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REVIEW ARTICLE
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Evaluate the Accuracy of the Diagnostic Test of Ultrasound Imaging for Endodontic: A Systematic Review and Meta-analysis

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ABSTRACT

Objective: approximately 6.3% of adult teeth have apical periodontitis; the commonest kinds of periapical lesions are cyst and abscess (55-6%) and granuloma (46-84%). This systematic review and meta-analysis evaluated the accuracy of the diagnostic test of ultrasound imaging for endodontic.

Methods: Using the electronic databases, we searched Cochrane Library, PubMed, and Embase for performing a systematic review of literature during the last decade from February 2011 to May 2021. Then, we employed the Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) tool to assess the quality of the obtained investigations included in the present meta-analysis. In order to extract the required data, two reviewers blindly and individually dealt with the data extraction from the respective abstracts and full-texts of investigations. Diagnostic odds ratio, positive and negative likelihood ratio with a confidence interval (CI) of 95%, random-effects model, and REML method have been computed. Moreover, we assessed Meta-analysis using a statistical software called Stata/MP 16, the fastest version of Stata.

Results: Totally, 94 topics and abstracts with potential relevance have been obtained in the electronic searches and eight studies required for this systematic review. Specificity and Sensitivity of ultrasonography for diagnosing the periapical granulomas equaled 92% (ES,0.92 95% CI 0.77,1.07) and 89% (ES,0.89 95% CI 0.74,1.04) and specificity and Sensitivity of ultrasonography for diagnosing periapical cyst equaled 92% (ES,0.92 95% CI 0.77,1.07) and 98% (ES,0.92 95% CI 0.83,1.13).

Conclusion: Ultrasonography can be one of the alternative tools for differential diagnosis of periapical lesions (cysts and granulomas) with an endodontic origin.

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INTRODUCTION

The result of a local inflammatory reaction in responding to an untreated microbial infection is apical periodontitis.[1] Apical periodontitis causes destruction of periapical tissue and bone resorption.[2] A systematic study has reported that approximately 6.3% of adult teeth have apical periodontitis.[3] Moreover, granuloma (46-84%), cyst, and abscess (55-6%) have been considered as the commonest kinds of periapical lesions.[4] One study found that the spread of periapical cysts was 24%.[5] After root canal treatment, apical periodontitis may improve, but recovery is not possible in some cases, and periapical lesion surgery should be performed.[6] Experimental diagnosis of the periapical lesion in periapical granuloma or periapical cyst conditions would be performed by clinical examinations and two-dimensional (2D) radiography. Recently, the use of cone-beam computed tomography (CBCT) has been considered for assessing the degree of this lesions.[7, 8] A recent study by Ricucci et al. (2020) indicated that a number of periapical cysts could heal following the root canal treatments and that we did not observe any differences in the treatment of true and a bay-cyst.[5] Of course, our hypothesis that periapical cysts could improve following the root canal treatment/re-treatment, only evidence-based studies prove that accurate and non-invasive pre-operative diagnosis of the periapical lesion would essential.[9] There are several methods for diagnosing periapical lesions, including CBCT, ultra-sonography (US) as well as magnetic resonance imaging (MRI).

Studies indicated the moderate ability of CBCT for differentiating between cysts and periapical granulomas.[10, 11] Studies show that MRI findings are comparable to histopathological findings to

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distinguish between periapical granulomas and periapical cysts. The disadvantages of this method are the long scan time, non-applicability in children, non-applicability in patients who have implants, high cost.[12] The US has been considered as one of the real-time non-invasive, non-ionizing imaging techniques. Studies show that it is possible to employ the US with color/power Doppler in the differential diagnosis of the periapical lesions of the endodontic origin.[13] Some studies support the utilization of the US in the differential diagnosis of periapical lesions. Therefore, achieving an appropriate treatment plan is essential.[14-16] This Systematic Review and Meta-analysis aimed at the evaluation of the diagnostic test accuracy of ultrasound imaging for endodontic.

