ORIGINAL RESEARCH

Accuracy of transvaginal sonoelastography for differential diagnosis between malignant and benign cervical lesions: A systematic review and meta-analysis

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Abstract
Background: To evaluate the performance of transvaginal sonoelastography (TVSE) for differential diagnosis between malignant and benign cervical lesions using a meta-analysis.

Methods: An independent literature search was conducted on the English medical database, including PubMed, Embase and Medline, Cochrane Library, Web of Science, and OVID. The diagnostic accuracy of TVSE was compared with that of histopathology, which is the gold reference standard for diagnosis. The accuracy of TVSE was assessed by calculating the pooled sensitivity, specificity, diagnostic odds ratio, and area under the curve (AUC). The imaging mechanisms, assessment methods, and QUADAS scores were assessed with a meta-regression analysis. A Deeks funnel plot was performed for evaluating publication bias.

Results: Six eligible studies reported a total sample of 615 cervical lesions (415 cancers, 200 benign lesions). TVSE showed a pooled diagnostic odds ratio of 21.42 (95% CI 13.65-33.61), sensitivity of 0.87 (95% CI 0.84-0.90), specificity of 0.79 (95% CI 0.72-0.84), and an AUC of 0.892 ($Q^* = 0.822$). The results of the meta-regression analysis showed that the imaging mechanism ($P = .253$), the assessment method ($P = .279$), or QUADAS score ($P = .205$) did not affect the study heterogeneity.
**INTRODUCTION**

Cervical cancer is the fourth most common female malignancies on a global scale.\(^1\) High-risk human papillomavirus (hrHPV) persistent infection is the necessary cause of cervical cancer.\(^2\) Approximately 90\% of cervical cancer occurred in underdeveloped or developing countries with inadequate screening and lack of HPV vaccination.\(^3\) The International Federation of Gynecology and Obstetrics (FIGO) staging system for cervical cancer was revised in 2018.\(^4\) Imaging and pathological evidence were included officially in the new staging system. Ultrasonography is a non-invasive imaging, which plays an indispensable role in evaluating patients with cervical cancer. It is currently believed that ultrasound diagnosis for patients with cervical cancer has the same accuracy as magnetic resonance imaging (MRI) if performed by an experienced ultrasonographists.\(^4\)

Based on the characteristics that malignant tissues are generally higher stiffness than benign components and adjacent healthy tissues, sonoelastography renders excellent soft-tissue contrast for identifying tumors. This technology, which was introduced in 1990, has been applied to the identification of lesions in the thyroid, breast, lymph nodes, liver, prostate, parotid, and gastrointestinal tract.\(^5\)-\(^13\) Compared with conventional ultrasound technology, elastography can significantly improve the diagnostic accuracy of diseases. Strain elastography (SE) and shear wave elastography (SWE) are readily available imaging techniques that measure the tissue strain in a noninvasive manner. However, SE can assess tissue stiffness only qualitatively or semi-quantitatively, and the force applied to create displacement is not sufficiently stable. SWE is a substantial advance in ultrasound elastography, in which data acquisition is operator-independent with interpretation quantitative and objective in nature.

With the continuous improvement of software in conventional ultrasound systems, transvaginal sonoelastography (TVSE), as emerging diagnostic imaging technology, emerged at this moment.\(^14\) Cervical tissue is of medium hardness and does not change with age. In the process of cervical cancer, the cervical tissue becomes hard significantly, which is an important point to distinguish from benign cervical lesions. Multiple previous researches have been published on the potential benefits of TVSE in detecting malignant cervical lesions.\(^15\)-\(^20\) Both SE and SWE can be used for the diagnosis of cervical diseases. However, the overall power of these studies is limited, and the benefits of the results are inconsistent. Therefore, the purpose of our research was to review the literature and perform a meta-analysis to assess the performance of TVSE for differential diagnosis of cervical lesions. We aim to also evaluate whether there is a difference in the accuracy and effectiveness of SE and SWE.

