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Diagnostic Performance Of MRI Vs. CT For Staging Hepatocellular Carcinoma: A Systematic Review

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Abstract

Background:

Hepatocellular carcinoma (HCC) is the third leading cause of cancer-related mortality worldwide. The diagnosis of HCC in its early stages improves the prognosis and survival of the patients; therefore, the imaging modalities are necessary for early diagnosis. Imaging plays a key function in diagnosis, staging, surveillance, and post-therapeutic follow-up. Magnetic resonance imaging (MRI) and computed tomography (CT) are two imaging modalities that can be used for HCC, and each modality has its own advantages.

Aim:

To assess the diagnostic performance of MRI vs. CT for HCC by reviewing the previous research concerned with this subject.

Methods:

The electronic scientific databases were explored to obtain related studies by using relevant keywords. The searching process was limited to original English studies comparing MRI and CT for HCC diagnosis and published in the past ten years.

Results:

Eight studies were in agreement with the criteria and were enrolled with a total number of 813 patients. There are different MRI and CT techniques reported, which were used for several purposes, including HCC diagnosis, staging, diagnosis of small lesions, and late recurrence.

Conclusion:

MRI had higher diagnostic performance compared to CT in several aspects, including staging. Combining both imaging modalities increases the diagnostic performance; however, this strategy can be costly. Therefore, the usage of a definite imaging modality for HCC should be individualized.

Keywords: MRI, CT, HCC, Diagnostic performance.

Introduction:

Hepatocellular carcinoma (HCC) is a major public health issue [1]; it is the most common primary liver cancer [2] and ranks sixth in incidence following breast, lung, colorectal, prostate, and gastric cancers

[3]. HCC represents 85-90% of all liver cancers, and it is the leading reason of cancer-related mortality among cirrhotic patients [4, 5]. Globally, it is the third leading cause of cancer-related mortality [6]. There are many common risk factors for HCC development, including alcohol, hepatitis C and B viruses (HBV & HCV), and non-alcoholic fatty liver disease (NAFLD) [2].

The progress in surgical interventions and locoregional treatment has led to improvements in the outcomes of HCC for early and intermediate tumors with projected median overall survival (mOS) of more than 60 and 30 months for early and intermediate tumors, respectively [4, 7]. The patients diagnosed at very early and early stages may be eligible for curative treatment, including resection, local ablation, and liver transplantation [1]. Staging of cancer is a procedure for diagnosing he nature and severity of the cancerous lesions [8].

The criteria for early stage HCC differ based on the staging systems; the "Bercelona Clinic Liver Cancer (BCLC)" system is one of the most widely implemented staging system for HCC; it indicates that the very early stage HCC includes single lesions of ≤2cm with maintained liver functions, and performance of zero, whereas the early stage includes single HCC≤3nodules, where each ≤3cm in diameter with maintained function and performance status of zero [9]. Another system is the "modified Union for International Cancer Control (mUICC)" staging system [6].

Nonetheless, 50-60% of HCC patients are diagnosed at or progress to an advanced stage of the disease, where the reported mOS is short of 6-8 months [4, 7]. Therefore, the prognosis of HCC depends on tumor stage, which reveals the significance of diagnostic tools [2]. HCC is a unique cancer compared to the other types, as its diagnosis can often be made radiographically with no histological confirmation [2].

Imaging plays a key function in diagnosis, staging, surveillance, and post-therapeutic follow-up [3]. Dynamic contrast-enhanced computed tomography (CT) has the advantage of detecting the hemodynamic alterations that take place in cirrhotic lesions as they develop into early HCC during the multistep process of hepatocarcinogenesis. The gradual reduction in normal arterial and portal nourishment and the formation of unpaired arteries are exemplarily exploited in multiphasic evaluation following administration of a contrast agent [3]. However, CT has some disadvantages, mainly encompassing radiation exposure and relatively low contrast resolution and tissue differentiation [3].

