The value of ultrasound and color doppler ultrasonography in the evaluation of periapical lesions in comparison to histopathological and/or surgical findings

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ABSTRACT

Background: Imaging techniques play a very important role in the specialty of endodontic. The ultrasonographic technique is non-expensive procedure, safe, and reproducible. The aim of the study was to determine the sensitivity, specificity, and accuracy of ultrasound and color Doppler ultrasonography in evaluation of periapical lesions (cyst, granuloma, mixed lesion "cyst within graulomas mass", and abscess.

Subject, Material and method: The sample consists of prospective study for 64 Iraqi participants who attended Karbalaa Specialized Center for Dentistry (males & females).

Those patients were diagnosed clinically and radiographically as having periapical lesions of dental origin. They were examined by real time ultrasound and color Doppler ultrasonography with echographic predilection about the type of the lesion based on three parameters measured by ultrasound including: content, outline, and the vascularity. The echographic diagnosis was compared to the final histopathological and /or surgical findings obtained from the periapical surgeries.

Results: The sensitivity, specificity and accuracy of ultrasound diagnosis were respectively as follow: for periapical cyst, they were 92.3%, 96.1%, and 95.3%. While for periapical granulomam, they were 87.0%, 92.7%, and 90.6%. For mixed lesions, they were 66.7%, 98.4%, and 96.9% and lastly for periapical abscess, they were 92.0%, 97.4%, and 95.3%. The ultrasound diagnosis in our study had an overall agreement of 89% between ultrasound diagnosis and final diagnosis based on histopathological and/ or surgical findings.

Conclusion: Ultrasound is a non- invasive, low cost, and complementary method for examination and diagnosis of periapical lesions and there is correlation of ultrasonographic findings with histopathological and /or surgical findings for final diagnosis.

Key words: periapical lesions, ultrasound, color Doppler. (J Bagh Coll Dentistry 2013; 25(Special Issue 1):59-66).

INTRODUCTION

Periapical lesions resulting from necrotic dental pulp are among the most frequently occurring pathologies found in the alveolar bone, exposure of the dental pulp to bacteria and their by-products, acting as antigens, may elicit non specific inflammatory responses as well as specific immunological reactions in the periradicular tissues, and cause the formation of periapical lesion [(1,2)]. Radiology is the first, but not the only, method used to identify intra- and extra-osseous jaw lesions [(3,4)]. Clinical examination and radiographs alone cannot differentiate between cystic and non cystic lesions. Being able to distinguish between the two may be of importance in predicting treatment failure [(5)], and it is very important to accurately diagnose the periapical lesions and exclude any rare chance of neoplastic occurrence [(6)]. Computerized tomography (CT) can be used to make a differential diagnosis between cystic and non cystic lesions [(7, 8)].

Unfortunately, routine use of CT is associated with high dosage of radiation, even though dose reduction methods have been established [(9)].

Magnetic resonance imaging (MRI) is useful in the diagnosis, but it is not practical in the dental field. Ultrasound has no ionizing radiation, no known harmful effects at the energies and doses used, in addition the technique is widely available and inexpensive [(10)].

MATERIALS AND METHODS

The study sample consists of 64 Iraqi patients (males and females) with periapical lesions referred for treatment to Kerbalaa Specialized Centre between September 2011 and April 2012. Their age ranged between (15-60) years old. The ultrasound examination was performed by using a Philips of HI 11 XE ultrasound system with 7.5 MHz linear array probe in (Al-Hussein general hospital). The parameters measured by ultrasound were as shown in figures (1, 2, 3, and 4):

1- Texture of the lesion: the interpretation of grey values on an image is based on a qualititative comparison of the echo intensity with that of normal tissue. Hypoechoic or transonic is an area with low echo intensity; anechoic is an area where no reflection occurs (i. e. any area filled with fluid), and hyperechoic is an area which has high echo intensity [(11)].

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2- Vascularity: by the color power Doppler, the vascularization within the lesion can be seen. A differential diagnosis between cystic lesion and granuloma may be done based on the following principles: cystic lesion is a transonic, well defined cavity filled with fluid and with no evidence of internal vascularization at the color power Doppler, while the granuloma is a distinct lesion shows hyperechoic texture and internal vascularization with out well defined contour.

3- The margin of the lesion: if it is regular or irregular.

