Original Article

Diagnostic accuracy of cone-beam breast computed tomography and head-to-head comparison of digital mammography, magnetic resonance imaging and cone-beam breast computed tomography for breast cancer: a systematic review and meta-analysis

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Background: Cone-beam breast computed tomography (CBBCT) is a new breast imaging technique, however, CBBCT is not yet widely used, and its future application will depend on its diagnostic potential and application value. Therefore, it is of great clinical significance to systematically review and analyze the diagnostic accuracy of CBBCT for breast cancer detection in existing studies and compare it with other traditional imaging methods for the diagnosis of breast lesions.

Methods: We searched PubMed, Embase, Web of Science, and Chinese databases until August 2022 for relevant papers. Studies evaluating the diagnostic accuracy of CBBCT in women with suspected breast cancer were included. Each study's quality was evaluated using the Quality Assessment of Diagnostic Performance Studies-2 (QUADAS-2) instrument.

Results: Eighteen studies with a total of 1,792 patients were included in the analysis. The overall pooled sensitivity and specificity of CBBCT in diagnosing breast cancer were 0.95 [95% confidence interval (CI): 0.91–0.97] and 0.72 (95% CI: 0.62–0.80), respectively. The area under the curve (AUC) for CBBCT was 0.92 (95% CI: 0.90–0.94). In a head-to-head comparison of CBBCT and digital mammography (DM), eight trials with 992 patients were included in the study, and the AUCs for CBBCT and DM were 0.94 (95% CI: 0.92–0.96) and 0.83 (95% CI: 0.80–0.83), respectively. In a head-to-head comparison of CBBCT and magnetic resonance imaging (MRI), four trials with 203 patients were included in the analysis; the AUC for CBBCT and MRI were 0.88 (95% CI: 0.85–0.91) and 0.96 (95% CI: 0.94–0.97), respectively.

Conclusions: This meta-analysis of CBBCT test accuracy indicated encouraging diagnostic performance. In the summary of head-to-head comparative studies, there is a tendency for CBBCT to have greater diagnostic accuracy than DM, although its diagnostic performance is marginally inferior to that of MRI. However, the meta-analysis results were derived from studies with limited sample sizes. There is a need for more extensive research in this setting.

Keywords: Breast cancer; cone-beam breast computed tomography (CBBCT); digital mammography (DM); magnetic resonance imaging (MRI); meta-analysis

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Introduction

Breast cancer is currently the most prevalent malignant tumor in the world, posing a grave threat to women's physical and mental health, with an estimated 2.26 million new cases and 68,000 deaths in 2020, accounting for 24.5% of all malignant tumor incidences and 13.6% of female deaths, respectively (1). If these malignancies are diagnosed at an early stage, their death rates may be significantly decreased.

Medical imaging examinations are widely used for tumor screening and diagnosis as they can non-invasively uncover the information contained in a patient's image. Cone-beam breast computed tomography (CBBCT) is a new breast imaging technology that the U.S. Food and Drug Administration licensed for diagnostic usage in 2015 (2). CBBCT is capable of reconstructing axial, sagittal, coronal, and arbitrary oblique tomographic pictures as well as three-dimensional images of the breast, hence removing tissue overlap on two-dimensional images. CBBCT can quickly scan a single breast without compressing the breast gland. Contrast-enhanced CBBCT (CE-CBBCT) can reveal breast lesions and nearby blood vessels, providing additional imaging data for diagnosis (3-5). However, CBBCT is not currently generally available, and its future use will depend on its diagnostic potential and application value relative to other conventional imaging modalities.

The most widely used clinical imaging modality for early diagnosis of breast cancer is mammography (MG), which is sensitive to calcification, but its limitation is that it is not good at imaging lesions of dense breast tissue (6-8). Breast magnetic resonance imaging (MRI) has the advantages of high soft tissue resolution and the ability to image multiple sequences, parameters, and directions, making it the most sensitive technique for detecting breast lesions, but MRI has limitations due to its long examination time, high price, and obvious noises (7,9-11).

There are limited existing articles assessing the diagnostic efficacy of CBBCT, and different studies have reported variations in the diagnostic accuracy of CBBCT. In a 2019 meta-analysis, Uhlig *et al.* (12) investigated the diagnostic effectiveness of CBBCT for benign and malignant breast lesions, finding that CE-CBBCT had a pooled sensitivity of 0.899 [95% confidence interval (CI): 0.785–0.956] and a pooled specificity of 0.788 (95% CI: 0.709–0.85). However, recent literature, including Chinese literature, was not included.

In addition, the accuracy of CBBCT in the current meta-analysis was numerically comparable to the accuracy of breast MRI reported in the meta-analysis by Peters *et al.* (13). Some studies have compared diagnostic accuracy head-to-head between CBBCT and MRI, as well as CBBCT and digital mammography (DM), but no meta-analysis has yet been performed to summarize the findings (14-32).

As a result, the purpose of this study was to conduct a systematic evaluation and analysis of the diagnostic accuracy of CBBCT for breast cancer detection in previous studies. To eliminate the differences between individual studies and explore the value of CBBCT in clinical application, we compared the diagnostic efficacy of CBBCT and DM, and the diagnostic efficacy of CBBCT and MRI in breast lesions. We present this article in accordance with the PRISMA reporting checklist (available at https://gs.amegroups.com/article/view/10.21037/gs-23-153/rc).

Highlight box

Key findings

- This meta-analysis of cone-beam breast computed tomography (CBBCT) showed encouraging diagnostic performance. The CBBCT has greater diagnostic accuracy than digital mammography (DM), although its diagnostic performance is marginally inferior to that of magnetic resonance imaging (MRI).

What is known and what is new?

- CBBCT is a new imaging technique, but it is not yet widely used in clinical diagnosis of breast cancer.
- Our meta-analysis included recent literature, including Chinese literature, to explore the diagnostic efficacy of CBBCT.

What is the implication, and what should change now?

- In the future, more prospective and multi-center studies are needed to further explore the clinical application value of CBBCT.

Methods

Our research was registered at PROSPERO successfully, and the registration number of this protocol was CRD42022358161 (https://www.crd.york.ac.uk/PROSPERO).

Search strategy

We exhaustively combed the PubMed, Embase, Web of Science, and Chinese Databases through August 2022 in order to locate all relevant material. The keywords were derived from the clusters of terms "breast cancer" and "computed tomography". The whole search methodology

may be found in the Appendix 1. The search for literature was not restricted by period, language, or location. To identify potential relevant research, we manually combed through the reference lists of reputable journals.

Criteria for inclusion and exclusion

Studies were considered for inclusion if all of the following criteria were met: (I) diagnostic clinical trials using CBBCT to assess the malignancy of breast tumors; (II) sufficient data to calculate sensitivity and specificity.

The following items were excluded from consideration: (I) duplicated articles; (II) abstracts; (III) irrelevant titles and abstracts; (IV) data that were unavailable; (V) phantom or simulation studies; (VI) other radiation studies of CBBCT, such as radiotherapy; and (VII) studies involving computer-aided detection (CAD), i.e., machine and deep learning applications in breast cancer diagnostic accuracy.