MRI has the benefit of assessing additional features such as the presence of fat and nodular cellularity, which are important in the assessment of nodules [3]. The determination of the best therapeutic modality for HCC patients requires the consideration of several items, including HCC stage, liver function, and comorbidities. Therefore, the HCC stage is important in the management plan [10] and prognosis [2]. So, this systematic review was performed to assess the diagnostic performance of MRI vs. CT for HCC.

Method and search strategy:

The guidance for writing this review was the PRISMA checklist **[11].** The electronic databases of "PubMed, Science Direct, Scopus, and Google Scholar" were explored to obtain related studies. The exploration procedure was performed using relevant keywords, including "Diagnosis, Performance, MRI, CT, HCC, Detection, and Staging". The searching process was limited to studies published in the past ten years. The obtained titles were reviewed precisely to prevent missing potential studies.

Eligibility criteria:

The findings were examined to choose only the articles with relevant titles comparing MRI and CT and excluded those focusing on one technique, as well as duplicate articles and those published before 2016. The next step was the inclusion of original articles and exclusion of other types of articles. The original articles were further refined to select English articles and preclude those written in other languages. More refining steps included reviewing each article to exclude those available for abstract only, not the full-text, and the articles reporting overlapped data. The scheme of the eligibility is displayed in figure 1.

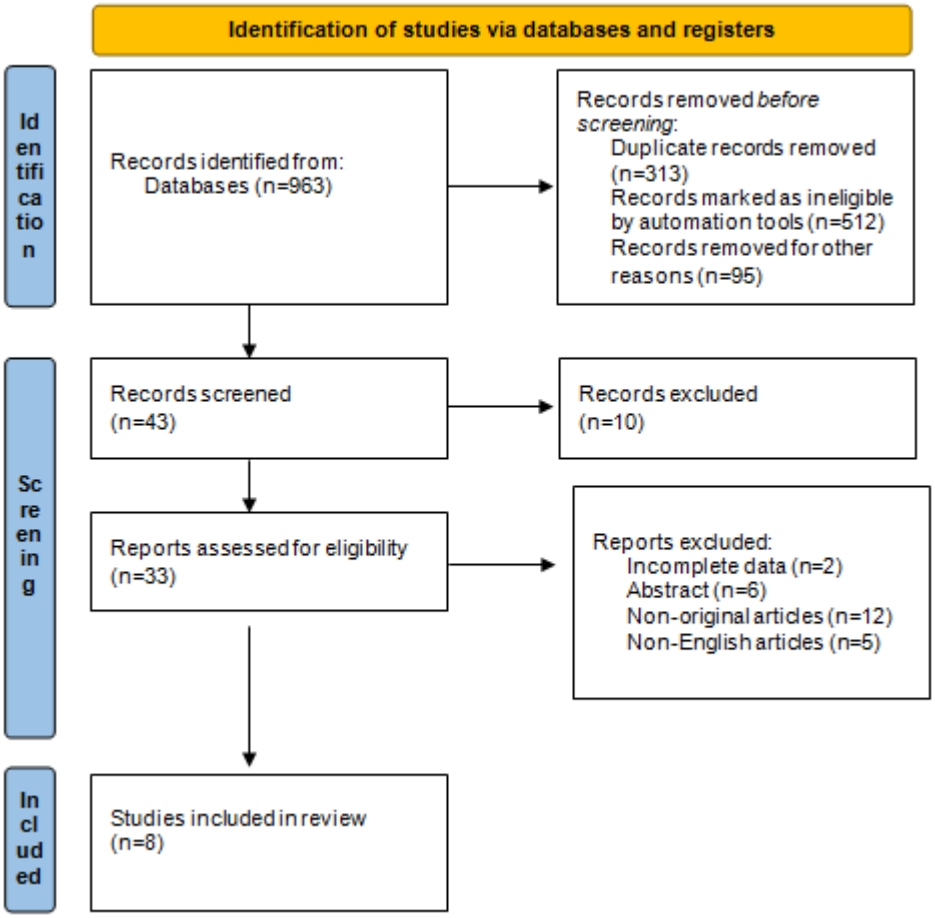

Fig 1: Eligibility Scheme

Data review and analysis:

Each eligible article was reviewed for the abstract to determine the data of interest for further extraction. The full article was then reviewed, and data were extracted using a specially designed Excel sheet. The extracted data was then reviewed and transferred to a pre-designed table to summarize the data under major titles.