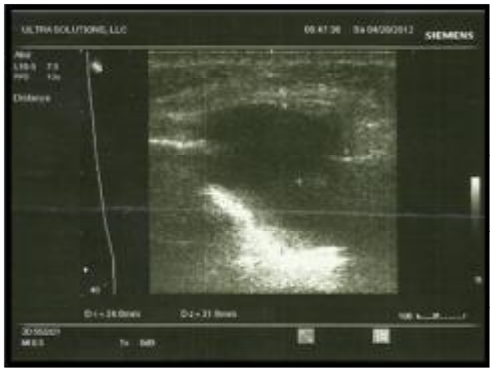

Figure 1: Ultrasound of periapical cyst show hypoechoic texture, well defined margin and reinforced bone

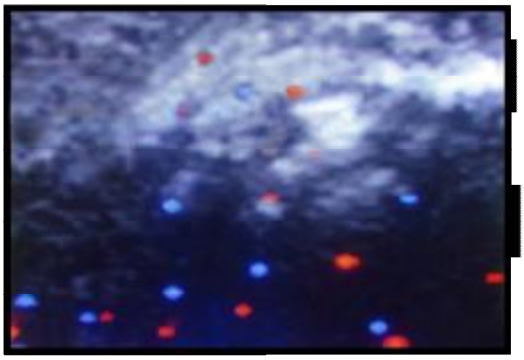

Figure 2: Uultrasound of periapical granuloma show hyperechoic texture and vascularization (blue and red spots)

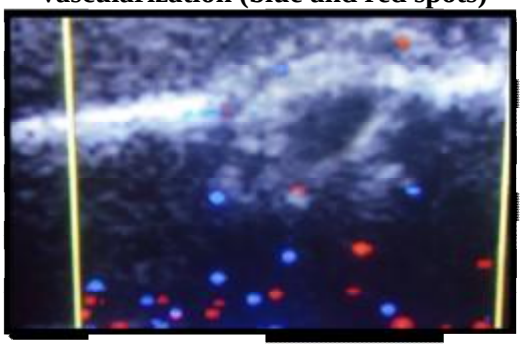

Figure 3: Ultrasound of mixed periapical cyst/granuloma show hypoechoic and avascular center with hyperechoic and vascular periphery

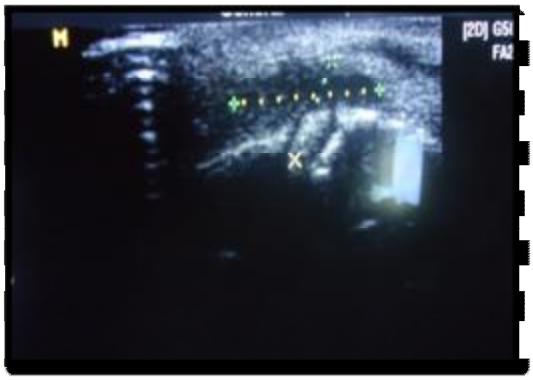

Figure 4: Ultrasound of periapical abscess show irregular margin and hypoechoic texture

Statistical data analysis

OR (odds ratio) to measure the strength of association between 2 categorical variables, such as the presence of certain US criteria and having a specific final diagnosis, the odds ratio (OR) was used. For example OR for the association between having a hypoechoic texture and having a final diagnosis of periapical cyst, equals the ratio of the odds of having the specific US criteria versus lacking it among cyst cases to the similar odds among non-cyst cases.

		Having periapical cyst		
		+	-	
Presence of specific US criteria	+	A	B	$OR = \frac{\frac{A}{B}}{\frac{C}{D}} = \frac{AD}{BC}$
	-	C	D	

Sensitivity is the conditional probability that a diseased person has a positive result.

Specificity is the conditional probability that a disease-free person has a negative test result.

Positive Predictive Value (PPV) is the conditional probability that a person with a positive test result is truly diseased.

Negative predictive value (NPV) is the conditional probability that a person with a negative test result is truly free of the disease.

Accuracy (percent agreement) is the proportion of true results among all test results (positive and negative) (12)

RESULTS

As shown in table (1):

The US diagnosis had an overall accuracy (agreement) of 89% with the final diagnosis. The US diagnosis was most accurate in periapical abscess (highest agreement) and least accurate for mixed lesion (lowest agreement).

As shown in table (2):
Three US criteria, namely: hypoechoic texture, avascular pattern, and well defined margin were tested for their strength of association in predicting a final diagnosis of periapical cyst (PAC). The presence of a well defined margin on US was the strongest criteria among the three tested. It increased the risk of having PAC by 294 times. Coming second in importance was hypoechoic texture, which increased the risk of positive diagnosis of PAC by 69.8 times. Avascular pattern ranked third in importance. It increased the risk of having PAC by 24.1%. All the three tested US characteristics had a statistically significant association with diagnosis of PAC

As shown in table (3)
The US criteria, namely: hyperechoic texture, vascular pattern, and the absence of well defined margin were tested for their strength of association in predicting a final diagnosis of periapical granuloma (PAG). The vascular pattern on color Doppler US was the strongest criteria among the three tested. A positive vascular pattern increased the risk of having PAG by 266.7 times. Coming second in importance was hyperechoic texture, which increased the risk of positive diagnosis of PAG by 84.4 times. The absence of well defined margin on US was the least important among the three. The vascular pattern and hyperechoic texture on US had a statistically significant association with diagnosis of PAG, while the irregularity of the lesion margin did not have statistical association with the diagnosis of PAG.

