	9	−6	−11	18	55	1,422	Anech	WD	Absent	Cyst
3	9, 10	−4	−54	20	46	1,166	Anech	WD	Absent	Cyst
4	10, 11	−22	−60	26	61	1,248	Anech	WD	Absent	Cyst
5	7	4	−40	11	39	1,642	Anech	WD	Absent	Cyst
6	6, 7	−11	−52	14	44	1,254	Anech	WD	Absent	Cyst
7	6, 7, 8	18	−8	29	52	1,119	F Hypoec	WD	Absent	Cyst
8	10	14	−22	34	57	1,401	F Hypoec	WD	Absent	Cyst
9	9, 10	17	−29	30	48	1,606	F Hypoec	WD	Absent	Cyst
10	7, 8	14	−10	22	62	1,216	F Hypoec	WD	Absent	Cyst
11	7	68	38	102	44	1,126	Pre Hypoec	PD	Traces	Granuloma
12	8	74	54	110	42	1,394	Pre Hypoec	PD	Traces	Granuloma

Anech, anechoic; CT, computed tomography; F Hypoec, focal hypoechoic; HU, hounsfield units; PDF, power Doppler flowmetry; Pre Hypoec, predominantly hypoechoic; WD, well defined; PD, poorly/ill defined.

record the history, clinical examination, radiographic findings, ultrasound examination, CT measurements, and histopathological findings (Table 1).

CT scans were performed with a multidetector CT scanner (16 slices/ second) as per recommendations given by Christoph et al. (9) to reduce the radiation dosage (collimation, 1 mm; pitch, 2; tube voltage, 80 kV; tube current, 40 mA). Also, all the protective measures were taken to protect the patient from radiation. The scan reconstruction interval was 0.8 mm, resulting in 60 to 100 overlapping images in each patient. Axial images were transmitted to a commercially available dental program (Denta scan, Advantage Windows; General Electric, Buc, France) to reformat panoramic and cross-sectional images of the maxilla in all three planes. Various slices of the lesion were studied, and the radiodensity of the lesion was measured at various areas within the lesion using Hounsfield units (HUs). After mapping, the lesion was scanned for the HU at the center of the lesion above the root. Also, minimum and maximum HU in the lesion area were measured along with standard values of cortical bone and lips. The values were tabulated for assessment.

An echographic evaluation was performed by using the LOGIQ-500 PRO diagnostic ultrasound machine (GE Medical Systems, Buc, France), with power Doppler flowmetry, using a high-definition, multifrequency ultrasonic probe (LA-39) operating at a frequency of 10 MHz. Thin anterior labial cortical bone or fenestration allowed the examiner to study the lesion. The lesions were assessed in all the three planes, and the echo characteristic of the lesion was determined. Power Doppler flowmetry was applied to detect the blood flow within the lesion. The images were analyzed, and the lesions were classified on the basis of echo characteristics and vascularity. The lesions were surgically removed and sent in a vial containing 10% buffered formalin to a pathology laboratory (Department of Pathology, All India Institute of Medical Sciences, New Delhi, India). The histopathological examination was done after staining the sections with hematoxylin and eosin.

Results

The lesions were diagnosed as a cyst or granuloma on the basis of HUs obtained from the CT scan and echo characteristics, and the findings were compared with histopathological findings.

CT Scan Examination

The lesions with HUs at center, ranging from −20 to +20, were classified as fluid-filled cavities or cysts, and those with HUs >40 were classified as solid, soft-tissue lesions. In 10 cases, the lesions had a HU value between −20 to +20 and were therefore classified as cystic cavities. In two cases, the lesions had a HU value more than 40 (68 and 74) and these lesions were classified as granulomas (Figs. 1–4).

Ultrasound Examination

Echographic evaluation showed the presence of periapical lesions in all 12 cases and was classified into three groups on the basis of echo characteristics and vascularity. Six lesions showed anechoic areas with well-defined smooth contours and margins. There was no evidence of internal vascularization on application of power Doppler flowmetry. These cases were diagnosed as cystic fluid-filled cavities. Four cases showed predominantly anechoic lesions with focal hypoechoic areas with no evidence of internal vascularization. These findings were indicative of pus-filled cavities. Two cases showed ill-defined margins with predominantly hypoechoic areas and traces of vascularization. These lesions were classified as granulomas.