Results:

There were eight studies that met the criteria and were enrolled in this review [12-19] (Table 1). The studies were published between 2019 and 2025. The designs of the studies were either prospective[12, 13, 19] or retrospective [15-18], whereas one study didn't report the design [14]. The studies were conducted on different populations, including HCC subjects undergoing or considered for locoregional therapy [12], subjects received curative HCC treatment and didn't relapse for more than two years [13], primary HCC subjects [14, 16], early stage HCC subjects [15], chronic hepatic diseases or having suspected liver cancer subjects [17, 18], and those with liver cancer smaller than 3cm suspected with malignancy [19]. The total number of patients was 813 subjects with a range of 39 [12, 18] to 203 [13].

Also, different approaches of CT and MRI techniques were used and they included, comparing CTLP and MRI and combination for diagnosis and follow-up [12], CECT and NC-MRI for late recurrence [13], CT and MRI and their combination for diagnosis and staging [14], CT and MRI for detecting early sage [15], CT and MRI for the diagnosis of small HCC [16], multiphasic CT and NC-MRI for the diagnosis of HCC [17], triple phase CECT and DW-MRI for HCC evaluation [18], and dynamic CT

and MRI for diagnosis of small HCC [19]. There were three studies that reported the performance of the MRI and CT combination [12, 14, 19].

Higher sensitivity was recorded for MRI compared to CTLP in HCC diagnosis and follow-up (P>0.05) [12], for NC-MRI compared to CECT for the diagnosis of late recurrence (P=0.01) [13], for NC-MRI compared to multiphasic CT for diagnosis of HCC (P <0.001) [17], for MRI in detecting early stage HCC compared to CT [15], and for MRI in diagnosing small HCC compared to CT (P=0.001) [16]. Also, slightly higher sensitivity was found for DW-MRI compared to CECT for HCC evaluation [18] and for MRI compared to dynamic CT for diagnosing small HCC 19].

MRI also has greater specificity compared to CTLP (P> 0.05) [12], whereas the sensitivity of NC-MRI was comparable to that of CECT (P=0.9) [13], but NC-MRI specificity was higher compared to multiphasic CT (P<0.001) [17]. However, MRI had lower specificity compared to CT in early detection of HCC [15], and in diagnosing small HCC (P=0.3) [16]. Both DW-MRI and CECT had the same specificity for diagnosing HCC [18], but MRI displayed slightly less sensitivity compared to dynamic CT for diagnosing small HCC [19].

The accuracy of NC-MRI was greater than that of CECT (P=0.006) [13] and multiphasic CT (P<0.001) [17]. MRI had superior diagnostic accuracy of stages I-VI compared to CT [14], and for early detection of HCC compared to CT [15], and for diagnosing small HCC (P=0.002) [16], but another study revealed slightly higher accuracy of MRI compared to dynamic CT for diagnosing small HCC [19]. However, the accuracy of DW-MRI was considerably higher compared to CECT (P<0.001) [18].

Additionally, MRI detected a slightly larger number of tumors compared to CT [14]. Also, the interobserver agreement was higher for MRI (k=0.82) compared to CT (k=0.76) for detecting early HCC [15]. MRI had a higher PPV (P=0.1) and a greater NPV (P=0.01) compared to CT [16]. Regarding diagnostic confidence, NC-MRI had 0-0.91, whereas CT had 0.49-0.81 diagnostic confidence for HCC detection [17]. The final diagnostic odds ratio (DOR) for MRI was much higher (DOR 29.29) compared to dynamic CT (DOR 19.43) for small HCC diagnosis [19].