Using the aforementioned inclusion and exclusion criteria, two researchers independently reviewed the remaining publications' titles and abstracts to determine their eligibility for the next step. Researchers addressed their disagreements through consensus. The articles selected by mutual decision of the two researchers were acquired in full text for subsequent data extraction analysis.

Quality evaluation

Utilizing the Quality Assessment of Diagnostic Performance Studies-2 (QUADAS-2) instrument, two researchers independently evaluated the included studies' level of quality. The following criteria were used to evaluate each study: patient selection, index test, reference standard, flow, and timing. The application of these domains was then classified as high, low, or ambiguous based on the risk of bias. Any disagreements were discussed with a third reviewer in order to be resolved.

Data extraction

Data extraction was carried out independently for each included article by two researchers. The consensus among the researchers was used to settle disagreements. The retrieved data included the author, year, study characteristics (country, study design), patient characteristics (number of patients, number of lesions, mean patient age), and technical aspects (equipment, scanner model). The sensitivity and specificity or the matching raw data supplied from each of the included studies were used to calculate the true positive, false negative, false positive, and true negative values.

Statistical analysis

Using random-effect analysis, the combined sensitivity and specificity for CBBCT, MRI, and DM were given as estimates with 95% CIs. The area under the curve (AUC) was computed after the construction of the summary receiver-operating characteristic (SROC) curves. Cochrane Q and I^2 statistics were used to evaluate the heterogeneity among the pooled studies. I^2 values of 25%, 50%, and 75% were chosen to represent minimum, moderate, and large heterogeneity, respectively. In the case of considerable heterogeneity, meta-regression analysis was used to explore the cause of the heterogeneity. The covariates were (I) mean age of patients included (>50 *vs.* ≤50 years); (II) number of patients included (>80 *vs.* ≤80); (III) ethnicity (Asian *vs.* the rest); (IV) study type (retrospective *vs.* prospective); (V) type of CBBCT scanner (CBBCT Invented by University of California at San Diego *vs.* Koning CBBCT); (VI) CBBCT sequence [CE-CBBCT *vs.* non-contrast CBBCT (NC-CBBCT)]. Publication bias was assessed by Deeks' funnel plot. Meta-Disc 1.4 was used to analyze whether threshold effects existed in diagnostic meta-analysis. Furthermore, all analyses were carried out using Stata 15.1 (Stata Corporation).

Results

Literature search and study selection

A total of 1,108 publications were found during the original search; after eliminating 393 duplicate research publications, 715 studies remained. Six hundred and eighty-four studies were omitted according to their titles or abstracts. After carefully reviewing the entire texts of the remaining 31 articles, an additional 13 were disqualified for the following reasons: population repeated (n=3); insufficient data could not be retrieved (n=10). The study selection approach is shown in *Figure 1* as a PRISMA flow diagram.

Study description and quality evaluation

The 18 qualifying studies had sample sizes ranging from 30 to 212 and a total of 1,792 patients who had previously undergone CBBCT examination before invasive tests and

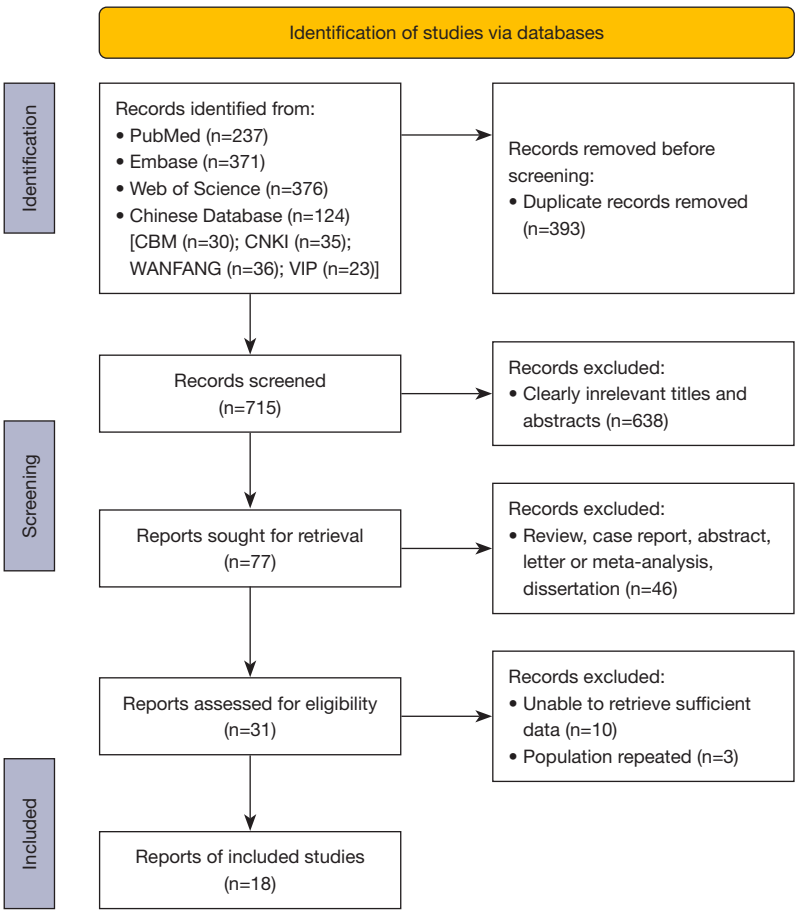

Figure 1 PRISMA flowchart of inclusion and exclusion criteria. CBM, China Biology Medicine; CNKI, China National Knowledge Infrastructure; VIP, China Science and Technology Journal Database; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-analyses.

treatments. They were published before August 2022. *Table 1* provides a summary of the study, patient characteristics, and technical elements.

Figure 2 demonstrates our evaluation of these studies regarding the risk of bias according to the QUADAS-2 tool. One of the studies was ranked as having a "high" risk of bias according to the QUADAS-2 recommendations. The included studies' quality was deemed to be satisfactory.

CBBCT diagnostic performance for breast cancer

The study comprised a total of 18 studies with 1,792 patients. No threshold effect was found in this diagnostic meta-analysis (P=0.418). In detecting breast cancer, the combined overall sensitivity and specificity for CBBCT were 0.95 (95% CI: 0.91–0.97) and 0.72 (95% CI: 0.62–0.80) with high heterogeneity (88.36%), respectively (*Figure 3*). The SROC curve is depicted in *Figure 4*, and the AUC for CBBCT was 0.92 (95% CI: 0.90–0.94).

In order to investigate the sources of heterogeneity, meta-regression analysis was conducted, which was not conducted in other studies. We found that ethnicity (P<0.001 for sensitivity), patient count (P<0.001 for sensitivity), study type (P<0.05 for specificity), and type of equipment (P<0.05 for specificity) were potential causes of heterogeneity for CBBCT (*Table 2*). *Figure 5* shows that there was no significant publication bias in the study (P=0.32).