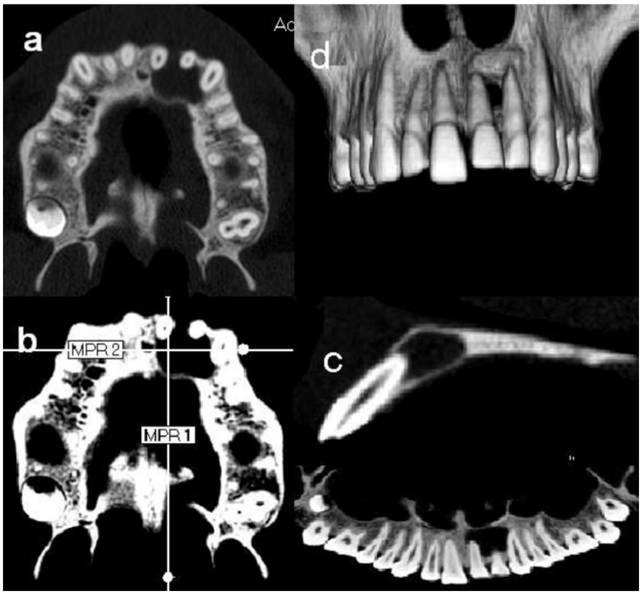

Figure 1. (*a–c*) Axial, sagittal, and coronal view of the lesion. (*d*) Three-dimensional reconstruction of maxilla showing the lesion over the apices of left incisors.

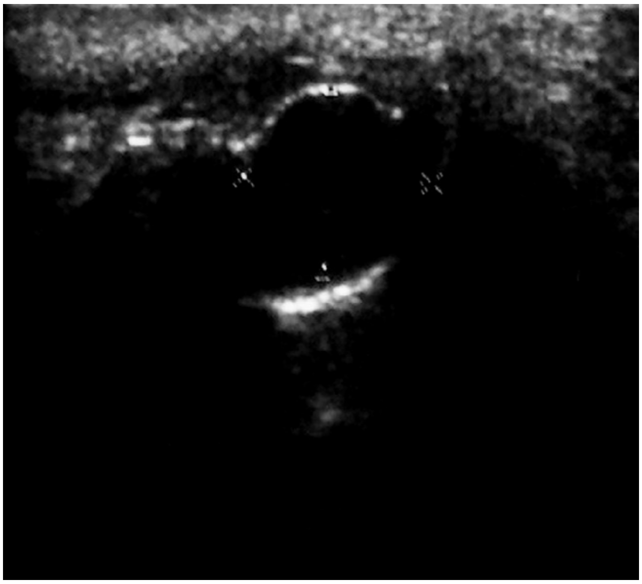

Figure 2. Ultrasound image showing anechoic areas with well-defined margins and no internal vascularization on application of color-power Doppler flowmetry.

Histopathological Examination

In all 12 cases, the histopathological findings were consistent with the diagnosis obtained by CT scan and ultrasound power Doppler flowmetry.