**MATERIALS AND METHODS**

This study was conducted in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines (Figure 1).\(^21,22\)

**Search strategy**

A systematic search of PubMed/MEDLINE, Cochrane Library Databases, EMBASE, Web of Science, and OVID for all available current literature published up to 12 June 2019 was performed without any constraints. The Medical Subject Heading (MeSH) terms and relevant text words were searched individually or in combination according to the strategy shown in Table 1. We manually scan the identified study reference list to further determine the relevant study.

**Selection criteria/eligibility**

Following the electronic search strategy, we manually scanned reference lists on the basis of the title and abstract to determine the suitable articles. The inclusion criteria for the studies were the following: (a) population: patients

**Conclusion:** TVSE has a relatively high and satisfactory value for differential diagnosis between malignant and benign cervical lesions. The diagnostic performance of strain elastography and shear wave elastography were similar and good. However, to accommodate heterogeneity and publication bias, high-quality studies are required to further comparative effectiveness analyses to verify the efficacy of ultrasound detection.

**KEYWORDS**
cervical neoplasms, elasticity imaging techniques, ultrasonography

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**TABLE 1**

| MeSH Terms | Relevant Text Words |
|------------|---------------------|
| cervical neoplasms | cervical cancer, cervical disease |
| elasticity imaging techniques | elastography, SWE, SE |
| ultrasonography | ultrasound, TVSE |
with cervical lesions; (b) intervention: TVSE without histopathological or cytological examination was performed for the independent diagnosis of cervical lesions; (c) comparison: the accuracy of TVSE diagnostic in benign-malignant differentiation of cervical lesions was evaluated according to the reference standard of pathological examination; (d) outcomes: studies with available or derivable data to construct 2 × 2 contingency tables; (e) Studies published in the English language. The exclusion criteria were as follows: (a) Reviews, case reports, editorial comments, conference reports, and letters were excluded; (b) The data in the literature were incomplete or the corresponding authors were contacted via e-mail to request supplement missing data but without reply in 15 days; (c) If the studies from the same department, the earlier study or the study with the smaller number of cases was excluded.

2.3 | Data extraction

The literature search and the subsequent analyses were independently conducted by two authors (Y.Z and XFL), based on predefined selection criteria. The extracted data included study ID (first author and year of publication), published regions, patient characteristics (number and age range), number of lesions, mechanism and assessment method of TVSE, the reference standard, and the study results. Accurate true positives (TPs), false positives (FPs), false negatives (FNs), true negatives (TNs), and cut-off value were extracted directly from the original literature or calculated from the data provided.

2.4 | Quality assessment

Two reviewers evaluated the quality of the individual trial, applying the Quality Assessment of Diagnostic Accuracy Studies (QUADAS) criteria,23 which is recommended by the Cochrane Diagnostic Test Accuracy Working Group. The QUADAS criteria have a total of 14 standards, which is evaluated one by one with “yes,” “no” or “unclear.” Ultimately, the closer the score is to the full score of 14, the higher quality of the article is. Any disagreements were resolved by consensus.

2.5 | Statistical analysis

Meta-analysis of test accuracy data was used Meta-DiSc version 1.4 (Hospital Ramón y Cajal, Madrid 2006), STATA (Version 12.0, Stata Corporation), RevMan 5.3 software (The Nordic Cochrane Centre, Rigshospitalet 2008) and SPSS Statistics (Version 22.0, SPSS Inc). The threshold effect was analyzed using the Spearman correlation coefficient. Cochran’s $Q$ statistics and the inconsistency index ($I^2$) test were used to evaluate Heterogeneity between studies. If the heterogeneity $I^2 \geq 50\%$ or $P < .05$, the results were combined by the random-effects model, otherwise a fixed-effects
model was performed. According to the model, we calculated the pooled diagnostic odds ratio (DOR), sensitivity, specificity, area under the curve (AUC), and $Q^*$ index. We explored potential sources of heterogeneity through meta-regression analysis. The potential publication bias was analyzed by Deeks’ funnel plot which was generated by STATA. A $p$ value less than 0.05 was considered indicative of substantial publication bias. Interobserver consistency of screening articles was performed by Cohen's $\kappa$ analysis using SPSS software.