The findings regarding the combination revealed that combined CTLP and MRI resulted in greater sensitivity (P<0.05) with maintained specificity (P>0.05) for the diagnosis and follow-up of HCC. Additionally, the combined approach led to an LR category change in 5 treated and 19 untreated lesions and affected management in 5 cases [12]. Another study reported fusion of MRI and CT revealed that the fusion resulted in more accuracy in determining the number (P<0.001), maximum diameter (P<0.001), and pathological staging of HCC compared to each imaging modality alone. Additionally, the fusion strategy was superior in agreement for determining the number of lesions compared to CT and MRI. Also, the fusion strategy improved the diagnostic accuracy for stage II (P=0.03) and III (P=0.01) [14]. The last study revealed that the specificity of combined MRI and dynamic CT was 92% which was higher compared to that of each modality alone [19].

Table 1: Summary of studies‘ data

Author & year	Design	Characteristics of the patients	Tool	Results and main findings
Kalarakis et al 2025 [12]	Prospective	-Population: HCC patients considered for or undergoing locoregional therapy -N=39 *Treated HCC=33 (35.1%) *Untreated lesions=61 (64.9%) -N of lesions=94 Lesions	*CTLP & MRI & combination *For diagnosis and follow-up	*For MRI and CTLP, the sensitivity was 75.9% vs 72.2%, whereas the specificity was 100%Vs 95% (P> 0.05). *Combining both tools elevated sensitivity to 85.2 % (P< 0.05) and maintained specificity at 97.5 % (P> 0.05). *The combined approach led to an LR category change in 5 treated and 19 untreated lesions and affected management in 5 cases.
Kim et al 2025 [13]	Prospective intra-individual head-to-head comparison trial	-Patients underwent curative therapy for HCC and remained free of recurrence for over 2 years -N=203 *Intrahepatic recurrence=21 *aortocaval lymph node metastasis=1	*CECT & NC-MRI *Diagnostic performance of late recurrence	*NC-MRI resulted in detection accuracy of (96.6%), which was greater than CECT (91.6%) (P=0.006). *NC-MRI had greater sensitivity (77.3% vs. 36.4%; P=0.01), while specificity was comparable between NC-MRI and CECT (98.9% vs. 98.3%; P=0.9).
Teng et al 2025 [14]	----	-Patients with primary HCC -N=60	*CT&MRI & CT/MRI fusion *Diagnosis and staging	*MRI detected slightly more number of tumors (1.58±1.12) compared to CT (1.37±1.37). *Imaging fusion imaging was more accurate in determining the number (P<0.001), maximum diameter (P<0.001), and pathological staging of HCC lesions compared to single CT or MRI. *CT/MRI fusion imaging was superior to CT in determining the number of lesions (Kappa 0.695 vs 0.654) and MRI (Kappa 0.872 vs 0.695). *MRI was superior in diagnostic accuracy of stage I, II, III & IV compared to CT (91.67% vs 83.33%), (90.91% vs 81.82%), (78.95% vs 63.16%), and (85.71 % vs 71.43%) * Fusion imaging improved the diagnostic accuracy of stages II (P=0.03) and III (P=0.01) tumors.
Ravishankar et al 2024 [15]	Retrospective	-Population: Early-stage HCC -N=105	*CT& MRI *Detecting the early stage	*MRI had a greater sensitivity (92%) in detecting early-stage HCC lesions compared to CT (80%). *CT had greater specificity (86%) compared to MRI (78%).