The Fagan nomogram

For CBBCT, the negative post-test probability (the

Table 1 Characteristics of studies included in cone-beam breast computed tomography

Study	Published year	Type of study	Country	No. of patient	No. of lesion	Mean patient age (years)	Equipment	Type of CBBCT	No. of reader [mean years of experience]	Sens.	Specf.	Study intervention
Aminololama-Shakeri *et al.* (22)	2016	Prospective study	USA	39	39	55	UCSD	CE	2 [>5]	16/19	19/20	CBBCT *vs.* DM
He *et al.* (20)	2016	Prospective study	China	NC: 92; NC + CE: 120	NC: 172; NC + CE: 270	48	Koning	NC; CE	2 [>10]	97/110	279/332	CBBCT *vs.* DM *vs.* US
Zhao *et al.* (14)	2015	Prospective study	USA	65	85	55.6	Koning	NC	2 [>7]	39/45	35/40	CBBCT *vs.* DM
Cole *et al.* (32)	2015	–	–	235	–	–	Koning	NC	–	65/144	77/91	CBBCT *vs.* DM
Jung *et al.* (19)	2017	Retrospective study	–	30	34	–	–	–	4 [7]	8/8	19/26	CBBCT
Wienbeck *et al.* (16)	2018	Retrospective study	Germany	41	100	57.9	Koning	NC; CE	2 [>7]	NC: 29/51; CE: 45/51	NC: 43/49; CE: 35/49	CBBCT *vs.* MRI *vs.* DM
Wienbeck *et al.* (15)	2017	Retrospective study	Germany	65	112	67.8	Koning	NC	2 [18.5]	70/77	12/35	CBBCT *vs.* DM
Chen *et al.* (21)	2020	Prospective study	China	98	100	49	Koning	CE	1 [15]	51/74	18/26	CBBCT
Uhlig *et al.* (17)	2019	Prospective study	Germany	49	100	57.9	Koning	NC + CE; CE	2 [5]	NC + CE: 49/55; CE: 47/55	NC + CE: 33/45; CE: 34/45	CBBCT
Zhang *et al.* (25)	2021	Retrospective study	China	46	50	45	Koning	CE	2 [1 senior doctor; 1 junior doctor]	39/40	7/10	CBBCT *vs.* MRI
Zhang *et al.* (24)	2021	Retrospective study	China	38	38	44.6	Koning	CE	2 [1 senior doctor; 1 junior doctor]	25/27	7/13	CBBCT *vs.* MRI
Liu *et al.* (28)	2021	Retrospective study	China	97	113	48.47	Koning	CE	–	101/103	5/10	CBBCT *vs.* DM
Yang *et al.* (26)	2022	Retrospective study	China	75	83	46.8	Koning	NC	2 [1 senior doctor; 1 junior doctor]	35/38	42/45	CBBCT *vs.* DM
Zhang *et al.* (23)	2021	Retrospective study	China	139	143	48.74	Koning	CE	2 [senior doctor]	120/126	10/17	CBBCT *vs.* DM
Liu *et al.* (29)	2022	Retrospective study	China	78	92	45.28	Koning	CE	–	78/83	7/9	CBBCT *vs.* MRI
Zeng *et al.* (31)	2020	Retrospective study	China	127	127	47.3	Koning	–	–	108/108	5/19	CBBCT *vs.* US
Ma *et al.* (27)	2021	Prospective study	China	198	240	48	Koning	CE	–	135/136	73/104	CBBCT *vs.* US
Liu *et al.* (30)	2018	Retrospective study	China	160	165	47	Koning	CE	2 [1 senior doctor; 1 junior doctor]	83/87	71/78	CBBCT *vs.* DM

CBBCT, cone-beam breast computed tomography; Sens., sensitivity; Specf., specificity; UCSD, CBBCT Invented by University of California at San Diego; CE, contrast-enhanced cone-beam breast computed tomography; DM, digital mammography; NC, non-contrast cone-beam breast computed tomography; Koning, Koning CBBCT; US, ultrasound; MRI, magnetic resonance imaging.

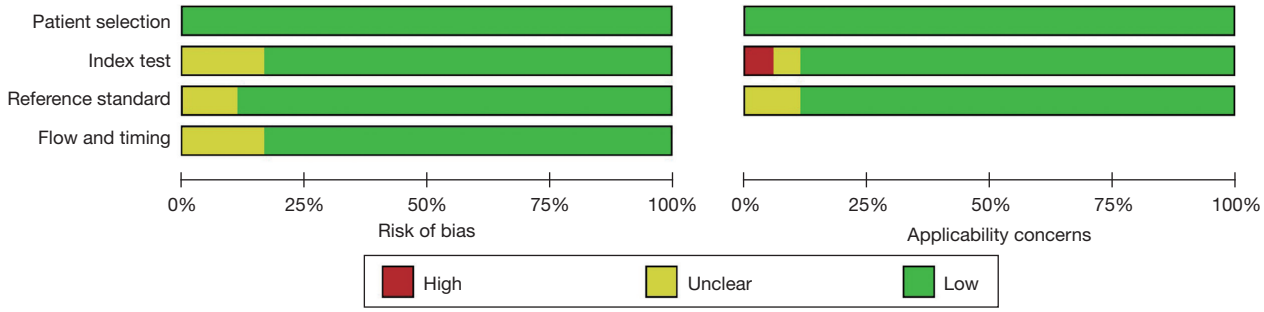

Figure 2 Risk of bias and applicability concerns: reviewers' judgments about each domain for each included study.

