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Systematic Review

Meta-Analysis of Abbreviated MRI Scanning Reveals a High Specificity and Sensitivity in Detecting Breast Cancer

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Abstract

Background: Breast cancer (BC) is the most common malignancy and the leading cause of mortality among women. Various diagnostic tools for early diagnosis and tumor progression detection have helped patients receive precise and timely treatment. This meta-analysis aims to evaluate the accuracy of abbreviated magnetic resonance imaging (ABB-MRI) data in the diagnosis of BC. **Methods**: The Preferred Reporting Items for Systematic Reviews and Comparative Meta-Analysis for Diagnostic Test Accuracy (PRISMA-DTA) guidelines were followed to perform the meta-analysis. Data from articles published in the last 5 years reporting ABB-MRI as a diagnostic tool were collected by searching the relevant databases using multiple subject keywords and free words. Meta-Disc 1.4 software was used to analyze the data and plot the relevant graphs. **Results**: We identified 1250 articles while searching the relevant electronic databases. After removing duplicate studies and data, the titles and abstracts of 1149 studies were reviewed. A total of 18 publications that satisfied the inclusion criteria were finally included in the meta-analysis. The calculated pooled specificity and sensitivity were 0.90 and 0.87, respectively. This study confirms the ABB-MRI protocol's high diagnostic sensitivity and specificity in malignant breast cancer detection. **Conclusions**: Abbreviated MRI seems to function as a useful supplement because it is highly sensitive and specific, on par with the full MRI scan, as shown in multiple independent studies as well as this pooled analysis. These findings confirm the utility of ABB-MRI in the accurate detection of malignant BC lesions in high-risk women that cannot be detected by mammography or ultrasound.

Keywords: breast cancer; meta-analysis; mammography; MRI; diagnosis; abbreviated MRI

1. Introduction

Breast cancer (BC) is one of the most prevalent cancers and the leading cause of death among women [1]. Various advanced diagnostic techniques currently being used for the early detection and progression of BC have facilitated its precise and timely treatment [2,3]. Among the most difficult aspects of diagnosing BC is distinguishing it from benign lesions, including breast fibroma, fibroadenosis, and lobular proliferation. In the vast majority of countries, mammography is employed to detect or screen for BC. It has a wide range of diagnostic applications; however, its clinical applicability is limited to breast tissue density. Because the breast tissue of young women and Asian women is dense in general, mammography may only provide limited information to distinguish benign from malignant breast tumors. Magnetic resonance imaging (MRI) has recently been used in the differential diagnosis and clinical research of BC, which not only adds to the diagnostic method but also raises several questions, such as how to combine these methods with other diagnostic tools to achieve precise diagnoses [4]. The quality of an MRI scan is less affected by breast density when compared to mammography and can distinguish between malignant and benign tumors with great accuracy. Furthermore, mammography may show more false positives than MRI test [4]. As a result, MRI was used to examine breast abnormalities, and studies showed that MRI may detect lesions in high-risk women that mammography or ultrasound fails to detect. In March 2007, the American Cancer Society published a guideline that recommended annual MRI screening for women with a lifetime risk of BC greater than 20–25 percent [5]. Various MRI-associated diagnostic protocols are incorporated for the analysis of BC in populations bearing high-risk screening, including the ULTRAFAST protocol, Digital Breast Tomosynthesis (DBT), Abbreviated MRI protocol (ABB-MRI), and Full Diagnostic Protocol MRI (FDP-MRI) [4]. The applicability of ABB-MRI protocol in BC detection has been evaluated in various independent studies and is by far considered an ideal approach with several advantages over other MRI diagnostic protocols. Besides offering comparable performance metrics, ABB-MRI requires only a few hours to complete the image acquisition cycle, thus allowing the screening of more patients each day as compared to the FDP-MRI [6]. Another potential advantage is that ABB-MRI can reduce the number of diagnostic tests needed for BC diagnosis, making it a powerful supplement for the treatment of BC [6]. Overall, the available data suggest that the ABB-MRI protocol has better applicability in BC screening and detection, considering its cost-effectiveness, short detection time, and comparable accuracy to the FDP protocol [6–15]. It is a valid protocol utilized to examine preoperative staging and reduce the complexity of image acquisition [10]. Numerous studies have been performed to assess the diagnostic performance of MRI in the evaluation of breast lesions and therapeutic response to chemotherapy [4,5,16–18]. However, the patient characteristics, MRI techniques, and diagnostic criteria for malignancy in the studies differ substantially, which may have compromised the comparison of the diagnostic performance of breast MRI between the studies. As a result, a thorough evaluation of the diagnostic accuracy and characteristics of the MRI data is needed, which will help with the choice of breast imaging technologies and the interpretation of study outcomes. To provide strong validation to ABB-MRI, pooled data from independent studies, when combined inculcate convincing results highlighting the diagnostic power and accuracy of this technique. Meta-analysis is a quantitative and formal epidemiological study design used to systematically assess previous research studies to derive conclusions about that body of research [19]. It is useful in increasing the statistical power of the original and replicated studies. Pooling data from different independent studies and performing a meta-analysis on the pooled data helps to validate the specificity of the MRI technique in BC diagnosis. Our study aimed to perform a meta-analysis of the available data to check the accuracy of ABB-MRI in patients with breast lesions. The analysis will hopefully indicate if ABB-MRI detects the pathologic condition in BC patients with improved sensitivity and specificity.