Discussion

Pulpal inflammation and necrosis eventually produce periradicular changes or apical pathology in the form of either a granuloma or a cyst. However, clinical examination and routine radiographs alone cannot differentiate between cystic and noncystic lesions. In the past, various methods have been suggested, with limited success to diagnose the lesion without performing a biopsy. McCall and Wald (10) proposed that periapical cysts could be differentiated radiographically from granulomas on the basis of their larger size (ie, more than 9.5 mm in diameter) and the presence of a radiopaque cortex. Grossman (11) suggested that although radiographic differentiation of cysts and granulomas was possible in most cases, small radicular cysts could not always be differentiated from granulomas. In 1960, Forsberg and Hagglund (12) reported the use of an x-ray contrast medium that they injected into periapical lesions through prepared root canals. In those lesions that later proved histologically to be cysts, the injected contrast medium assumed a round, smooth-bordered, evenly dense appearance. In lesions that proved to be granulomas, the contrast medium assumed an irregular shape with ragged borders and variable radiographic density. However, Cunningham and Penick (13) in 1968 were unable to show any correlation between the radiographic appearance of injected lesions and the histological diagnoses. Howell and De la Rosa in 1968 (14) reported on the cytologic examination of aspirates from the lesions. On the basis of their results, they concluded that the characteristic cell patterns found in cyst aspirates might permit an accurate provisional diagnosis of these lesions. Morse et al. in 1973 (15) described a chair-side method for differentiating cysts and granulomas. This involved the use of alkaline copper tartrate to color fluid aspirates from periapical lesions. A consistent color difference related to differences in protein content was observed for cysts and granulomas. The authors noted, however, that colors for cysts and granuloma were similar (dark and medium blue, respectively) and that this might result in diagnostic errors. In addition, they speculated that granulomas with high protein content might yield a color equivalent to that of a cyst and thus be wrongly diagnosed as a cyst. Also, there are several reports in the endodontic and general dentistry literature of serious lesions mimicking as endodontically related periapical pathosis, which needs to be diagnosed and excluded from routine periapical lesions. Burkes in 1985 (16) described a case of a mandibular right first premolar that had a diffuse periapical radiolucency that appeared to be a lesion of endodontic origin. When a biopsy was eventually performed, the lesion was diagnosed as an adenoid cystic carcinoma. Shah and Sarkar in 1992 (17) reported a case of maxillary left lateral incisor having an open immature

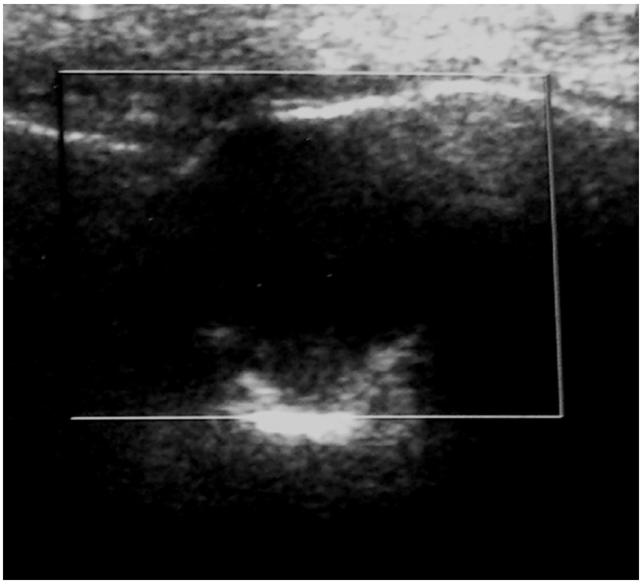

Figure 3. Ultrasound image showing predominantly anechoic lesions with focal hypoechoic areas with smooth margins and no internal vascularization on application of color-power Doppler flowmetry.

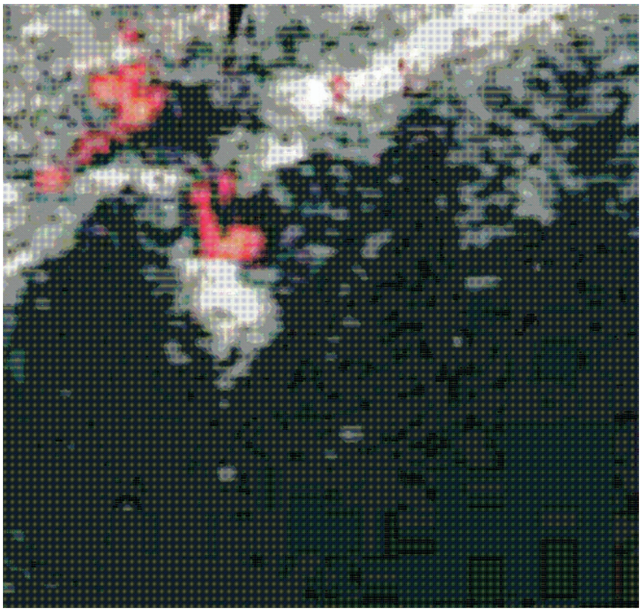

Figure 4. Ultrasound image showing predominantly hypoechoic lesions with ill-defined margins and internal vascularization on application of color-power Doppler flowmetry.

apex and associated large periapical radiolucency. Conservative treatment failed to show any improvement. Apical surgery was performed, and the histopathological diagnosis was of a plasmocytoma. Hence, it is very important to accurately diagnose the periapical lesions and exclude any rare chance of neoplastic occurrence.