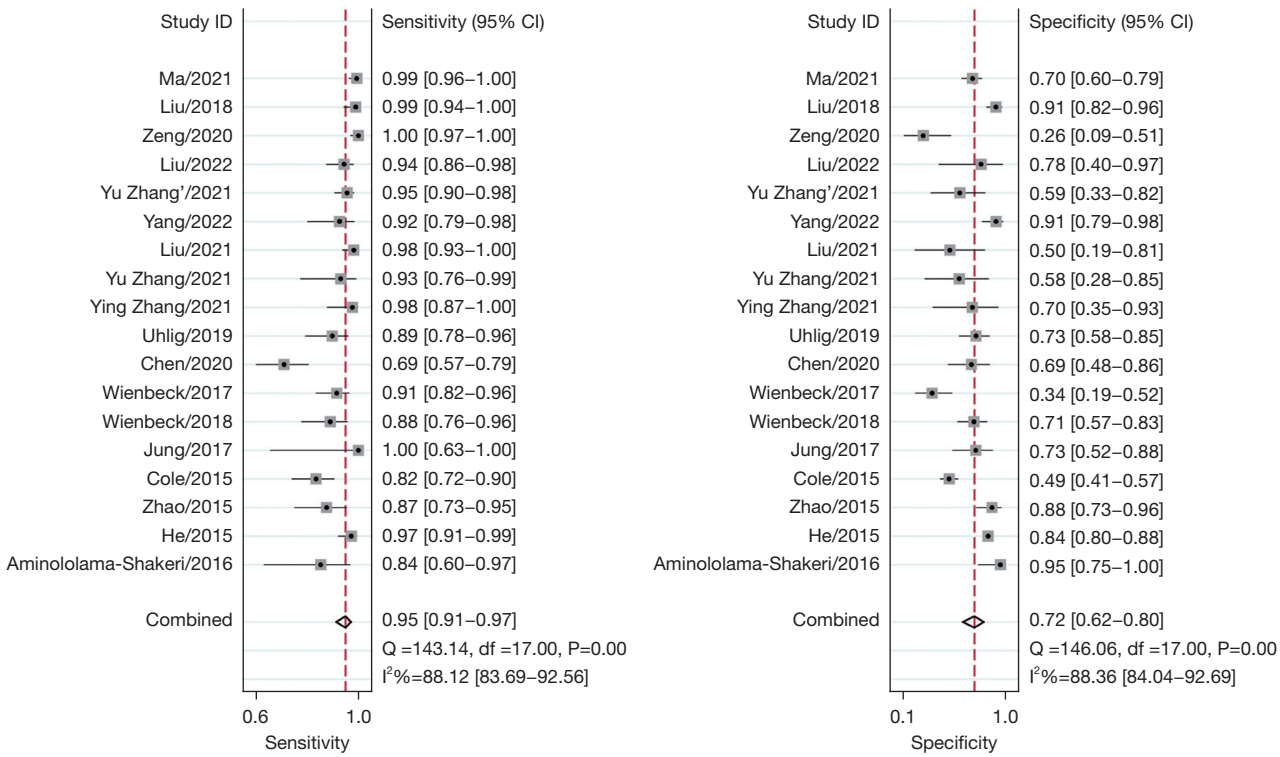

Figure 3 Forest plots using random effect model and univariate meta-analysis model for CBBCT in 18 qualifying studies showing pooled sensitivity and pooled specificity. CI, confidence interval; CBBCT, cone-beam breast computed tomography.

probability of being malignancy when the test is negative) drops to 7% and the positive post-test probability (the probability of being benign when the test is positive) rises to 77% when the pretest probability (prevalence of breast cancer) is assumed to be 50%, which is the medium value of our included studies (*Figure 6*).

Comparison of CBBCT and DM diagnostic performance for breast cancer

A total of eight studies with 992 subjects were included in the analysis. We aim to head-to-head compare the diagnostic accuracy for breast cancer of CBBCT and

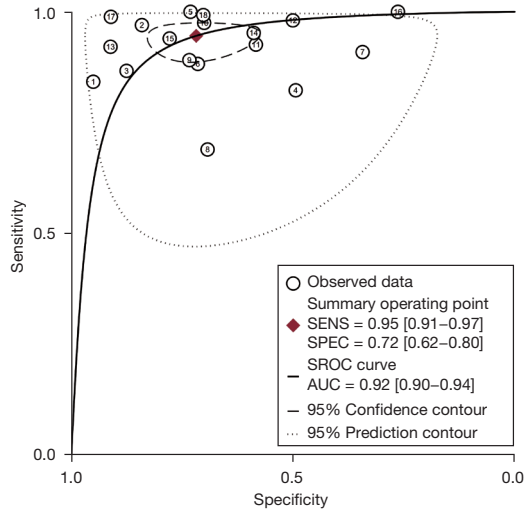

Figure 4 The plot of diagnostic performance using bivariate SROC curve of CBBCT in 18 qualifying studies. SENS, sensitivity; SPEC, specificity; SROC, summary receiver operating characteristics; AUC, area under the curve; CBBCT, cone-beam breast computed tomography.

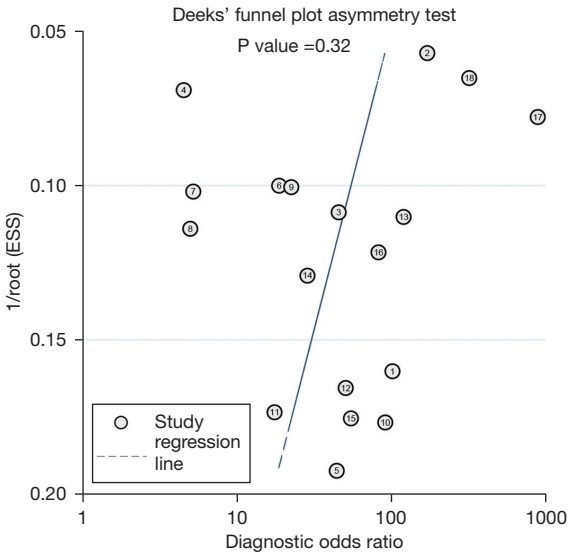

Figure 5 Funnel plots of the likelihood of bias in all included studies. ESS, explained sum of squares.

Table 2 Subgroup analysis of diagnostic performance of CBBCT

Covariate/subgroup	Studies, n	Sensitivity (95% CI)	P value of sensitivity	Specificity (95% CI)	P value of specificity
Age					
>50 years	5	0.96 (0.94–0.99)	0.64	0.72 (0.60–0.85)	0.30
≤50 years	11	0.89 (0.80–0.97)		0.75 (0.58–0.92)	
Ethnicity					
Asian	11	0.96 (0.94–0.99)	<0.001	0.72 (0.60–0.85)	0.53
The rest	5	0.89 (0.80–0.97)		0.75 (0.58–0.92)	
Study type					
Retrospective	11	0.96 (0.93–0.99)	0.23	0.67 (0.55–0.80)	0.02
Prospective	6	0.91 (0.85–0.98)		0.81 (0.70–0.93)	
Number of patients					
>80	8	0.92 (0.87–0.97)	<0.001	0.76 (0.65–0.88)	0.76
≤80	10	0.96 (0.92–0.99)		0.66 (0.52–0.81)	
Type of equipment					
USCD	1	0.85 (0.57–1.00)	0.57	0.96 (0.85–1.00)	0.01
Koning	16	0.94 (0.91–0.97)		0.70 (0.60–0.80)	
Type of CBBCT					
NC	13	0.89 (0.79–0.99)	0.63	0.70 (0.49–0.90)	0.64
CE	4	0.95 (0.92–0.98)		0.72 (0.61–0.84)	

Some articles did not provide information such as age, ethnicity, and type of study, so we did not include these articles in the subgroup analysis. CBBCT, cone-beam breast computed tomography; CI, confidence interval; UCSD, CBBCT Invented by University of California at San Diego; Koning, Koning CBBCT; NC, non-contrast cone-beam breast computed tomography; CE, contrast-enhanced cone-beam breast computed tomography.