As shown in table (4):
Four US criteria, namely: hypoechoic texture, anechoic texture, avascular pattern, and the absence of well defined margin were tested for their strength of association in predicting a final diagnosis of PAA. The avascular pattern was the strongest criteria among the four tested, this increased the risk of having PAA by 80.6 times. Coming second in importance was the anechoic texture which increased the risk of having PAA by 62.7 times. The absence of well defined margin ranked third in importance that it increased the risk of having PAA by 29.0, while the hypoechoic texture did not have statistical association with the diagnosis of PAA.

As shown in table (5)
Three US criteria, namely: mixed texture (hypoechoic center and hyperechoic periphery), mixed vascularity (avascular center and vascular periphery) and the absence of well defined margin were tested for their strength of association in predicting a final diagnosis of mixed lesion. The mixed texture and mixed vascularіy increased the risk of having mixed lesion by 120 times, while the absence of well defined margin did not have statistical association with the diagnosis of periapical mixed lesion.

As shown in table (6):
For periapical cyst (PAC):
Two US criteria had a perfect sensitivity (100%).These criteria are hypoechoic texture and avascular pattern which are most useful when being negative since it can exclude possible presence of PAC with 100% confidence (negative predictive value).
The most specific US criterion was a well defined margin 96.1%.
A well defined margin was also the criterion associated with highest accuracy (95.3%).
An US diagnosis of PAC had an overall accuracy of 95.3%, sensitivity of 92.3%, and a specificity of 96.1%.

As shown in table (7):
For periapical granuloma (PAG):
The most sensitive US criteria was the absence of well defined margin 91.3% which is most useful when being negative since it can exclude the possibility of being PAG with 96.8% confidence(negative pretest probability).
The most specific US criterion was the vascular pattern 97.6.
The vascular pattern was also the criterion associated with highest accuracy (93.8%).
An US diagnosis of PAG had an overall accuracy of 90.6%, sensitivity of 87% and specificity of 92.7%.

As shown in table (8):
For periapical abscess (PAA):
1. Two US criteria had a perfect sensitivity (100%).These criteria are the absence of well defined margin and the avascular pattern which are most useful when being negative since it can exclude possible presence of PAA with 100% confidence (negative predictive value).
2. The most specific US criterion was the anechoic texture (100%).
3. The anechoic texture was the criterion associated with highest accuracy (78.1%).
4. An US diagnosis of PAA had an overall accuracy of 95.3%, sensitivity of 92% and specificity of 97.4%.

As shown in table (9):
For periapical mixed lesions:
The most sensitive US criteria was the absence of well defined margin 100% which is most useful when being negative since it can exclude the possibility of being mixed PAL with 100% confidence (negative pretest probability).

Two US criteria were the most specific. These criteria were the mixed texture and mixed vascularity, each criterion had specificity of 98.4%.

The mixed texture and mixed vascularity were the criteria associated with highest accuracy (96.9%).

An US diagnosis of mixed PAL had an overall accuracy of 96.9%, sensitivity of 66.7% and specificity of 98.4%.