METHODS

Search strategy

Using the electronic databases, we searched Cochrane Library, Embase, and PubMed for performing this systematic literature during the last decade from February 2011 to May 2021. The reason for choosing studies in the last ten years is to provide sufficient evidence in this area and use newer studies. Hence, we employed a software program called Endnote X8 to find the electronic topics with these mesh concepts and terms:

("Periapical Periodontitis"[Mesh] OR "Periapical Granuloma" [Mesh] OR "Periapical Diseases"[Mesh] OR "Periapical Tissue" [Mesh] OR "Periapical Abscess"[Mesh] OR "Radicular Cyst" [Mesh] OR "Periodontal Abscess"[Mesh]) AND ("Root Canal Obturation"[Mesh] OR "Apexification"[Mesh] OR "Dental Pulp Diseases"[Mesh])) AND ("Ultrasonography"[Mesh] OR "Ultrasonics"[Mesh] OR "Diagnostic Imaging"[Mesh] OR "diagnostic imaging" [Subheading] OR "Ultrasound, High-Intensity Focused, Transrectal"[Mesh] OR "Ultrasonography, Doppler"[Mesh] OR "Ultrasonography, Interventional"[Mesh])) AND ("Data Accuracy"[Mesh] OR "Dimensional Measurement Accuracy"[Mesh])) AND ("Observational Studies as Topic"[Mesh] OR "Observational Study" [Publication Type] OR "Observational Studies, Veterinary as Topic"[Mesh])) OR "Cross-Sectional Studies"[Mesh]) OR "Case Reports" [Publication Type]) OR "Case-gr Studies"[Mesh].

We performed the present systematic review according to the main consideration of the PRISMA Statement-Preferred Reporting Items for the Systematic Review and Meta-analysis[17], and PICO approach (Table1).

Selection Criteria

Inclusion Criteria

1. Cross-Sectional research, Observational Studies, case series as well as Case Reports.
2. Adult teeth or permanent teeth
3. Age >18 years of age
4. English language

Table 1: PICO strategy

PECO strategy	*Description*
P	Population: adult patients
I	Intervention: ultrasonography
C	Comparison: Histopathological examination
O	Outcome: Diagnostic accuracy of US

Exclusion criteria

1. *In-vitro* studies, reviews, animal investigations as well as clinical studies
2. Studies without reference standard (histopathology)

Extraction of data and analysis method

We could extract data using researches based on the study, year, design, size of the participants or samples, age, sex, and diagnostic test. Moreover, we employed the Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) tool for assessing the quality (risk of bias and concerns regarding applicability) of the investigations in the present meta-analysis[18]. This scale was measured for dimensions (selection (3 items), index test domain (2 items), reference standard domain (2 items), as well as timing domain and flow (4 items) with a total of 12 items. According to the responses as Low/High/Unclear, to evaluate the overall risks of bias of any studies with QUADAS-2, according to the responses as Low/High/Unclear.

In order to extract data, two reviewers blindly and individually dealt with the data extraction from abstracts and full texts of investigations. Before the screening process, we ran kappa statistics to verify the agreement level between the reviewers, and analyses showed kappa values >0.80.

Diagnostic odds ratio, positive and negative likelihood ratio with 95% CI, random-effects model, and REML method have been computed. Additionally, we applied random effects for addressing the potent heterogeneity, and I2 implied heterogeneity so that I2-values >50% showed moderate to high heterogeneity. Finally, we used Stata/MP16 to evaluate meta-analysis.

RESULTS

Considering the research objective, we obtained 214 studies in the primary searches with the respective keywords. In the first step of selecting investigations, 200 studies were selected to review the abstracts. Then, studies with no required inclusion criteria were excluded from the study, and we studied the full texts of 16 investigations. In the end, we chose eight investigations (Figure1).