				*The interobserver agreement between the evaluating radiologists was substantial for both CT (k=0.76) and MRI (k=0.82). *The overall diagnostic accuracy of MRI (88%) was marginally superior to that of CT (85%) in detecting early HCC lesions.
Chakra et al 2023 [16]	Retrospective	-Population: Primary HCC -N=100	*CT &MRI *Diagnosis of small HCC	*The sensitivity of MRI and CT was 78.82% & 62.35% (P=0.001) *The specificity of MRI and CT was 78.46% & 73.85% (P=0.3) *The accuracy of MRI and CT was 78.67% & 67.33% (P=0.002) *The PPV of MRI and CT was 82.72% & 75.71% (P=0.1) *The NPV of MRI and CT was 73.91% & 60% (P=0.01)
Wei et al 2021 [17]	Retrospective	-Population: Patients with chronic hepatic disease or who have suspected liver cancer (at risk of liver cancer) -N=201 -Nodules=248	*multiphasic CT & NC-MRI *Diagnosis of HCC	*Regarding HCC detection, NC-MRI had greater sensitivity (0.843 vs. 0.762, P<0.001) and accuracy (0.755 vs. 0.571, P < 0.001) than the multiphase CT. *The NC-MRI and CT specificity was (0.864 vs. 0.809, P < 0.001). *NC-MRI had 0-0.91 diagnostic confidence, and multiphase CT had 0.49-0.81 diagnostic confidence for HCC detection.
Tarmizi et al 2021 [18]	Retrospective	-Population: patients with chronic liver disease suspected of HCC -N=39	*Triple phase CECT& DW-MRI *Diagnostic performance for HCC evaluation	*Regarding DW-MRI and CECT, respectively, the sensitivity was (95% vs 85%), specificity was (95% vs 95%), and accuracy was (95% vs 90%; P< 0.001).
Hsaio et al 2019 [19]	Prospective	-Population: Patients with liver cancer smaller than 3 cm suspected of malignancy -N=66	*Dynamic CT & MRI *Diagnostic value for small HCC less than 3 cm	*The sensitivity of MRI and CT was 90.2% and 82.9%, whereas the specificity was 76% and 80%, with a DOR of 29.29 for MRI and 19.43 for CT. *The accuracy of MRI and CT in diagnosing small HCC was 83.1% and 81.5%, respectively. *The specificity for combined MRI and CT for HCC diagnosis was 92%.

HCC; Hepatocellular carcinoma, CTLP; Computed tomography liver perfusion, MRI; Magnetic resonance imaging, CECT; Contrast-enhanced multiphasic computed tomography, NC-MRI; Non-contrast magnetic resonance imaging, PPV; Positive predictive value, NPV; Negative predictive value, DW-MRI; Diffusion weighted magnetic resonance imaging, DOR; Diagnostic odds ratio.

Discussion:

Staging and early detection of HCC are often critical for survival outcomes [8]. HCC patients who are diagnosed at early stages of the disease with no metastasis are eligible for curative therapy and consequently have a good prognosis of 50-70% survival at five years [20-22]. Nonetheless, the prognosis when HCC is diagnosed at an advanced stage is poor. Hence, early detection and diagnosis of HCC is necessary for better outcomes [22]. The non-invasive diagnosis of HCC is based on the presence of a specific vascular profile on imaging techniques [23]. This review was established to assess the diagnostic performance of MRI vs. CT for HCC.

CECT is commonly used for the noninvasive characterization and detection of focal liver lesions owing to its high density resolution and high scanning speed [24, 25]. The features, especially the dynamic enhancement patterns of such lesions on CT, are essential for categorizing lesions [23]. Multiphase CECT is often the first diagnostic imaging modality [26]. MRI is the imaging technique of choice in the evaluation of focal liver lesions, especially in the diagnostic phase and during the follow-up post-treatment in HCC subjects [23]. DW-MRI offers functional quantitative data on the microstructure of the tissues by means of water proton mobility differences and cellular density evaluation [23].

In the current review, we found that the comparison between MRI and CT was heterogeneous and conducted between different techniques of each modality. Additionally, the implementation of imaging techniques reported in the included studies focused not only on staging but also on other purposes such as the diagnosis of small HCC, late recurrence, and follow-up. Regardless of the different techniques of MRI and CT used and compared in the included studies, we found that MRI was superior to CT regarding sensitivity, and MRI had better sensitivity compared to CT for HCC staging, diagnosing small lesions, follow-up, and diagnosis. However, MRI displayed inconsistent specificity compared to CT, where some MRI techniques displayed higher sensitivity, whereas others displayed lower sensitivity compared to CT. Additionally, the specificity of MRI varied with the purpose of implementation, where one study revealed that NC-MRI was comparable in specificity to CECT for the detection of late recurrence [13], whereas another study revealed that NC-MRI displayed higher specificity compared to multiphasic CT in HCC diagnosis [17]. Such findings indicate that regardless of MRI techniques, MRI was superior to CT techniques in sensitivity, whereas MRI specificity varies with the technique used and the purpose of usage in HCC.