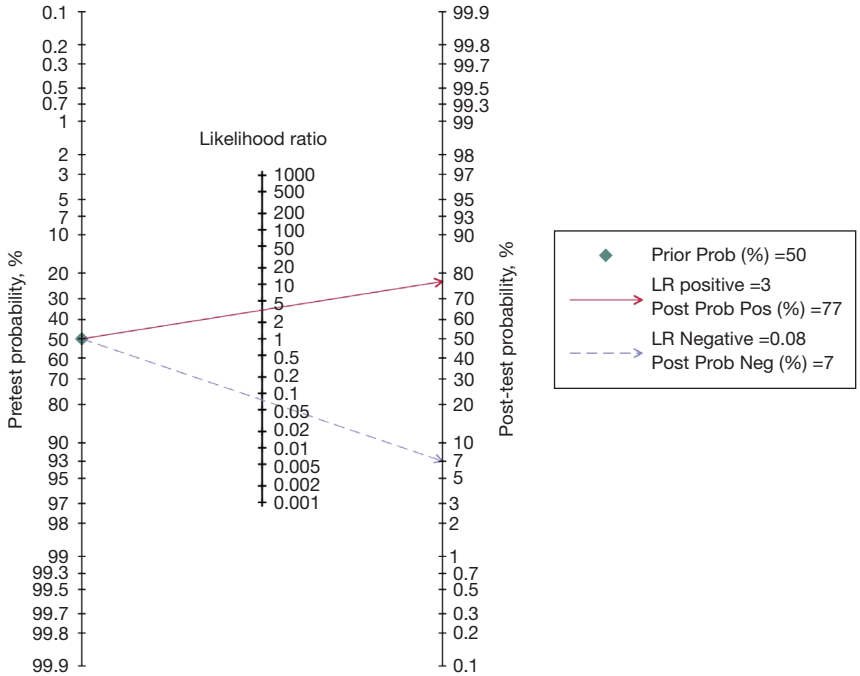

Figure 6 Fagan nomogram of pretest probability and negative post-test probability for CBBCT. The pretest probability was set at 25%. LR, likelihood ratios; CBBCT, cone-beam breast computed tomography.

DM. The pooled overall sensitivity and specificity for CBBCT in detecting breast cancer were 0.93 (95% CI: 0.89–0.96) and 0.76 (95% CI: 0.60–0.87), while those for DM were 0.78 (95% CI: 0.68–0.86) and 0.75 (95% CI: 0.62–0.84) (*Figures 7,8*). The SROC curve is depicted in *Figure 9*, and the AUCs for CBBCT and DM were 0.94 (95% CI: 0.92–0.96) and 0.83 (95% CI: 0.80–0.86), respectively.

Comparison of CBBCT and MRI diagnostic performance for breast cancer

A total of four studies with 203 patients were included in the analysis. We aim to head-to-head compare the diagnostic accuracy of breast cancer of CBBCT and MRI. The pooled overall sensitivity and specificity for CBBCT in detecting breast cancer were 0.90 (95% CI: 0.79–0.96) and 0.79 (95% CI: 0.65–0.88), while those for MRI were 0.91 (95% CI: 0.79–0.97) and 0.89 (95% CI: 0.72–0.97) (*Figures 10,11*). *Figure 12* shows the SROC curve and the AUC for CBBCT and MRI were 0.88 (95% CI: 0.85–0.91) and 0.96 (95% CI: 0.94–0.97), respectively.

Discussion

A unique breast imaging technique called CBBCT has shown significant diagnostic potential in the detection of breast cancer. Using sensitivity, specificity, and mean AUC of SROC as markers of diagnostic accuracy, we did a systematic review and found 18 published papers on the reliability of CBBCT for the identification of benign and malignant breast lesions. This is the first meta-analysis of direct comparisons of CBBCT and DM, as well as CBBCT and MRI for the diagnosis of benign and malignant breast lesions, to the best of our knowledge.

The pooled overall sensitivity and specificity for CBBCT in identifying breast cancer in this meta-analysis were 0.95 (95% CI: 0.91–0.97) and 0.72 (95% CI: 0.62–0.62), respectively. CBBCT's SROC curve and AUC were 0.92 (95% CI: 0.90–0.94). When we aggregated overall sensitivity and specificity for CBBCT, we found a lot of variation. Using meta-regression analysis, we investigated the causes of heterogeneity among the studies and their quantitative implications on diagnostic performance. The results show that the ethnicity and the number of patients were significant factors that influenced heterogeneity

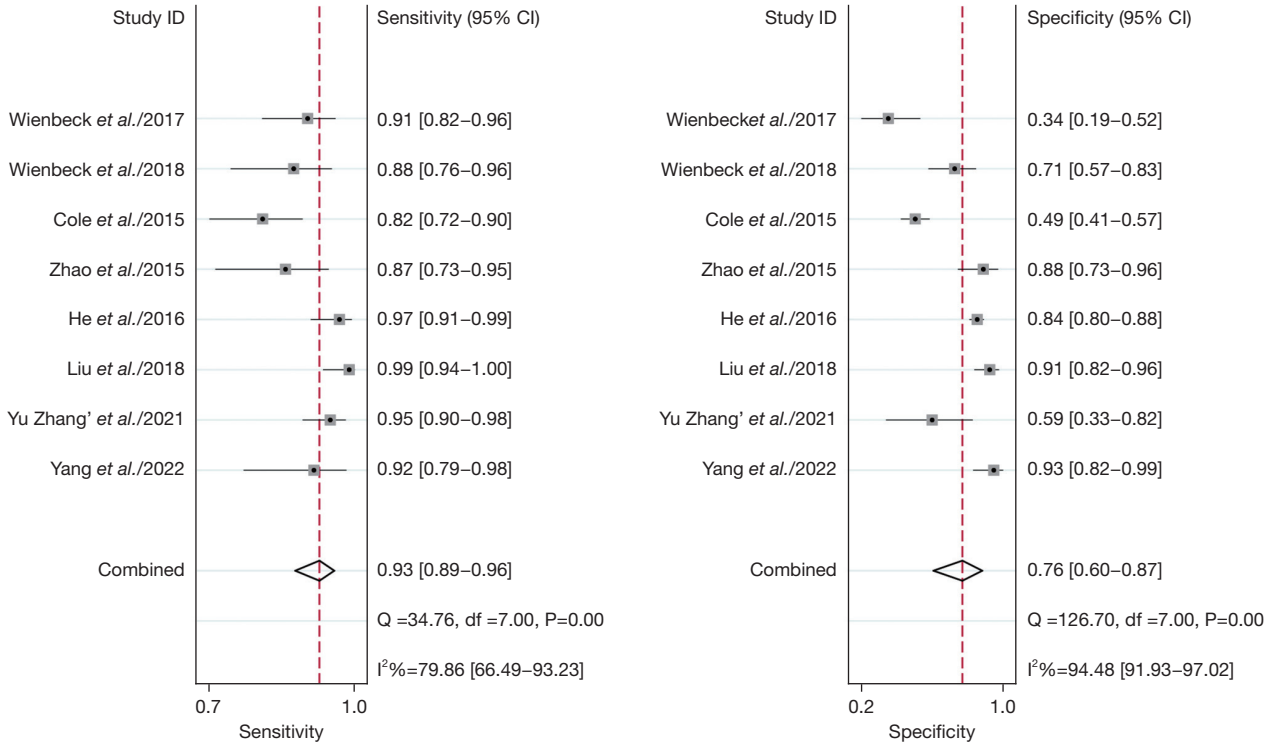

Figure 7 Forest plots using random effect model and univariate meta-analysis model for CBBCT in eight qualifying studies showing pooled sensitivity and pooled specificity. CI, confidence interval; CBBCT, cone-beam breast computed tomography.