3 | RESULTS

The document retrieval yielded 465 articles, of which 104 were from PubMed/MEDLINE, 8 from Cochrane Library Databases, 163 from EMBASE, 117 from Web of Science, and 73 from OVID. Removed duplicate articles, 339 articles were reviewed in title and abstract, and from them, 13 were further reviewed in full text. Finally, there were six studies including 615 patients with 415 cancers and 200 benign lesions that were finalized to be performed by the systematic review for qualitative synthesis and quantitative analysis (meta-analysis) (Figure 1).15-20

3.1 | Eligible studies characteristics

Table 2 showed the principal characteristics of the included studies. In the step of excluding records by title and abstract, there were some controversies between the two reviewers. However, the analysis showed an excellent interobserver agreement ($\kappa = 0.96$). Ultimately, all the controversial articles were retained in this step. There was no controversy in the other steps of screening ($\kappa = 1$).

3.2 | Assessment of quality

As shown in Table 3 and Figure 2, the qualities of each eligible study met the most quality criteria with a high QUADAS score. However, none of the studies mentioned whether the pathologists were unaware of the TVES results. The exclusion criteria were not described in two studies.17,18 In one study, radiologists performed the examination with knowledge of the results of the reference standard.17 Another study did not mention whether the ultrasound examiners uninformed about the histological characteristics of the respective cervical lesions.19
3.3  |  Diagnostic accuracy for differentiating between benign and malignant cervical lesions

The result of the diagnostic threshold showed that there was no significant threshold effect and the Spearman correlation coefficient was 0.267 \( (P = .623) \). Meta-analysis was performed and the overall pooled sensitivity, specificity, and DOR were 0.87 \( (95\% \text{ CI 0.84-0.90}) \), of 0.79 \( (95\% \text{ CI 0.72-0.84}) \), and 21.42 \( (95\% \text{ CI 13.65-33.61}) \), respectively (Figure 3). The summary receiver operating characteristic curve is symmetric \( (P = .378) \) and the AUC is 0.8(492)92 \( (Q* = 0.822) \), which illustrates an overall relatively high

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**TABLE 2  Characteristics of Eligible Studies**

| Study ID | Country   | No. of patients | No. of lesions | Mean age (years) | Reference Standard | Type of lesions (number of lesions) |
|----------|-----------|-----------------|----------------|------------------|-------------------|-------------------------------------|
| 1        | China     | 178             | 178            | 47.7             | Biopsy or postoperative pathology, TCT | squamous cell carcinoma (121), adenocarcinoma (17), cervical fibroids (32), and polyps (8) |
| 2        | Egypt     | 40              | 40             | 62.5             | Pathology         | primary cancer cervix (27), recurrent cancer cervix (5), and cervical fibroids (8) |
| 3        | Ukraine   | 87              | 87             | 46.5             | Pathology         | squamous cell carcinoma (34), tumors of androgen origin (12), other histological forms of carcinoma (clear cell, small cell etc) (6), undifferentiated tumors (10), cervicitis (11), and dysplasia (14) |
| 4        | China     | 84              | 84             | 48.0             | Pathology         | malignant cervical lesions (44), cyst (17), polyps (14), and leiomyoma (9) |
| 5        | China     | 116             | 116            | 53.6             | Pathology         | squamous cell carcinoma (47), adenocarcinoma (11) and normal tissue (58) |
| 6        | China     | 110             | 110            | 45.5             | Pathology         | squamous cell carcinoma (59), adenocarcinoma (11), adenosquamous (8), carcinosarcoma (3), polyps (5), leiomyoma (2), erosion (9), and inflammation (13) |