Regarding accuracy, different techniques of MRI displayed better accuracy compared to different CT techniques for HCC staging, diagnosis, detection of late recurrence, and diagnosing small HCC. Only one study revealed slightly higher accuracy of MRI compared to CT [19]. Additional findings revealed that MRI was also superior to CT in detecting a greater number of tumors, displaying greater interobserver agreement for early HCC detection, higher PPV and NPV, higher diagnostic confidence, and DOR. All such findings reveal that MRI is better than CT in diagnosing and staging HCC, even in recurrent cases.

Similar to our findings, a meta-analysis published in 2015 revealed that the sensitivity of MRI was greater than that of CT for HCC in non-surveillance settings [27]. The HCC stages can be divided into four stages, including stage I through stage IV, where the latter represent the higher stage of more severe and developed cancer [8]. In our analysis, we found that the sensitivity and accuracy of MRI were superior in diagnosing and staging HCC through all four stages [14]. It was stated that with careful evaluation of CT images for most liver lesions, the diagnosis can be made with high accuracy [24]. However, we found that MRI displayed greater accuracy compared to CT. Additionally, MRI could detect a slightly larger number of lesions compared to CT [14].

A previous analysis published in 2018 compared CECT to extracellular contrast-enhanced MRI and Eovist MRI for HCC diagnosis. It was found that MRI had considerably higher sensitivity, but with similar specificity. Additionally, MRI was more sensitive for diagnosing small HCC lesions of less than 1cm, but with lower specificity compared to CT [28]. Such findings were similar to ours, where MRI had high sensitivity, but lower specificity compared to CT.

A recent analysis published in 2024 evaluated the diagnostic values of CECT and contrast-enhanced MRI after treatment by transarterial chemoembolization. It was deduced that MRI may be superior to CECT regarding sensitivity, accuracy, and DOR [29]. Similarly, we found that MRI had greater sensitivity, accuracy, and DOR. An earlier analysis was published in 2015 and compared the diagnostic performance of dynamic CT and MRI using conventional extracellular contrast agents and MRI using hepatobiliary contrast agents. Also, MRI was more sensitive compared to CT in the diagnosis of HCC (P=0.02) [30]. Therefore, combining MRI and CT may further improve the diagnostic performance. There were three studies in our analysis that reported the findings of the combined strategy, and it was demonstrated that combining MRI and CT resulted in greater sensitivity, accuracy, and interobserver agreement.

Despite the fact that MRI is considered to be a slightly more informative imaging modality, its scanners are far less available compared to CT scanners, and the analysis of such scanners can be time-consuming; occasionally, physicians can make errors [8]. Also, CT allows reproducible, fast, and non-invasive examination, especially for those with reduced general health state and restricted compliance, where CT provides adequate examination in contrast to MRI, which is more dependent on patient compliance [26].

Additionally, in a previous analysis, it was revealed that despite the advantages of MRI in diagnosis of HCC, it was linked with higher cost, less consistent imaging quality, and greater technical complexity, including longer scan time. Therefore, it was deduced that no one imaging modality could be definitively recommended over the other, and the selection of the imaging modality should be individualized, considering both the risks of either imaging test and the patient's clinical status [28].

Conclusion:

Generally, MRI had higher diagnostic performance compared to CT in several aspects, including staging, diagnosis of small cancer, and diagnosis of late recurrence. MRI had greater sensitivity and accuracy compared to CT; however, the specificity of MRI was varied based on the MRI technique used and the purpose of implementation. Therefore, individualizing the usage of definite imaging modality by selecting the imaging modality based on each condition and purpose of usage for each patient is necessary, as the implementation of a combination of MRI and CT will be costly despite its greater performance compared to each modality alone.

Limitations, strengths, and recommendations:

The limitations of this review include the involvement of retrospective studies and the small sample size of the included studies. The main strength is the inclusion of the more recent studies focused on the current subject. Further studies to investigate the diagnostic performance in relation to cost-effectiveness are required.

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