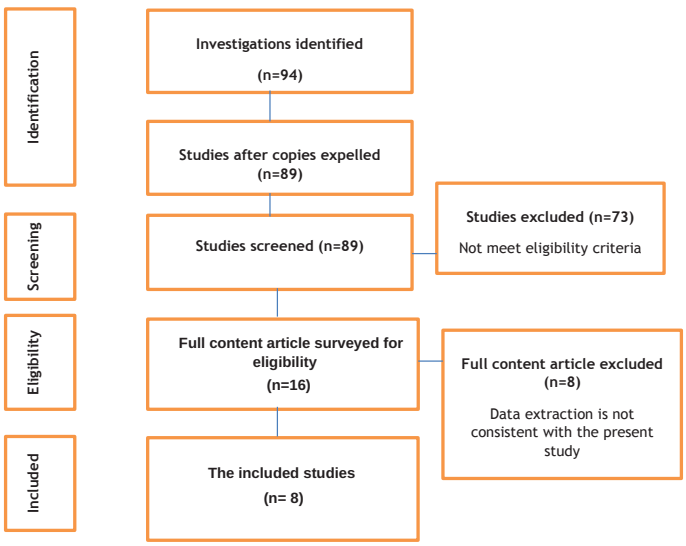

Fig. 1: Study Attrition

Characteristics

Eight studies (Cross-Sectional) have been included in the present article. The number of participants equaled 178 who ranged between 13 -65 years (Table 2).

Bias assessment

According to the QUADAS-2 tool, six research acquired a total score equal to 2/4, 2 investigations acquired a score of 3/4. This result indicates the lower risk of bias in each investigation included (Table 3). All studies in selection had higher risks of bias, and in the reference, the standard domain showed lower risks of bias (Table 3).

Sensitivity of ultrasonography to diagnose periapical granulomas

Sensitivity of ultrasonography for diagnosing the periapical granulomas equaled 89% (ES, 0.89 95% CI 0.74, 1.04) among six investigations which showed heterogeneity (I2 < 0%, P=0.54) (Figure 2).

Specificity of ultrasonography for diagnosing periapical granulomas

As mentioned earlier, specificity of ultrasonography for diagnosing periapical granulomas equaled 92% (ES, 0.92 95% CI 0.77, 1.07) among six investigations, showing (I2 < 0%, P=0.65) (Figure 3).

Table 2. Investigations chosen for our meta-analysis and systematic review.

		Number of patients		*Mean/range of age (years)*	*Ultrasound diagnosis*			*Histopathology diagnosis*		
Study. Years	*Research design*	*female*	*male*		*periapical cyst*	*periapical granuloma*	*mixed lesion*	*periapical cyst*	*periapical granuloma*	*mixed lesion*
Sonmez et al.,2019[16]	cross-sectional	23	10	18-62	15	5	Nil	12	8	Nil
Cotti et al.,2018[15]	cross-sectional	8	11	38.9	2	0	Nil	2	NR	NR
Tikku et al. (2016)[14]	cross-sectional	30		14-45	3	20	NR	3	27	NR
Sandhu et al.,2015[19]	cross-sectional	30		15-50	0	16	NR	0	16	NR
Khambete et al.,2015[20]	cross-sectional	10		19-40	4	4	2	4	4	2
Parvathy et al.,2014[21]	cross-sectional	20		NR	11	9	0	11	9	0
Prince et al. (2012)[22]	cross-sectional	15		13-65	12	2	1	14	1	0
Goel et al.,2011[23]	cross-sectional	21		15-45	12	8	1	13	7	1

Table 3: Risk of bias assessment (Low (+), unclear (?), high (-)).

Study	selection	index test domain	reference standard domain	flow and timing domain	Total score
Sonmez et al.,2019[16]	-	?	+	+	2
Cotti et al.,2018[15]	-	+	+	+	3
Tikku et al.,2016[14]	-	?	+	+	2
Sandhu et al.,2015[19]	-	+	+	-	2
Khambete et al.,2015[20]	-	?	+	+	2
Parvathy et al.,2014[21]	-	+	+	+	3
Prince et al.,2012[22]	-	?	+	+	2
Goel et al.,2011[23]	-	?	+	+	2