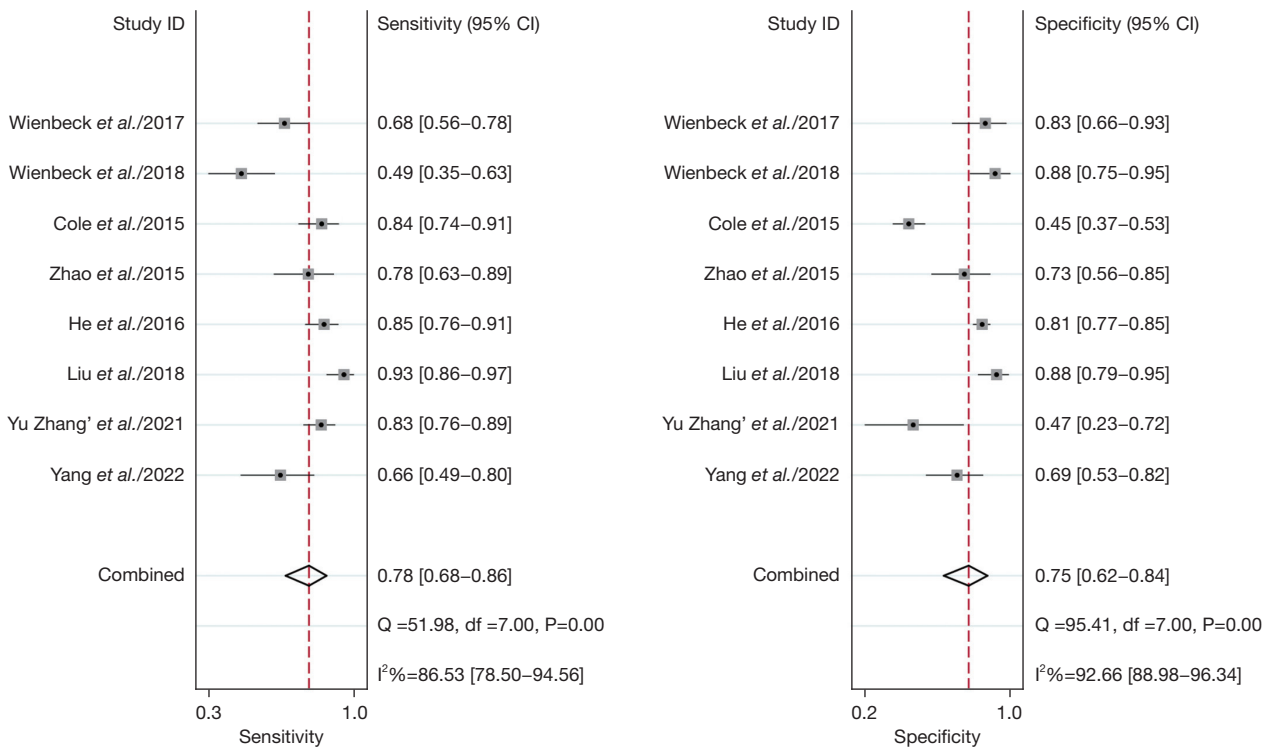

Figure 8 Forest plots using random effect model and univariate meta-analysis model for DM in eight qualifying studies showing pooled sensitivity and pooled specificity. CI, confidence interval; DM, digital mammography.

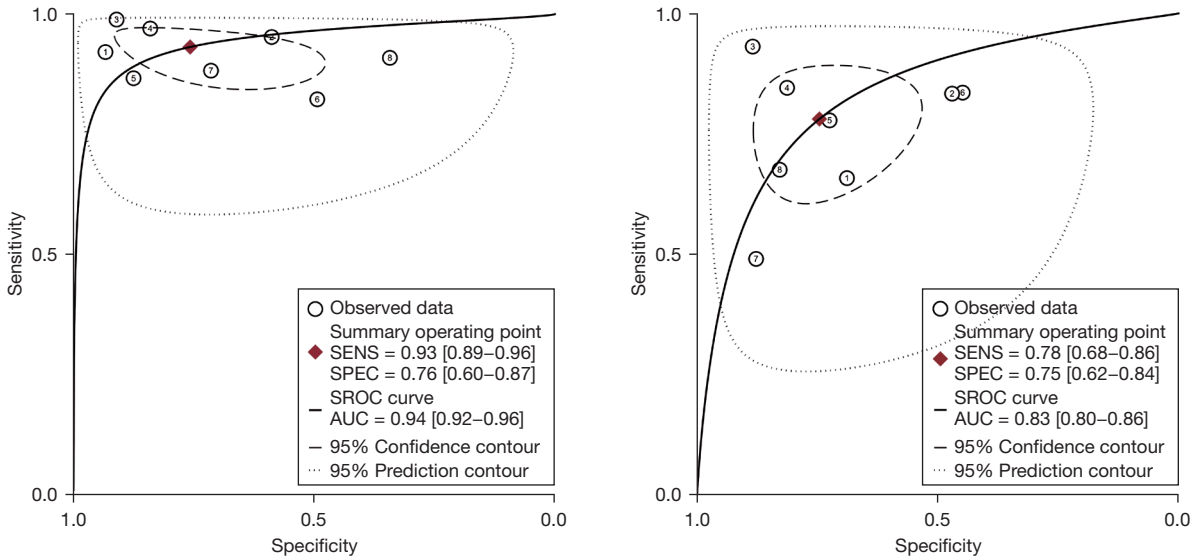

Figure 9 The plot of diagnostic performance using bivariate SROC curve of CBBCT and DM in eight qualifying studies. SENS, sensitivity; SPEC, specificity; SROC, summary receiver operating characteristics; AUC, area under the curve; CBBCT, cone-beam breast computed tomography; DM, digital mammography.