2. Materials and Methods

2.1 Literature Search

Data from relevant studies published in the last 5 years was collected. The study search was conducted using the Eligible Studies Criteria for Systematic Meta (PRISMA) guidelines [20]. A thorough electronic systematic search of the PubMed, Medline, Google Scholar, Ovid, EMBASE, Web of Science, Chinese National Knowledge Infrastructure (CNKI), and Cochrane Library databases was undertaken up to and including May 25, 2022. The electronic search terms used were breast cancer, breast neoplasms or breast lesions or breast tumor or mammary neoplasms or mammary cancer or mammary tumor and breast neoplasms or breast lesions or breast tumor, or breast cancer+ magnetic resonance imaging, or MRI. To avoid the omission of studies, we used subject keywords plus free words in our search. The available languages were limited to English. Articles showing concurrence with the ABB-MRI protocol were primarily included in this meta-analysis. Moreover, relevant reference lists from the included studies were also taken into consideration for further data interpretation [11]. After screening, the extracted relevant data were analyzed with Meta-Disc 1.4 software (Ramón y Cajal Hospital, Madrid, Spain) [21].

2.1.1 Inclusion and Exclusion Criteria

Inclusion criteria:

(i) Abbreviated MRI-based studies for the detection of BC, whether prospective or retrospective.

(ii) Studies with sufficient data on true positives (TP), false positives (FP), false negatives (FN), and true negatives (TN) can be recovered or inferred.

(iii) Both screening studies and enriched cohorts based on ABB-MRI protocol.

(iv) The gold standard diagnostic procedures were pathology or cytology.

(v) Data published in peer-reviewed journals

Exclusion criteria:

(i) Published information or data that has been duplicated.

(ii) Data published in abstracts and conference proceedings.

(iii) Experiments with animals.

(iv) Studies with insufficient data to calculate TP, FP, FN, and TN.

2.1.2 Data Extraction

The full-text publications were evaluated independently, and data from the included research were acquired. From the original papers included in this study, the following information and data were gathered:

(i) The primary author's cited studies.

(ii) The period in which the study was published.

(iii) The sample size and the presence or absence of breast lesions.

(iv) The ages of patients covered.

(v) Type of MRI and manufacturer.

(vi) Distribution of TP, FP, FN, and TN from 2017–2022 full-text publications.

2.2 Statistical Analysis

Meta-Disc 1.4 software [21] was used to analyze the pooled sensitivity, specificity, positive likelihood ratio (PLR), negative likelihood ratio (NLR), diagnostic odds ratio (DOR), and area under the curve (AUC). The quality of studies and risk of bias were assessed with Review Manager 5.2 (The Cochrane Collaboration, 2010, Odense, Denmark). Meta-regression analysis was used to analyze research type, MRI unit, and diagnosis standard using Meta-Disc. Other applicable statistical tests (Chi-square, I^2, Cochran-Q) were also performed using Meta-Disc. p value of < 0.05 was considered statistically significant.

3. Results

3.1 Searching for Relevant Literature and Identifying Research

After conducting a comprehensive search of relevant electronic databases and other sources, we identified 1250 articles in the beginning. After removing duplicate studies and other irrelevant articles, the titles and abstracts of 1149 studies were reviewed before being included (Fig. 1). Of these, only 18 articles were included in the meta-analysis per the inclusion criteria.