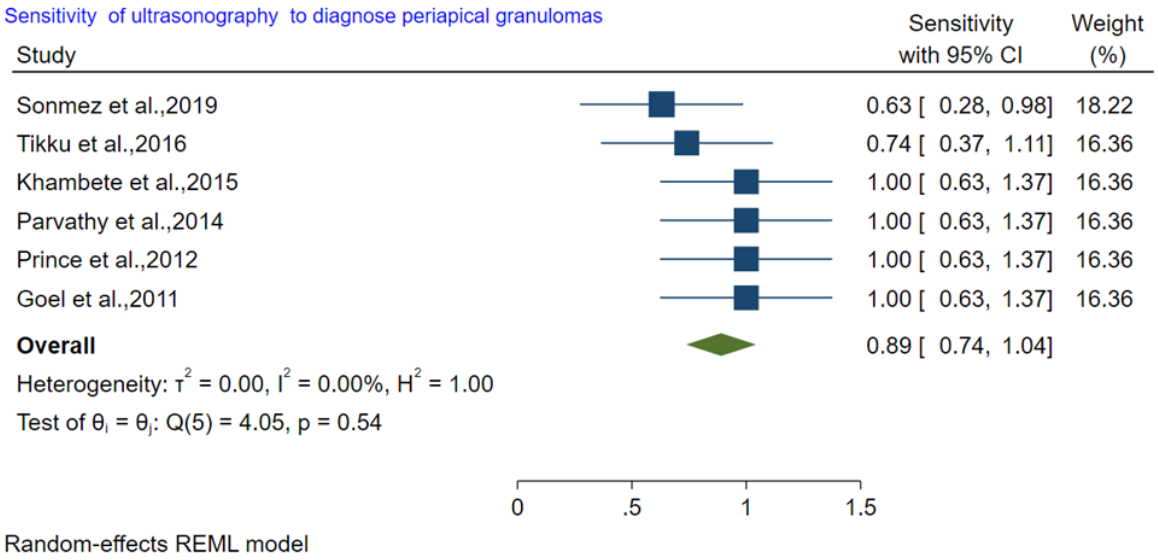

Fig. 2: The Forest plot showed a sensitivity of ultrasonography to diagnose periapical granulomas

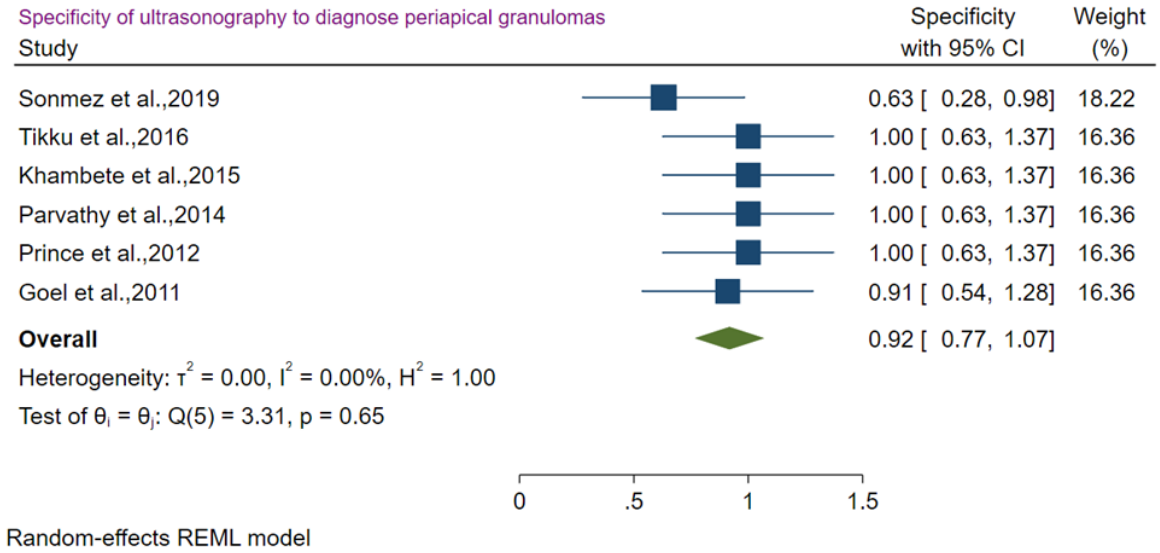

Figure 3: Forest plot showed a specificity of ultrasonography to diagnose a periapical granulomas.