The use of CT scans was introduced by Trope et al. in 1989 (6) and the use of ultrasound with power Doppler flowmetry was reported by Cotti et al. in 2003 (7) in differential diagnosis of periapical lesions. Since then, very few studies have been undertaken to validate their findings. Nair and Nair (18) and Cotton et al. (19) reviewed the use of CT scans in the diagnosis of periapical lesions. Low et al. (20) and Estrela et al. (21) compared periapical radiography and cone-beam CT scans for the preoperative diagnosis of apical periodontitis and concluded that a CT scans was more accurate to identify the apical periodontitis. Simon et al. in 2006 (22) used gray values obtained by cone-beam CT scans to differentially diagnose 17 large periapical lesions. They concluded that the cone-beam CT scan may provide a better, more accurate, faster method to differentially diagnosis a solid from a fluid-filled lesion or a cavity. However, so far, no study has been undertaken to evaluate both CT scans and ultrasound simultaneously and validate the findings with definitive diagnosis by histopathological diagnosis. Therefore, the present study was undertaken to assess the diagnostic ability of CT scans as well as ultrasound and to compare it with histopathological diagnosis to assess whether periapical lesions could be accurately diagnosed preoperatively, in cases in which nonsurgical treatment is planned to treat large periapical lesions. The diagnosis with all the three modalities coincided in all 12 cases. Denta scan software was used to format the images obtained from the CT scan. The Denta scan images help the clinician to make a three-dimensional model of the lesion, giving an added advantage over routine radiographs. The clinician is able to better visualize the lesion; can accurately discern whether the margins are smooth, corticated, or ragged; can use the image for patient education; and, finally, can make the correct treatment plan.

A major concern with the use of CT scan is its high radiation dosage. In the present study, guidelines by Christoph et al. (9) were used. Using these guidelines, the effective radiation dosage produced by this method was 0.56 ± 0.06 mGy, which is equivalent to a standard panoramic radiograph. The measurement of the lesion was taken in HUs. A Hounsfield unit is used to describe the amount of x-ray attenuation of each voxel (volume element) in three-dimensional image obtained by CT scan. The voxels are normally represented as 12-bit binary numbers and therefore have $2^{12} = 4{,}096$ possible values. These values are arranged on a scale from $-1{,}024$ HU to $+3{,}071$ HU, calibrated so that $-1{,}024$ HU is the attenuation produced by air and 0 HU is the attenuation produced by water. Tissue fluids, soft and hard tissues produce attenuations in the positive range. In the present study, all the lesions had HUs in the range of -20 to $+20$, and, hence, all the lesions were labeled as cystic lesions. The limitation with the use of ultrasound was that it is only possible in cases with windows in bone or where the bony architecture has been altered. But the advantage of ultrasound is that it completely eliminates the radiation exposure and can accurately give information about the size, shape, and architecture of the lesion.

The results of the present study indicate that CT scans and ultrasound with power Doppler flowmetry can provide an additional or alternate but more accurate dignosis of periapical lesions with validity equivalent to histopathological diagnosis. If the ultrasound diagnosis gives as accuarate a result as the histopathological diagnosis, it can prove to be a very valuable tool in the noninvasive method of diagnosis of periapical lesions, whether they are of endodontic or nonendodontic origin and whether they are a granuloma or a cyst. A further study on larger number of cases is required to confirm the findings of the present study. Further refinements in the techniques for better defination and interpretation of images produced by CT scans and ultrasound with power Doppler flowmetry can probably increase its usage and find newer applications in endodontic diagnosis.

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