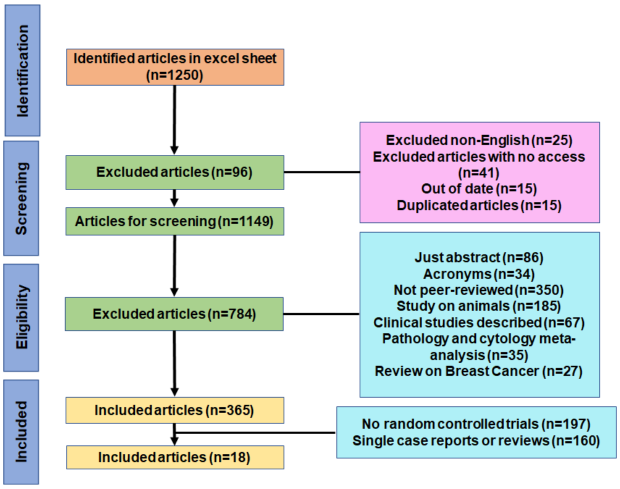

Fig. 1. PRISMA flow diagram.

3.2 Quality Assessment

A PRISMA model [20] was used to assess the quality of the studies that were included (Fig. 1). Each study was reviewed by two independent reviewers.

3.3 Statistical Analysis

The pooled dataset included 12,689 patients from 18 studies published in the last 5 years that have used the ABB-MRI protocol for BC lesion detection. The distribution of TP, TN, FP, and FN values is given in Table 1 (Ref. [6–10,13–15,22–31]). A forest plot of the pooled positive likelihood ratio (LR) along with a 95% confidence interval (95% CI) is shown in Fig. 2. We observed a pooled LR of 7.83 with a narrow 95% CI of 5.33–11.52. The ABB-MRI protocol showed varying sensitivity and specificity results for the individual studies, with a pooled sensitivity of 0.87 (Fig. 3) and a pooled specificity of 0.90 (Fig. 4). These two parameters of diagnostic testing can be described using the receiver operating characteristic curve (ROC). According to Zhang *et al.* [2], a ROC curve referred to as the summary receiver operating characteristic (SROC) curve may be regarded as a meta-analysis of multiple distinct tests of the same test index in terms of their odds ratio (OR). By computing the area under the SROC curve, one may obtain the area under the curve (AUC) and Q* (Fig. 5). The SROC point where sensitivity and specificity are identical is denoted by Q*. The Q* index represents the summary measure of overall data accuracy along with interrelated test comparisons. Our research included ABB-MRI data values to plot the SROC curve and evaluate the AUC, which was found to be 0.9497, along with a Q* value of 0.8901, suggesting a higher degree of diagnostic accuracy [11]. Additionally, we performed a separate analysis on the pooled data of 12 screening and 6 enriched cohort studies to compare the sensitivity and specificity of ABB-MRI between these cohorts. For screening studies, we observed a pooled specificity and sensitivity of 0.91 and 0.75, respectively along with an AUC value of 0.94. For the enriched cohort, the pooled specificity and sensitivity were 0.77 and 0.95, respectively along with an AUC value of 0.93.

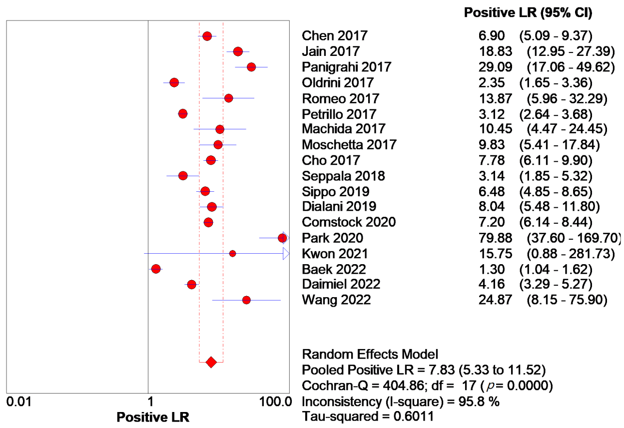

Fig. 2. Forest plot of likelihood ratios for positive test results from studies following the abbreviated MRI protocol in the detection of breast cancer.

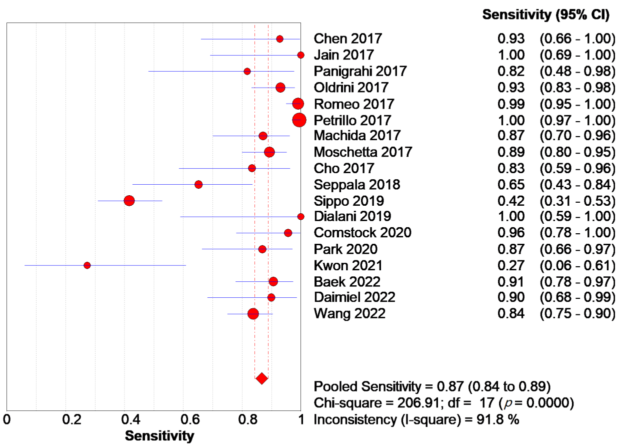

Fig. 3. Sensitivity plot for ABB-MRI patients with 95% confidence intervals for BC detection.