DISCUSSION

Ultrasound is easy, reproducible, and the equipment is relatively cheap compared to the other advanced imaging modalities. The images obtained are easy to read once the observer is trained. By obtaining a real time image, a working diagnosis can be made without delay and it also prevents unnecessary exposure of the patient to ionizing radiation [8, 13]. From a biological standpoint , in experimental and clinical studies, no adverse effect of US waves have been shown to occur in the tissues as a consequence of echographic examination, and even if the effect of repeated echographic examination is less certain, the risks entailed by radiography are much greater [14,15,16].The possibility of identifying lesion content before any surgical procedure can be obtained by using US examination, using the higher frequency (7.5 MHz) in the technique to increase the signals penetration of the lesion [17]. The current study used sample size (n=64) and a clear methodology relating the US diagnostic criteria to final diagnosis obtained by histopathology and / or surgical assessment. Allowing for an accurate reporting of validity parameters of each US criteria, making the US as an excellent guide for the surgeon. In the present study four pathological types of PAL were identified. The most commonly identified lesion was PAA in two fifth of the sample (39.1%) followed by PAG in more than one third (35.9%). Ranked third in frequency was PAC reported in one fifth (20.3%) of the sample. A rare finding was a mixture of periapical cyst and granuloma in only 4.7% of the sample. The US diagnosis in our study had an overall agreement of 89% with the final diagnosis based on histopathological and /or surgical evaluation. The agreement was higher for PAA (95.8%) compared to PAC and PAG (85.7% and 87.0% respectively). Dib et al in 1996 in their study on a sample of 72 patients with intraosseous lesions of the jaws reported an overall agreement of US ranging between 92.3% for lesions with solid content, 73.9% for lesions with liquid content, 92.8% for lesions with mixed content, and 7.7% for lesions with dense liquid content. Other pioneer studies based on very small sample size reached to a conclusion that US in combination with color Doppler were sensitive and very useful in differentiating between PAC and PAG and correlated well with the histological findings of the PALs; however no validity parameters were reported because of the small sample size [16,18,19].

The conclusions that can be drawn from this study are:

1. This study supported the fact that real time imaging ultrasound as a new imaging technique that can be used in endodontic field for the study of periapical lesions.
2. US is a good diagnostic tool for differentiation of PALs (cyst, granuloma, abscess, and cystic cavity within granuloma) based on ultrasonic selected criteria including; echo content, vascularity, and lesion margin.
3. US was highly sensitive in the diagnosis of PAC (92.3%), followed by PAA (92.0%), then PAG (87.0%), while the sensitivity of US diagnosis of mixed PAL was relatively moderate (66.7%).
4. US was highly specific in the diagnosis of mixed PAL (98.4%), followed by PAA (97.4%), then PAC (96.1%), and lastly the specificity of US diagnosis of PAG was 92.7%.
5. The US diagnosis in our study had an overall agreement of 89% with the final diagnosis based on histopathological and /or surgical evaluation. The agreement was higher for PAA (95.8%) compared to PAC (85.7%) and PAG (87.0%), and it was less for mixed cyst/granuloma periapical lesions (66.7%).
6. The strength of association (OR) was greater in PAA (437.0) followed by in PAC (294.0) then in mixed PAL (120) and lastly in PAG (84.4).

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Table 1: Agreement between US and final diagnosis

	Final diagnosis									
	Periapical granuloma		Periapical cyst		Periapical abscess		Mixed periapical Cyst Granuloma		Total	
	N N	%	N	%	N	%	N	%	N	%
U/S diagnosis										
Periapical granuloma	20	87.0	0	0.0	2	8.7	1	4.3	23	100.0
Periapical cyst	2	14.3	12	85.7	0	0.0	0	0.0	14	100.0
Periapical abscess	0	0.0	1	4.2	23	95.8	0	0.0	24	100.0
Mixed periapical Cyst Granuloma	1	33.3	0	0.0	0	0.0	2	66.7	3	100.0
Percent agreement = 89%										

Table 2: Strength of association between US criteria and positive final diagnosis of PAC

	Total	Positive final diagnosis of periapical cyst				
	N	N	%	OR	P	95% CI of OR
U/S diagnosis of periapical cyst						
Negative	50	1	2	Ref		
Positive	14	12	85.7	294.0	<0.001	(24.6 to 3518.2)
Hypoechoic texture on U/S						
Negative	37	0	0	Ref		
Positive	27	13	48.1	69.8	<0.001	(8.4 to 578.8)
Avascular pattern						
Negative	24	0	0	Ref		
Positive	40	13	32.5	24.1	0.003	(2.9 to 196.3)
Irregular lesion margin on U/S						
Irregular	50	1	2	Ref		
Regular	14	12	85.7	294.0	<0.001	(24.6 to 3518.2)

Table 3: Strength of association between US criteria and positive final diagnosis of PAG

	Total	Positive final diagnosis of periapical granuloma				
	N	N	%	OR	P	95% CI of OR
U/S diagnosis of periapical granuloma						
Negative	41	3	7.3	Ref		
Positive	23	20	87	84.4	<0.001	(15.6 to 457.4)
Hyperechoic texture on U/S						
Negative	41	3	7.3	Ref		
Positive	23	20	87	84.4	<0.001	(15.6 to 457.4)
Vascular pattern						
Negative	43	3	7	Ref		
Positive	21	20	95.2	266.7	<0.001	(26 to 2729.8)
Irregular lesion margin on U/S						
Regular	14	2	14.3	Ref		
Irregular	50	21	42	4.3	0.072[NS]	(0.9 to 21.5)