**Ultrasound system**

| Ultrasound system                                                                 | Index of elastography | Cut off Point for malignancy | TP (n) | FP (n) | FN (n) | TN (n) |
|-----------------------------------------------------------------------------------|-----------------------|------------------------------|--------|-------|-------|--------|
| 1 Aixplorer diagnostic US equipment (SuperSonic Imagine, Aix-en-Provence, France) with a conventional vaginal US transducer (SE 12-3, 7 MHz) | SWV                   | 4.15 m/s                     | 123    | 11    | 15    | 29     |
| 2 Aplio XG system (Toshiba Medical System, Tokyo, Japan) with a 7.0-MH endo-vaginal probe | strain ratio          | 8.7                          | 30     | 0     | 2     | 8      |
| 3 Esaote MyLab Class C device (Italy) with transvaginal EC1123                   | stiffness ratio       | Elastogram type 2c           | 55     | 7     | 7     | 18     |
| 4 Hitachi EUB-8500 ultrasound system equipped with an 8.4-MHz transvaginal probe (Hitachi Medical Systems Co, Ltd, Tokyo, Japan) | strain ratio          | 4.525                        | 36     | 6     | 8     | 34     |
| 5 Acuson S2000 diagnostic ultrasound system (Siemens Healthcare, Ehrangen, Germany) equipped with a 3.5 MHz abdominal probe | VTQ values            | 3.41 m/s                     | 46     | 13    | 12    | 45     |
| 6 HITACHI Vision 900 system (Hitachi Medical System, Co, Ltd, Tokyo, Japan) equipped with a 7.0-MHz intravaginal probe | strain ratio          | 4.53                         | 72     | 6     | 9     | 23     |

**Abbreviations:** FN, false negative; FP, false positive; SWV, shear wave velocity; TCT, Cervical fluid base thin cytologic test; TN, true negative; TP, true positive; VTQ, virtual touch quantification.
3.4 | Heterogeneity results

The forest plot of the DOR was performed to explore the no-threshold effect. There was no considerable heterogeneity detected (Cochran’s $Q = 3.28$, $P = .658$). It was suggested that there was no obvious heterogeneity and the threshold effect, so that it can be combined within the group. There was no heterogeneity was detected for sensitive ($I^2 = 18.5\%$, $P = .293$) and specificity ($I^2 = 21.8\%$, $P = .270$). Afterward, to further analyze the possible sources of heterogeneity, all studies were divided into different subgroups for a meta-regression analysis, as shown in Table 4. The results suggested that the imaging mechanism ($P = .253$), the assessment method ($P = .279$) or QUADAS score ($P = .205$) was not the cause of heterogeneity.

3.5 | Evaluation of publication bias

In this meta-analysis, the Deeks’ funnel plot asymmetry test indicated a potential publication bias ($P = .019$) (Figure 5).


4 | DISCUSSION

Cervical cancer is increasing year by year in low- and middle-income countries, with the second highest incidence rate and the third highest rate of mortality among female malignant tumors. About 85% of new cases and 90% of deaths occur in underdeveloped areas. The diagnosis of cervical lesions generally follows the "three-ladder" screening program (Thinprep Cytologic Test → Colposcopy → Histopathology). With the considerable progress of ultrasound technology, the diagnosis and treatment of cervical cancer have become more objective and accurate. Sonoelastography is an innovative ultrasonographic technique, applying for evaluating tissue elasticity and stiffness. Compared to conventional ultrasound, the advantage of TVSE is that the visualized information of cervical lesions is provided directly, to more intuitively assess tumor volume, depth of penetration, and extension to adjacent tissues. TVSE is considered a promising, economic, and noninvasive method for the diagnosis of cervical lesions.

The diagnostic efficacies of TVSE for cervical lesions are a hot topic, which has been researched extensively. The results of these studies considered that TVES could help identify cervical lesions, with sensitivity and specificity ranging from 79.3% to 93.8% and from 72.0% to 100%, respectively. In the current meta-analysis, it demonstrated that a pooled sensitivity and specificity TVSE were 0.87 and 0.79, respectively. The pooled DOR was 21.42 and the AUC was 0.892. Thus, we hold the opinion that the overall diagnosis value of TVSE achieved a relatively high and satisfactory level. The TVSE can be used with conventional B-mode ultrasound to help confirming the diagnosis. Moreover, for cervical cancer imaging screening, TVSE is a new option, especially in the low- and lower-income countries.