Table 1. Characteristics of enriched studies based on the Abbreviated MRI protocol for meta-analysis using Meta-Disc Software.

S.No.	Author	Type of Study	TP	FP	FN	TN	References
1	Chen, 2017	Screening study	13	46	1	296	[22]
2	Jain, 2017	Screening study	10	29	0	552	[23]
3	Panigrahi, 2017	Screening study	9	18	2	622	[24]
4	Cho, 2017	Screening study	15	221	3	1842	[28]
5	Sippo, 2019	Screening study	35	182	49	2648	[30]
6	Dialani, 2019	Screening study	7	29	0	223	[31]
7	Comstock, 2020	Screening study	22	187	1	1220	[9]
8	Park, 2020	Screening study	20	7	3	636	[8]
9	Kwon, 2021	Screening study	3	0	8	26	[10]
10	Baek, 2022	Screening study	39	28	4	12	[15]
11	Daimiel, 2022	Screening study	18	88	2	319	[13]
12	Wang, 2022	Screening study	83	3	16	86	[14]
13	Oldrini, 2017	Enriched cohort	54	19	4	29	[6]
14	Romeo, 2017	Enriched cohort	109	5	1	65	[7]
15	Petrillo, 2017	Enriched cohort	206	96	1	205	[25]
16	Machida, 2017	Enriched cohort	27	5	4	55	[26]
17	Moschetta, 2017	Enriched cohort	67	10	8	100	[27]
18	Seppala, 2018	Enriched cohort	15	16	8	61	[29]

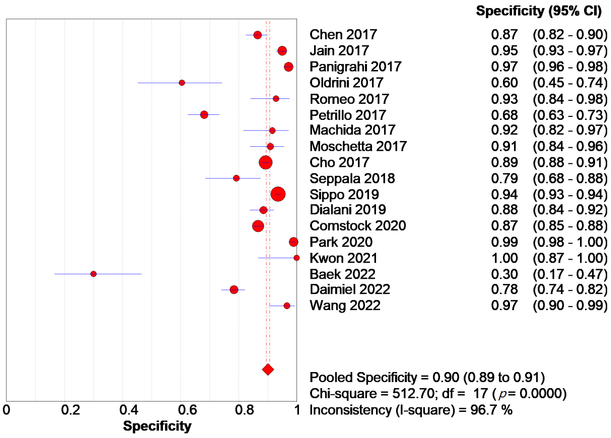

Fig. 4. Specificity curve for ABB-MRI patients along with a confidence interval of 95% to detect BC.

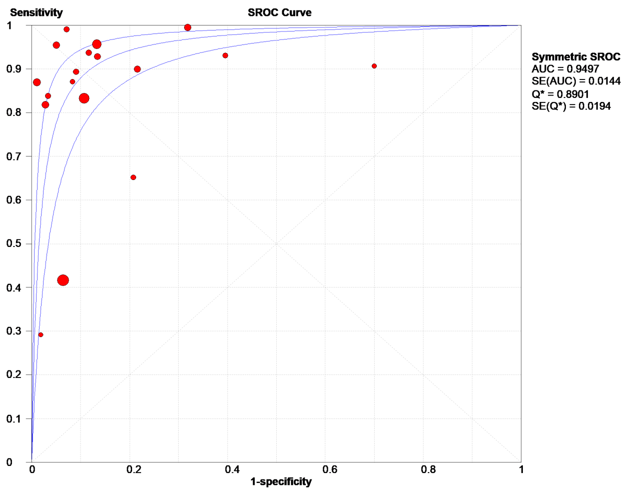

Fig. 5. Receiver operating characteristic curve representing specificity against sensitivity values through ABB-MRI protocols for the detection of BC. The summary measure of overall data accuracy, along with relevant test comparisons, is represented by the Q* index.