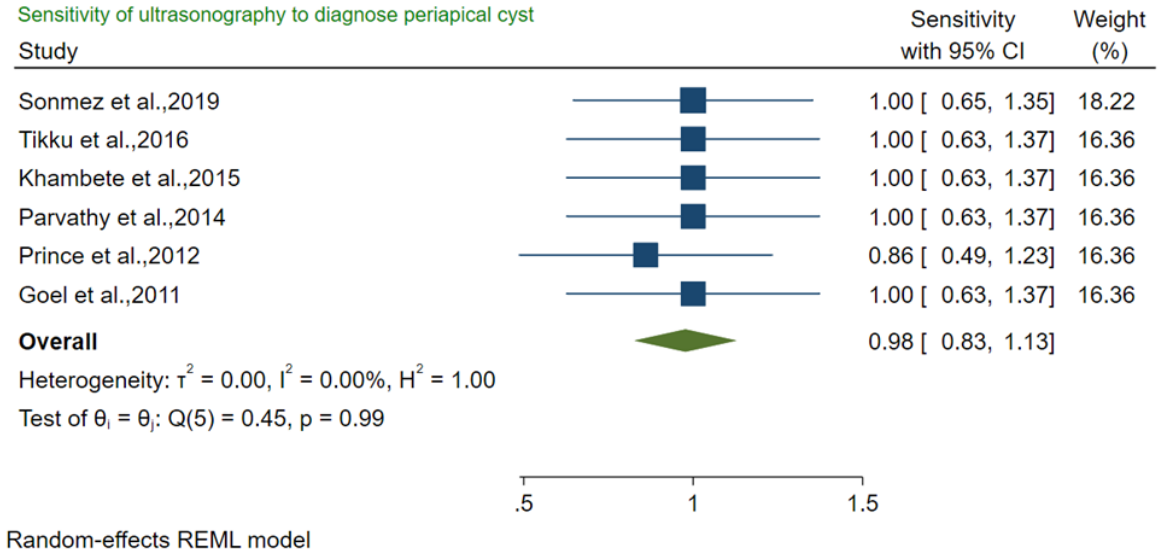

Figure 4: The Forest plot showed Sensitivity of ultrasonography to diagnose a periapical cyst.

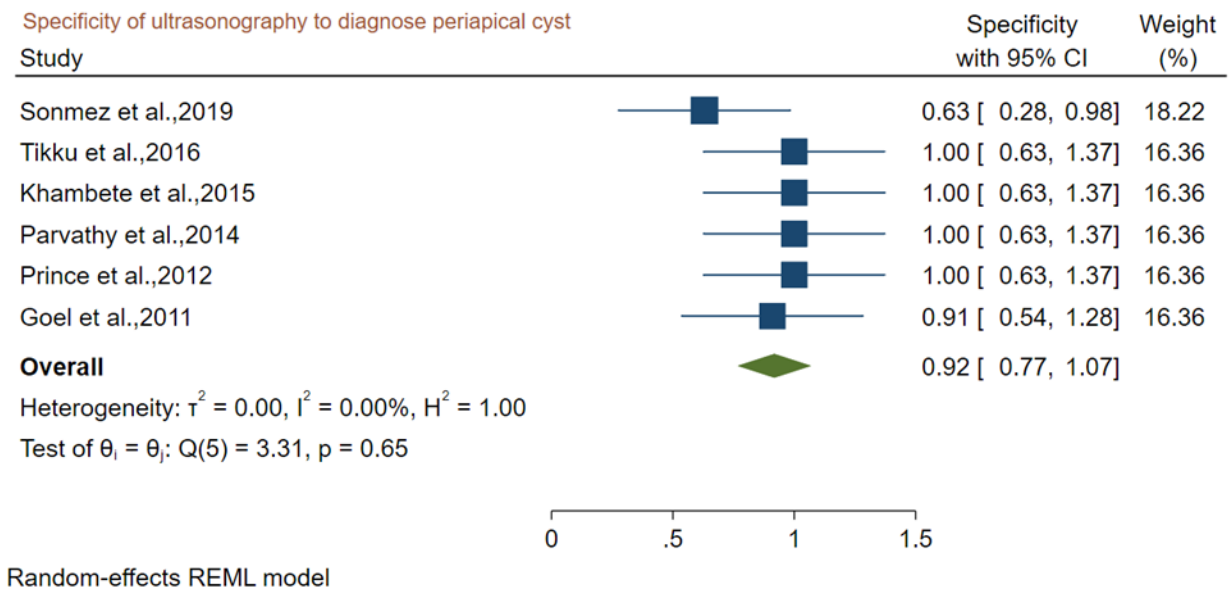

Figure 5: The Forest plot showed a specificity of ultrasonography to diagnose a periapical cyst.