Table 4: Strength of association between US criteria and positive final diagnosis of PAA

	Total	Positive final diagnosis of periapical abscess				
	N	N	%	OR	P	95% CI of OR
U/S diagnosis of periapical abscess						
Negative	40	2	5	Ref		
Positive	24	23	95.8	437.0	<0.001	(37.5 to 5093.1)
Hypoechoic texture on U/S						
Negative	37	13	35.1	Ref		
Positive	27	12	44.4	1.5	0.452[NS]	(0.5 to 4.1)
Anechoic texture on U/S						
Negative	53	14	26.4	Ref		
Positive	11	11	100	62.7	<0.001	(7.5 to 524.4)
Avascular pattern						
Negative	24	0	0	Ref		
Positive	40	25	62.5	80.6	<0.001	(9.9 to 654.1)
Irregular lesion margin on U/S						
Regular	14	0	0	Ref		
Irregular	50	25	50	29.0	0.002	(3.6 to 235.9)

Table 5: Strength of association between US criteria and positive final diagnosis of mixed PAL

	Total	Positive final diagnosis of periapical cyst/granuloma				
	N	N	%	OR	P	95% CI of OR
U/S diagnosis of mixed periapical cyst/granuloma						
Negative	61	1	1.6	Ref		
Positive	3	2	66.7	120.0	0.003	(5.4 to 2688.8)
Hypoechoic center / hyperechoic periphery texture on U/S						
Negative	61	1	1.6	Ref		
Positive	3	2	66.7	120.0	0.003	(5.4 to 2688.8)
Avascular center / vascular periphery						
Negative	61	1	1.6	Ref		
Positive	3	2	66.7	120.0	0.003	(5.4 to 2688.8)
Irregular lesion margin on U/S						
Regular	14	0	0	Ref		
Irregular	50	3	6	2.1	0.511[NS]	(0.2 to 20.6)

Table 6: Validity of US criteria for PAC

				PPV at pretest probability =		NPV at pretest probability =
	Sensitivity	Specificity	Accuracy	50%	90%	10%
U/S diagnosis of periapicalcyst						
Negative	923	96.1	953	95.9	99.5	99.1
Positive						
Hypoechoic texture on U/S						
Negative	100	72.5	711	78.4	97.0	100.0
Positive						
Avascular pattern						
Negative	100	47.1	57.8	65.4	94.4	100.0
Positive						
Irregular lesion margin on U/S						
Irregular	92.3	96.1	95.3	95.9	99.5	99.1
Regular						

Table 7: Validity of US criteria for PAG

				PPV at pretest probability=		NPV at pretest probability = 10%
	Sensitivity	Specificity	Accuracy	50%	90%	
U/S diagnosis of periapical granuloma						
Negative	87	92.7	90.6	92.3	99.1	98.5
Positive						
Hyperectoic texture on U/S						
Negative	87	92.7	90.6	92.3	99.1	98.5
Positive						
Vascular pattern						
Negative	87	97.6	93.8	97.3	99.7	98.5
Positive						
lrregular lesion margin on U/S						
Irregular	91.3	29.3	51.6	56 4	92.1	96.8
Irregular						

Table 8: Validity of US criteria for PAA

				PPV at pretest probability=		NPV at pretest probability = 10%
	Sensitivity	Specificity	Accuracy	50%	90%	
U/S diagnosis of periapical abscess						
Negative	92	97.4	95.3	97.3	99.7	99.1
Positive						
Hypoechoic texture on U/S						
Negative	48	61.5	56.3	55.5	91.8	91.4
Positive						
Anechoic texture on U/S						
Negative	44	100	78.1	100.0	100.0	94.1
Positive						
Avascular pattern						
Negative	100	61.5	76.6	72.2	95.9	100.0
Positive						
Irregular lesion margin on U/S						
Regular	100	35.9	60.9	60.9	93.4	100.0
Irregular						

Table 9: Validity of US criteria for mixed PAL

				PPV at pretest probability=		NPV at pretest probability= 10%
	Sensitivity	Specificity	Accuracy	50%	90%	
U/S diagnosis of mixedpenapical cyst granuloma						
Negative	66.7	9S.4	96.9	97.7	99.7	96.4
Positive						
Hypoechoic center hyperechoic periphery texture on U/S						
Negative	667	98.4	96.9	97.7	99.7	96.4
Positive						
Avascular center vascular penphery						
Negative	66.7	93.4	96.9	97.7	99.7	96.1
Positive						
Irregular lesion margin on U/S						
Regular	100	23	26.6	56.5	92.1	100.0
Irregular						