Through the meta-regression analysis, we did not find heterogeneous in sensitivity or specificity, so we conducted subgroup analyses to further investigate the potential sources by regression analysis. The results revealed no difference between the diagnostic efficacy of SE and SWE, without constituting heterogeneity. In terms of assessment methods, the scoring system was usually used for qualitative methods, with subjective opinions from operators. Thus, theoretically, the performance estimates for quantitative and semiquantitative methods were relatively objective and more reliable for diagnosis through an automatic calculation of ultrasound machine. It has been reported that SWE can quantitatively analyze the elastic characteristics of cervical cancer (the maximum shear wave velocity value, 5.24 ± 1.11 m/s) and the benign cervical lesions (the maximum shear wave velocity value, 3.93 ± 0.39 m/s). However, our finding seems to be different from the expectation. This was probably because only one trial using qualitative methods was included, so we did not conclude that quantitative and semiquantitative methods were superior to qualitative ones. The difference between ARFI and SSI was not evaluated, because ARFI and SSI each had only one related study. Above all, combined with statistical analysis, no heterogeneous sources were found.
FIGURE 3 Forest plots of the pooled DOR (A), sensitivity (B), and specificity (C) of TVSE for differential diagnosis between malignant and benign cervical lesions.

| Study | Diagnostic OR (95% CI) |
|-------|------------------------|
| Liu   | 21.62 (8.99 - 51.96)   |
| Shady | 207.40 (9.07 - 4,744.48)|
| Bakay | 20.20 (6.24 - 65.43)   |
| Lu    | 25.00 (8.01 - 81.15)   |
| Su    | 13.27 (5.47 - 32.17)   |
| Sun   | 30.67 (9.86 - 95.38)   |

Random Effects Model
- Pooled Diagnostic Odds Ratio = 21.42 (13.65 to 33.61)
- Cochran-Q = 3.63; df = 5 (p = 0.6042)
- Inconsistency (I-square) = 0.0%
- Tau-squared = 0.0000

FIGURE 4 Summary receiver operating characteristic (SROC) curve on TVSE for differential diagnosis between malignant and benign cervical lesions. The middle curve is the SROC curve. The upper and lower curves show the 95% confidence intervals.
In the six pieces of literature, there are differences in the diagnostic equipment, technical level, and prevalence rate used in various research institutes, and different regions may also be the source of heterogeneity. The operator’s subjective judgment and the overlap of elasticity coefficients of different tissues may lead to heterogeneity. Histopathological diversity in malignant and benign cervical lesions may be another potential source of heterogeneity. Cervical dysplasia with a large number of stroma fibrous inclusions may be responsible for an increase in stiffness.17 Cervical tissue is mainly composed of muscles. Although the elasticity of cervical tissues is not influenced by age, it may change due to different physiological conditions. For example, during pregnancy, the cervical tissue becomes soft and the elasticity is reduced under the action of hormones.27 Unfortunately, the hormone levels of patients were not recorded and analysis in all the studies. We sought to analyze whether TVSE could distinguish among the different pathological types of cervical cancer and whether TVSE is affected by tumor size. However, both analyses were not fully filled because of the data deficient in most of the studies.

The six relative studies were finalized through a rigorous screening process. According to the QUADAS questionnaire, most of the studies were of high quality. The QUADAS score did not constitute study heterogeneity through a meta-regression analysis. However, specificity in relatively lower quality studies seemed to have a better performance, as shown in Table 4. The two studies with lower QUADAS score might be conducted under unblind conditions, which probably influenced the results and shown better performance.17,19 In addition, it was unclear whether the histopathologists were