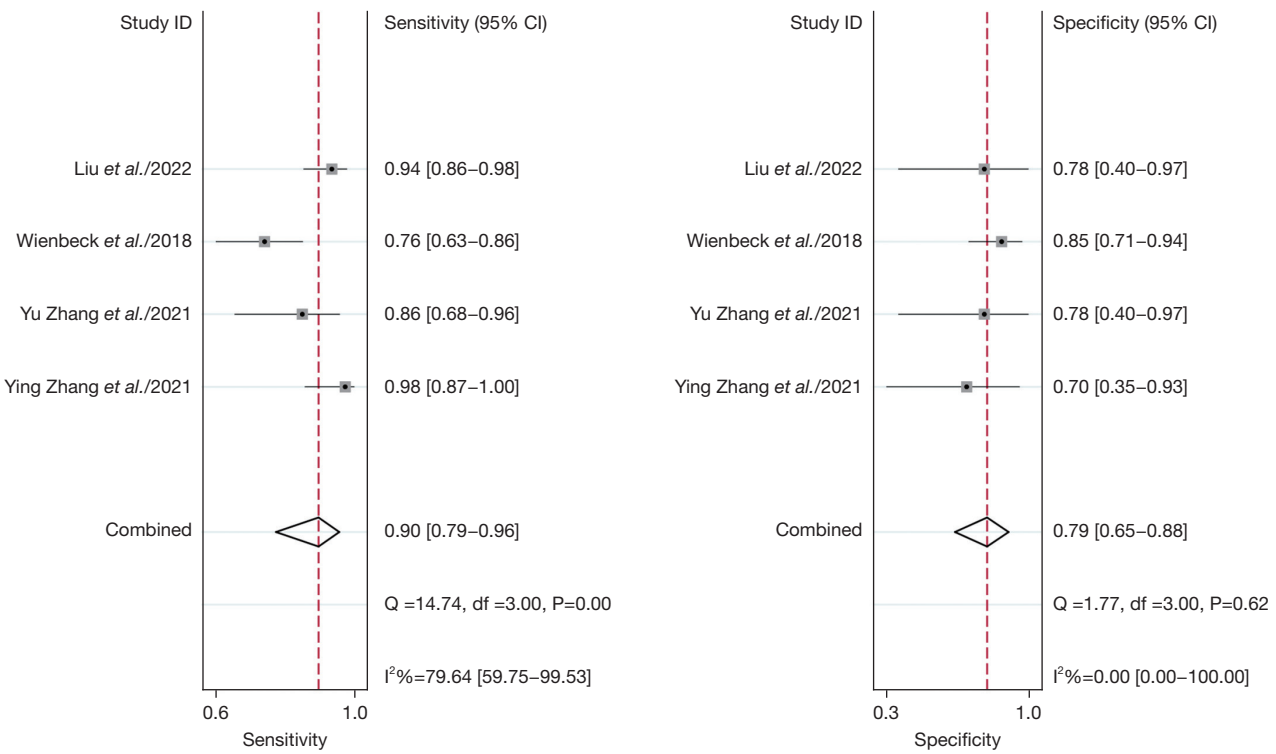

Figure 10 Forest plots using random effect model and univariate meta-analysis model for CBBCT in four qualifying studies showing pooled sensitivity and pooled specificity. CI, confidence interval; CBBCT, cone-beam breast computed tomography.

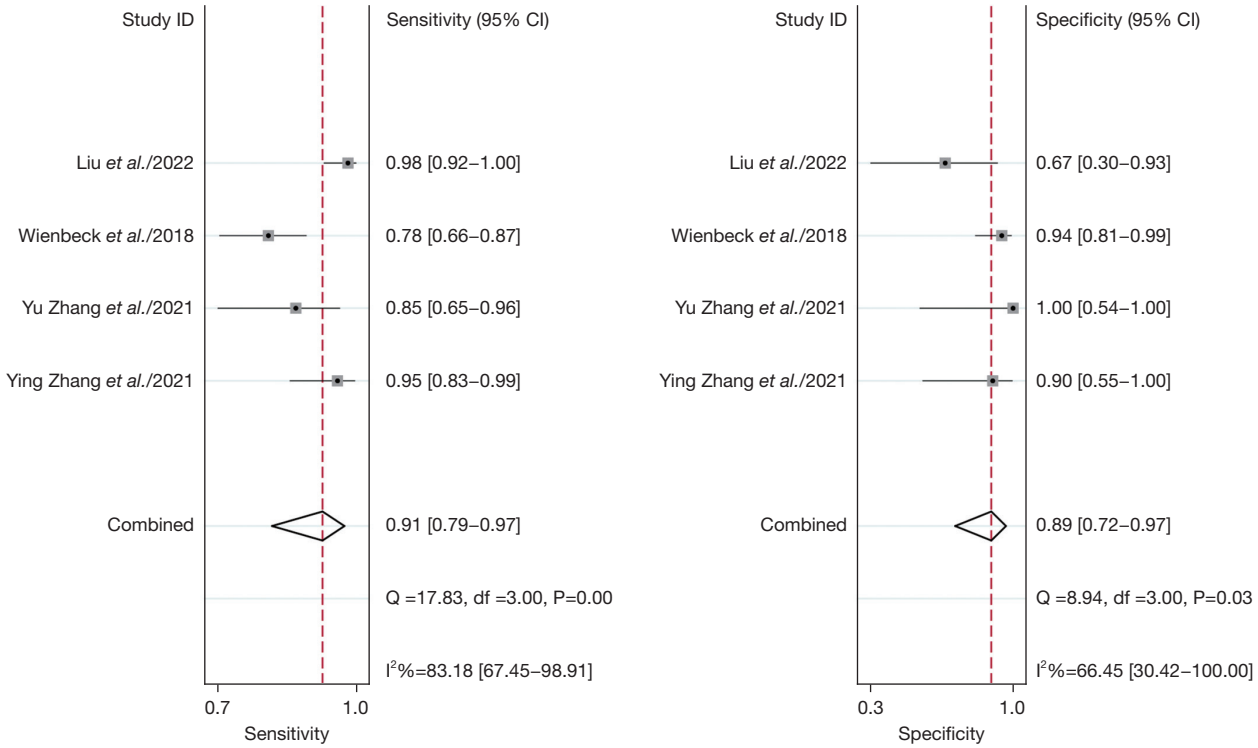

Figure 11 Forest plots using random effect model and univariate meta-analysis model for MRI in four qualifying studies showing pooled sensitivity and pooled specificity. CI, confidence interval; MRI, magnetic resonance imaging.