4. Discussion

Recently, Baxter *et al.* [11] performed a meta-analysis on data pooled from five screening and eight enriched cohort studies to compare ABB-MRI with FDP-MRI and concluded that no statistically significant difference exists between these two protocols in the diagnosis of BC. However, the authors reported a reduced specificity of both protocols in the pooled enriched cohort (0.83 and 0.84 in ABB-MRI and FDP-MRI, respectively) when compared with the pooled screening cohort (0.92 and 0.95 in ABB-MRI and FDP-MRI, respectively). Since then, more independent studies on ABB-MRI in BC detection have been published [13–15], all consistently demonstrating the advantage of ABB-MRI in BC detection and screening; therefore, these data clearly support the large-scale use of ABB-MRI-based BC screening, especially in women who have dense breast tissue for whom mammography is not sensitive enough to detect malignant BC. The current meta-analysis was performed by pooling all available data to evaluate the specificity and sensitivity of ABB-MRI with high statistical power due to increased patient number (n = 12,689). In addition to the studies included in the Baxter *et al.* [11] meta-analysis except for three studies that were published before 2017, we included eight more studies published between 2017–2022 in our meta-analysis, based on our inclusion criteria [8–10,13–15,23,30]. The diagnostic testing mentioned in the meta-analysis primarily focused on the high efficiency offered by the ABB-MRI protocol considering sensitivity and specificity as widely used markers. We estimated a high specificity (0.90) and sensitivity (0.87) of ABB-MRI from our pooled dataset, which corroborates with a previous report [11]. We also made a comparison between screening and enriched cohorts, similar to Baxter *et al*. [11], and detected a specificity of 0.91 and a sensitivity of 0.75 in the screening cohort and a specificity of 0.77 and a sensitivity of 0.95 in the enriched cohort. These findings broadly corroborate with the Baxter *et al*. [11] meta-analysis; however, we observed a slightly low sensitivity in the screening cohort than in the enriched cohort (0.75 *vs* 0.95). This could be due to the increased sample size.

For breast cancer detection, mammography, a commonly used test, was found to be less sensitive (0.75) and specific (0.71) than MRI-based detection (sensitivity = 0.92 and specificity = 0.70) [2], suggesting a stronger discriminating power of MRI over mammography [32]. Since the development of the MRI technique as a diagnostic tool, many different variants have been developed, including ABB-MRI. ABB-MRI has a high specificity and sensitivity than mammography and is considered a valid diagnostic tool for future screening and BC characterization in enriched cohorts [10,11]. Being less time-consuming, cost-effective, comparable in sensitivity and specificity to FDP-MRI, and superior to mammography, especially in women with dense breast tissue [15], ABB-MRI is gaining greater acceptance among clinicians for its faster interpretation time with high diagnostic accuracy. Comstock *et al*. [9] performed a comparative study between ABB-MRI and digital breast tomosynthesis (DBT) for BC detection in women with dense breast tissue and concluded that ABB-MRI significantly increased the detection rate compared with DBT. Similarly, data comparing ABB-MRI and full diagnostic MRI showed concurrence with the standard MRI protocols and were reliable enough to confer high diagnostic performance [11].

Based on the findings of this meta-analysis and many other similar previous studies, several diagnostic approaches can be used to guide therapeutic care: (1) Mammography is less expensive than MRI, despite its lower sensitivity; as a result, mammography will continue to be the gold standard in clinical BC imaging [32]. (2) MRI exams especially ABB-MRI should be prioritized for young women, taking into account the effects of ionizing radiation on the breasts and young women with a dense breast ratio and favorable physiological characteristics [33]. (3) The likelihood ratio (LR), which is a sensitivity-specificity ratio that better indicates the diagnostic test's accuracy should be used. According to epidemiological studies, LR+ >10 is a positive value for BC diagnosis, while LR– ≤ 0.1 is a negative value.

Findings-based diagnosis is the process of making the best diagnostic and treatment decisions for patients based on the "best" research results. Evidence-based medicine is the application of research findings to clinical practice to solve practical problems. When specific disease characteristics are found in BC, such as "refined salt calcification", mammography has a higher sensitivity and specificity than other procedures. Mammography is also preferred when detecting microcalcification, as patients with ductal carcinoma in situ (DCIS) give better interpretation with mammography [34]. MRI, including ABB-MRI, should be used to generate soft tissue-rich anatomical images, as mammography has difficulty demonstrating a lesion in dense breast tissue. To improve diagnostic accuracy, breast lesions are being diagnosed utilizing a variety of integrated imaging technologies [34,35]. Their diagnostic values differ, with each technique having its own advantages and disadvantages. Subgroup analysis may provide important information for diagnosis and identification in the future. The lack of benefit in terms of preventing additional surgery is particularly noteworthy in light of the rising rate of mastectomy associated with MRI use. Patients with a relatively limited disease on MRI scan should be more likely to require only one surgery for successful breast conservation and patients with a more extensive disease who have identified appropriately before surgery and undergo initial mastectomy, but this was not the case in the meta-analysis reported by Houssami *et al*. [36]. Preoperative MRI was linked to an increased likelihood of contralateral prophylactic mastectomy (CPM) for the secondary outcome [OR 1.91 (95% CI 1.25–2.91)] [36].