Sensitivity of ultrasonography to diagnose periapical cyst

Sensitivity of ultrasonography to diagnose periapical cyst was 98% (ES, 0.92 95% CI 0.83, 1.13) among six investigations, showing heterogeneity (I2<0%; P =0.99) (Figure 4).

Specificity of ultrasonography to diagnose periapical cyst

Specificity of ultrasonography to diagnose periapical cyst was 92% (ES, 0.92 95% CI 0.77, 1.07) among six investigations, showing heterogeneity (I2 < 0%, P=0.65) (Figure 5).

DISCUSSION

We initially employed ultrasonography for diagnosing periapical lesions in 2002. Researchers have shown the outputs of periapical cysts on ultrasonography as hypoechoic lesions that had no internal vascularity[24]. In 2016, Musu et al. Reported in a systematic review study that Ultrasonography could be an appropriate adjunct to the differential diagnosis of the periapical lesions[25]. Our study utilized QUADAS-2 for evaluating the quality of the investigations selected for meta-analysis. This tool is very sensitive and is recommended by Cochrane to evaluate the accuracy of diagnostic tests[26] systematically. All selected studies had high quality or lower risks of bias. All selected studies performed poorly and have been at the increased bias risk; there is no clear explanation of the patient registration method that can affect the quality of the study. In the field of timing and flow, all studies showed lower risks of bias, except Sandhu et al., 2015[19].

The Meta-analysis of the present study showed specificity and sensitivity of ultrasonography for diagnosing periapical granulomas equaled 92% and 89%, and the specificity and Sensitivity of ultrasonography to diagnose periapical cyst was 98% and 92%, respectively. Based on these findings, specificity and sensitivity of ultrasonography to diagnose periapical granulomas and the periapical cyst has been ultrasonography in a precise tool in differentiating periapical lesions. Lizio et al., 2018 reported accurate values for CBCT for differentiating the periapical granulomas and periapical cysts to be 0.91 and 0.87[9]. Furthermore, Guo et al. (2013) showed accurate values for differentiating the periapical granulomas, and periapical cysts for MRI were 0.76, 0.70, and 0.69[27]. Therefore, ultrasound imaging is a noninvasive and non-ionizing economic tool and has high specificity and sensitivity for diagnosing periapical cysts and periapical granulomas. Studies of the periapical lesions requiring preoperative and post-operative imaging would be more appropriate. In the present study, no heterogeneity was found between the studies. Sönmez et al., 2019[16] showed that outlier detection analysis identified a negative or positive effect on the specificity and sensitivity of diagnosing the periapical granulomas and peripheral cysts. Given the low risks of bias according to the highly sensitive QUADAS-2 instrument and the low heterogeneity of studies and publication bias, it can be argued that this study leads to a more accurate assessment of the available evidence. The present study had limitations, such as the diagnostic ability of Ultrasonography in evaluating the different stages of periapical lesions was not examined. Studies with a larger sample size, how to select the patient in the two groups are needed, as well as RCT studies and comparison of Ultrasonography with CBCT and MRI in relation to our objective.

CONCLUSION

The systematic review and meta-analysis result of the present study showed that ultrasonography's specificity and sensitivity in diagnosing periapical granulomas and cysts are very accurate. So that for both diagnoses, it is higher than 85%. Based on the evidence from the present study, it can be concluded that Ultrasonography can be one of the alternative tools for differential diagnosis of the periapical lesions (cysts and granulomas) of the endodontic origin. Despite the low use of Ultrasonography, it is recommended that more of these diagnostic tools be used in dentistry.

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