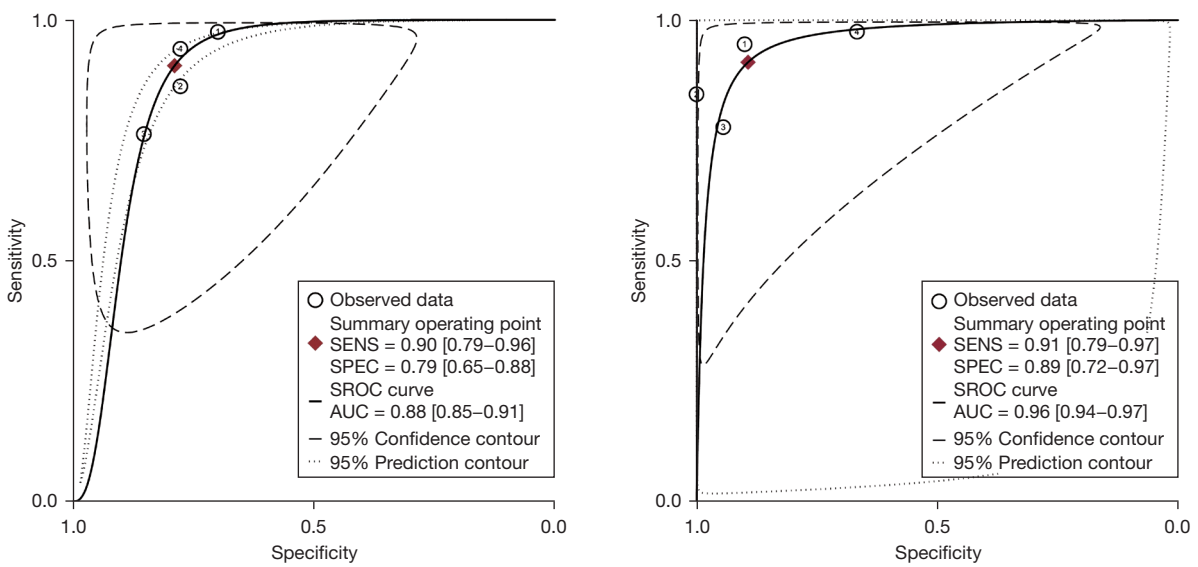

Figure 12 The plot of diagnostic performance using bivariate SROC curve of CBBCT and MRI in four qualifying studies. SENS, sensitivity; SPEC, specificity; SROC, summary receiver operating characteristics; AUC, area under the curve; CBBCT, cone-beam breast computed tomography; MRI, magnetic resonance imaging.

of sensitivity, study type, and type of CBBCT scanner were possible sources of heterogeneity of specificity. Nevertheless, there may be additional factors, such as differences in the patients, technique, and research design.

In comparison to the results of the meta-analysis presented by Uhlig *et al.* (12), which had a pooled sensitivity of 78.9%, specificity of 69.7%, and AUC of 0.817, the results of the meta-analysis presented by Komolafe *et al.* (33) had higher diagnostic efficiency in terms of pooled sensitivity, sensitivity, and mean AUC values (83.7%, 71.3%, and 0.831, respectively). These previous meta-analyses only analyzed literature with small sample sizes and studies in English. In addition, we performed a meta-regression analysis to explore heterogeneity. This meta-analysis yielded the highest diagnostic performance of CBBCT, which may be explained by the recent improvements in imaging technology and the improved level of readers' skill.

DM was the primary recommendation for breast cancer screening in the National Comprehensive Cancer Network (NCCN) guidelines (34). Head-to-head comparison between CBBCT and DM shows that the SROC curve and the AUC for CBBCT and DM were 0.94 (95% CI: 0.92–0.96) and 0.83 (95% CI: 0.80–0.86) respectively. In our research, it was concluded that the diagnostic efficacy of CBBCT was significantly better than that of DM. In addition, in DM imaging, the density of fibrous glandular tissue can mask tumors and lead to missed diagnosis, and normal glandular tissue may overlap to form tumor-like images. CBBCT reduces the interference of thickness and can detect microlesions equal to 0.2 mm (20).

In addition to the accuracy of the examination, another important evaluation indicator of imaging is radiation dose. Although the radiation dose of CBBCT is slightly higher than that of DM in most studies, the radiation dose of CBBCT for a single scan of a standard breast is 5.8 mGy, which does not exceed the radiation dose standard established by the FDA for DM for screening (total dose not to exceed 6 mGy), and the lifetime attributable risk of cancer induced by this radiation dose is extremely low (35). In the future, improvements anticipate the use of dual-energy approaches for the simultaneous capture of NC-CBBCT and CE-CBBCT in order to decrease radiation dosage (16).

In articles comparing the diagnostic efficacy of CBBCT and MRI, it is usually concluded that there was no statistical difference between the two imaging modalities, and most scholars also consider the diagnostic efficacy of CE-CBBCT to be comparable to that of MRI. However, in this research, head-to-head comparison between CBBCT and MRI shows that the SROC curve and the AUC for CBBCT and MRI were 0.88 (95% CI: 0.85–0.91) and 0.96 (95% CI: 0.94–0.97). In addition, MRI represents an important diagnostic tool to evaluate for axillary lymph node metastasis (36). CBBCT can be used as an imaging option for patients with contraindications to MRI. Other advantages of CBBCT over breast MRI include shorter examination times, less noise, and lower price. Although both imaging modalities require contrast agents with potential adverse effects, it is concerning that the long-term effects of gadolinium-based MRI contrast agents are unknown (37,38).

Calcifications and their morphology then become one of the key factors in the diagnosis of breast cancer. CBBCT has an excellent ability to identify fine, granular, clustered microcalcifications that can help in the diagnosis and management of early breast cancer. However, MRI is not sensitive to breast calcification foci (39). Especially for low-grade ductal carcinoma in situ (DCIS) containing microcalcifications, MRI examination is associated with a 12% false-negative rate due to the lack of enhancement of the lesion (40). Therefore, lesions with suspicious calcification on DM or CBBCT without suspicious enhancement on MRI at the corresponding location need to be treated with caution. The higher soft tissue resolution of MRI combined with the higher spatial resolution of CBBCT and the ability to identify microcalcifications is beneficial for accurate diagnosis of breast cancer, and some studies have combined CBBCT and MRI to achieve better diagnostic performance than individual examinations in several studies (25,29).

CBBCT has not yet become a routine clinical option because there is insufficient evidence-based medical evidence to support its necessity in the diagnostic setting. Future clinical trials of CBBCT in the diagnostic setting of breast cancer are still needed to further evaluate its diagnostic efficacy and define the applicable population. On the other hand, there is still a need to explore the value of CBBCT in breast cancer screening through prospective or retrospective studies due to various factors such as health economics, screening efficacy, and radiation exposure.

It is also necessary to discuss the limitations of our meta-analysis. First, due to the recent introduction of CBBCT as a screening or diagnostic imaging modality, there are no large multicenter prospective or clinical trial studies with standardized acquisition protocols available. This causes variations in the timing of CE-CBBCT acquisition and administration of intravenous contrast material. In addition,

no diagnostic criteria and standards for CBBCT have been developed. Most studies have referred to the diagnostic criteria of DM and MRI in breast imaging reporting and data system (BI-RADS) for the diagnosis of CBBCT images. Physicians have less experience in reviewing CBBCT, and the diagnostic agreement between different physicians can be reduced (30). These factors all contribute to an increase in potential bias. Finally, only four studies are included in the head-to-head comparison between CBBCT and MRI, which leads to small sample size. This is because we only included studies that used CBBCT and MRI for the diagnosis of breast cancer within the same patient cohorts to avoid patient selection bias as much as possible.

Conclusions

With promising sensitivity, specificity, and AUC values, our research concludes that the diagnostic performance of CBBCT in our meta-analysis is superior than that in the earlier meta-analysis. There is a tendency toward a greater sensitivity and diagnostic accuracy of CBBCT compared to DM for the diagnosis of breast cancer, according to a meta-analysis of head-to-head comparative studies. In contrast, when MRI and CBBCT were compared side by side, MRI's diagnostic effectiveness was somewhat superior. We expect that as the underlying imaging physics of this modality are better understood and CAD applications are developed, the diagnostic performance of CBBCT will continue to improve (41-43). More prospective studies comparing the diagnostic accuracy of CBBCT and MRI for breast cancer characterisation and detection are recommended.

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Footnote

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