| Subgroup | Number of studies | Pooled sensitivity (95% CI) | Pooled specificity (95% CI) | Pooled DOR (95% CI) | AUC | P value |
|----------|-------------------|----------------------------|----------------------------|---------------------|-----|--------|
| Mechanism |                  |                            |                            |                     |     | .253   |
| SE       | 4                 | 0.88 (0.83-0.92)           | 0.81 (0.72-0.88)           | 27.63 (14.39-53.06) | 0.918 |        |
| SWE (SSI and ARFI) | 2 | NA | NA | NA | NA | |
| Assessment Method | | | | | | |
| Qualitative | 1 | NA | NA | NA | NA | |
| (Semi)Quantitative | 5 | 0.87 (0.83-0.90) | 0.79 (0.73-0.85) | 21.64 (13.28-35.24) | 0.892 | .279 |
| QUADAS Score | 13.5 | 3 | 0.90 (0.85-0.93) | 0.78 (0.67-0.87) | 27.22 (13.83-53.60) | 0.9623 | .205 |
| ≤ 13 | 3 | 0.84 (0.77-0.89) | 0.79 (0.71-0.86) | 17.71 (9.68-32.38) | 0.877 | |

Abbreviations: ARFI, acoustic radiation force impulse imaging; NA, not available; SE, strain elastography; SSI, supersonic shear imaging; SWE, shear wave elastography.
aware of the results of TVSE assessments in all the studies, which probably influenced the results and caused accompanying heterogeneity.

To the best of our knowledge, this is the first meta-analysis to evaluate merely the accuracy in the identification of TVES for cervical lesions differentiating between malignant and benign lesions. There are some limitations to our study. First, only six relatively studies were included, leading to potential publication bias. Second, the restrictions from the unacceptable acquisition of unpublished data and English language might interfere with the reliability of the results. Third, the information about lesion size, parametrial invasion, and physiological conditions were incomplete in the six trials. Therefore, it was not possible to evaluate the diagnostic and clinical performance of TVSE in different ranges of lesion sizes, parametrial invasion, or physiological conditions.

In conclusion, our meta-analysis results indicate that TVES has a relatively high and satisfactory value for the identification of cervical lesions. Furthermore, from the current analysis, we considered that SE and SWE have a similar and good diagnostic performance for cervical lesions without constituting heterogeneity. Because of publication bias, large-sample, multi-center, prospective, and well-represented trials are still needed to confirm the findings. In addition, more studies should focus on the relationship between corresponding histopathological changes and TVSE.

CONFLICT OF INTEREST
None declared.

AUTHOR CONTRIBUTIONS
YZ, XFL, QL, and WH were involved in conception and design. YZ, XFL, and ZYH were involved in the acquisition of data (screening and data extraction). YZ, XFL, and GNZ were involved in statistical analysis and interpretation of data. YZ and XFL contributed equally to this work. All authors were involved in drafting, editing, and critical revision for important intellectual content. All authors gave final approval of the version to be published.

DATA AVAILABILITY STATEMENT
The data is available upon reasonable request.