Breast cancer detection through MRI imaging is the most sensitive diagnostic tool, outperforming conventional detection techniques like mammography, digital breast tomography, or ultrasound. Interestingly, the use of MRI has dramatically increased since 2003, despite a lack of evidence that it is effective in newly diagnosed BC patients [37]. According to a recent survey of 377 surgeons (with a 77% response rate) who treated BC patients between 2013 and 2015, 26% would request an MRI for a basic, screen-detected clinical stage-1 BC, 60% for BC patients 45 years or younger, and 54% for triple-negative BC patients. Additionally, the survey also reported that 29% of responding surgeons incorrectly indicated that preoperative MRI minimizes the need for re-excision in patients undergoing breast-conserving surgery, and 41% stated that preoperative MRI does not increase the likelihood of mastectomy. These findings show that a significant number of surgeons are unaware of the lack of benefit of MRI on preoperative outcomes, underscoring the importance of more educational outreach to the surgical community, supported by a comprehensive and up-to-date synthesis of the literature. These data can also be used to help with the development of therapeutic recommendations for BC treatment.

Besides, ABB-MRI and FDP-MRI, many other MRI-based techniques are also used in BC detection. A meta-analysis of combined dynamic contrast-enhanced MRI and diffusion-weighted imaging for BC diagnosis was reported in 2016. Similarly, a recent meta-analysis was reported by Zhou *et al*. [37], who showed the combined sensitivity and specificity of dynamic contrast-enhanced MRI (DCE-MRI) were 93.2% and 71.1%, respectively. The area under the curve for the SROC was 0.85. According to this meta-analysis, which is consistent with previous findings on the issue, the combined diagnostic sensitivity, specificity, and AUC-SROC were 0.87, 0.74, and 0.86, respectively [37]. The accuracy of diagnosing malignant and benign lesions was greatly improved after receiving a DCE-MRI scan. As a result of the higher diagnostic accuracy, a breast biopsy may be avoided [4].

The heterogeneity between groups and studies and the fact that most studies used a comparator group rather than randomization are all limitations of this meta-analysis. As a result, bias and confounding cannot be eliminated, and the interpretation of our findings should take this heterogeneity into account. Although we searched for but were unable to find unpublished data, the possibility of publication bias could not be ruled out due to the non-inclusion of such data if available. Due to the restrictions imposed by the basic data from the included studies, additional subgroup analysis was avoided. In addition, the ability to make statistical adjustments was limited by variability in the reporting of study-level data on variables such as age and tumor size. To account for the observed variance in the median or mean age across some of the nonrandomized trials, we employed stratification around the median study-level aggregate age in our core analysis (studies of all BC histological classifications).

5. Conclusions

The present meta-analysis focused on the utilization of highly efficient ABB-MRI protocol for improved diagnosis of BC with high sensitivity and specificity at low cost and high turnover rate, indicating advanced detection rates for better breast cancer treatment outcomes. This pooled analysis and other similar analyses convincingly prove the importance of ABB-MRI as a useful supplement for advanced breast cancer treatment. Growing interest enables improved validation of these parameters, including ABB-MRI in future trials, to screen cancer patients. However, before its routine use in clinical practice, ABB-MRI protocol needs further improvisation, standardization across various platforms, and validation by prospective multicenter clinical trials [38,39]. Future studies should focus on assessing the application of ABB-MRI in the detection of breast cancer stages, which will improve the quality of life of these patients through fast and cost-effective precise detection of the cancer stage. Nevertheless, it is believed that ABB-MRI will gain traction not only for providing advanced diagnosis and treatment of breast cancer but will serve as a useful tool in decreasing the incidence of late-stage breast cancer-related complications, consequently reducing the risk of mortality.

Author Contributions

BZ, WH, and JK performed the literature search, data compilation, and analyses and wrote the first draft. QC, AB, and QL reviewed the literature and edited the manuscript. QL conceived the project. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

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Conflict of Interest

The authors declare no conflict of interest.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.31083/j.ceog5006115.

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