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REFERENCES
1. Tsu V, Jeronimo J. Saving the World’s Women from Cervical Cancer. N Engl J Med. 2016;374:2509-2511.
2. de Sanjose S, Quint WGV, Alemany L, et al. Human papillomavirus genotype attribution in invasive cervical cancer: a retrospective cross-sectional worldwide study. Lancet Oncol. 2010;11:1048-1056.
3. Ferlay J, Soerjomataram I, Dikshit R, et al. Cancer incidence and mortality worldwide: sources, methods and major patterns in GLOBOCAN 2012. Int J Cancer. 2015;136:E359-E386.
4. Bhatla N, Denny L. FIGO cancer report 2018. Int J Gynaecol Obstet. 2018;143(Suppl 2):2-3.
5. Bhatia KSS, Tong CSL, Cho CCM, et al. Shear wave elastography of thyroid nodules in routine clinical practice: preliminary observations and utility for detecting malignancy. Eur Radiol. 2012;22(11):2397-2406.
6. Evans A, Whelehan P, Thomson K, et al. Differentiating benign from malignant solid breast masses: value of shear wave elastography according to lesion stiffness combined with greyscale ultrasound according to BI-RADS classification. Br J Cancer. 2012;107:224-229.
7. Lin P, Chen M, Liu B, et al. Diagnostic performance of shear wave elastography in the identification of malignant thyroid nodules: a meta-analysis. Eur Radiol. 2014;24:2729-2738.
8. Ying L, Lin X, Xie Z-L, et al. Clinical utility of acoustic radiation force impulse imaging for identification of malignant liver lesions: a meta-analysis. Eur Radiol. 2012;22:2798-2805.
9. Friedrich–Rust M, Ong M, Martens S, et al. Performance of transient elastography for the staging of liver fibrosis: a meta-analysis. Gastroenterology. 2008;134:960-974.
10. Pinto F, Totaro A, Calarco A, et al. Imaging in prostate cancer diagnosis: present role and future perspectives. Urol Int. 2011;86:373-382.
11. Zhang YF, Li H, Wang XM, Cai YF. Sonoelastography for different diagnosis between malignant and benign parotid lesions: a meta-analysis. Eur Radiol. 2019;29:725-735.
12. Leng X-F, Zhu YI, Wang G-P, et al. Accuracy of ultrasound for the diagnosis of cervical lymph node metastasis in esophageal cancer: a systematic review and meta-analysis. J Thorac Dis. 2016;8:2146-2157.
13. Waage JER, Bach SP, Pfeffer F, et al. Combined endorectal ultrasoundography and strain elastography for the staging of early rectal cancer. Colorectal Dis. 2015;17:50-56.
14. Klintworth N, Mantopoulos K, Zenk J, et al. Sonoelastography of parotid gland tumours: initial experience and identification of characteristic patterns. Eur Radiol. 2012;22:947-956.
15. Liu C, Li TT, Hu Z, et al. Transvaginal real-time shear wave elastography in the diagnosis of cervical disease. J Ultrasound Med. 2019;38(12):3173-3181.
16. Shady M, Abdel Latif M, Nabil H, El Sadda W. Could trans-vaginal sono-elastography help benign-malignant differentiation of cervical masses? Egyptian J Radiol Nucl Med. 2015;46:1291-1299.
17. Bakay OA, Golovko TS. Use of elastography for cervical cancer diagnostics. Exp Oncol. 2015;37:139-145.
18. Lu R, Xiao Y, Liu MH, Shi DZ. Ultrasound elastography in the differential diagnosis of benign and malignant cervical lesions. J Ultrasound In Med. 2014;33:667-671.
19. Su Y, Du L, Wu Y, et al. Evaluation of cervical cancer detection with acoustic radiation force impulse ultrasound imaging. Exp Ther Med. 2013;5:1715-1719.
20. Sun L-T, Ning C-P, Liu Y-J, et al. Is transvaginal elastography useful in pre-operative diagnosis of cervical cancer? Eur J Radiol. 2012;81:e888-e892.
21. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. J Clin Epidemiol. 2009;62:1006-1012.
22. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *J Clin Epidemiol*. 2009;62:e1-e34.

23. Whiting P, Rutjes AWS, Reitsma JB, et al. The development of QUADAS: a tool for the quality assessment of studies of diagnostic accuracy included in systematic reviews. *BMC Med Res Methodol*. 2003;3:25.

24. Jones CM, Athanasiou T. Diagnostic accuracy meta-analysis: review of an important tool in radiological research and decision making. *Br J Radiol*. 2009;82(978):441-446.

25. Ma XI, Li QI, Wang J-L, et al. Comparison of elastography based on transvaginal ultrasound and MRI in assessing parametrial invasion of cervical cancer. *Clin Hemorheol Microcirc*. 2017;66(1):27-35.

26. Zhang Y-F, Li H, Wang X-M, et al. Sonoelastography for differential diagnosis between malignant and benign parotid lesions: a meta-analysis. *Europ Radiol*. 2019;29:725-735.

27. Muller M, Aït-Belkacem D, Hessabi M, et al. Assessment of the cervix in pregnant women using shear wave elastography: a feasibility study. *Ultrasound Med Biol*. 2015;41(11):2789-2797.

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