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Meta-analyses

Meta-analysis of dual-energy computed tomography virtual non-calcium imaging to detect bone marrow edema

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ABSTRACT

Objective: This meta-analysis aimed to evaluate the accuracy of dual-energy CT (DECT) virtual non-calcium (VNC) imaging for the detection of bone marrow edema (BME).

Methods: A systematic literature search up to March 2017 was performed to find relevant original studies. Two reviewers independently selected studies, assessed literature quality, and extracted data. Pooled sensitivity, specificity, area under receiver operating characteristic (AUROC) curve, and other measures of DECT accuracy for detecting BME were calculated using random effects models. Risk of heterogeneity was assessed for the appropriateness of meta-analysis.

Results: Fourteen studies involving 2205 regions of vertebrae, hips, knees, and ankles were included. To evaluate the accuracy of BME detection using DECT, calculations were performed to obtain a pooled sensitivity of 0.812 (95% confidence interval [CI], 0.780–0.841) and specificity of 0.951 (95% CI, 0.940–0.960). The AUROC value was 0.9635. The major potential cause of heterogeneity was bone position. No significant publication bias was present.

Conclusion: DECT VNC imaging gives very good diagnostic performance for BME detection and will likely be an important and common modality for acute assessment in the future.

1. Introduction

Fractures of vertebrae and joints are common clinical problems associated with high costs and low quality of life [1–3]. In the elderly, osteoporotic vertebral fractures occur frequently, with an annual incidence of 1.1% in women and 0.6% in men [1,4]. Imaging modalities such as x-ray, computer tomography (CT), and magnetic resonance imaging (MRI) are essential in detecting bone fractures. Choosing the appropriate imaging modality is important for identifying fracture age, initiating timely treatment, preventing further complications, and avoiding new fractures [5,6].

Of the available imaging modalities, MRI is popular because of its advantages of showing bone marrow edema (BME) and estimating fracture age [7,8]. Unlike old fractures, recent fractures usually have associated BME and can benefit from rapid surgical intervention [9]. Although x-ray and conventional CT are more widely available compared to MRI, their ability to judge fracture age is limited because they cannot provide bone marrow details [10,11]. Dual-energy CT (DECT) is an emerging modality that detects BME using a virtual non-calcium (VNC) technique [4]. A few studies have shown that BME of the vertebrae, hips, knees, and ankles can be identified using DECT [4,7,12–23]. Using DECT in place of conventional CT provides a faster assessment of fracture and BME than MRI. This meta-analysis aimed to evaluate the accuracy of DECT VNC imaging to detect BME.

2. Material and methods

2.1. Search strategy

A systematic search of PubMed, EMBASE, MEDLINE, the Cochrane Library, and the China National Knowledge Internet (CNKI, http://www.cnki.net/) was performed to find suitable studies published in English or Chinese before March 2017. The keywords used were “dual-energy CT OR dual-energy computed tomography OR DECT” and “bone marrow edema OR bone marrow lesion OR BME OR BML.” The reference lists of all included studies were also scanned carefully to avoid missing relevant articles. Two reviewers extracted the data independently; and any discrepancies were settled by discussion.

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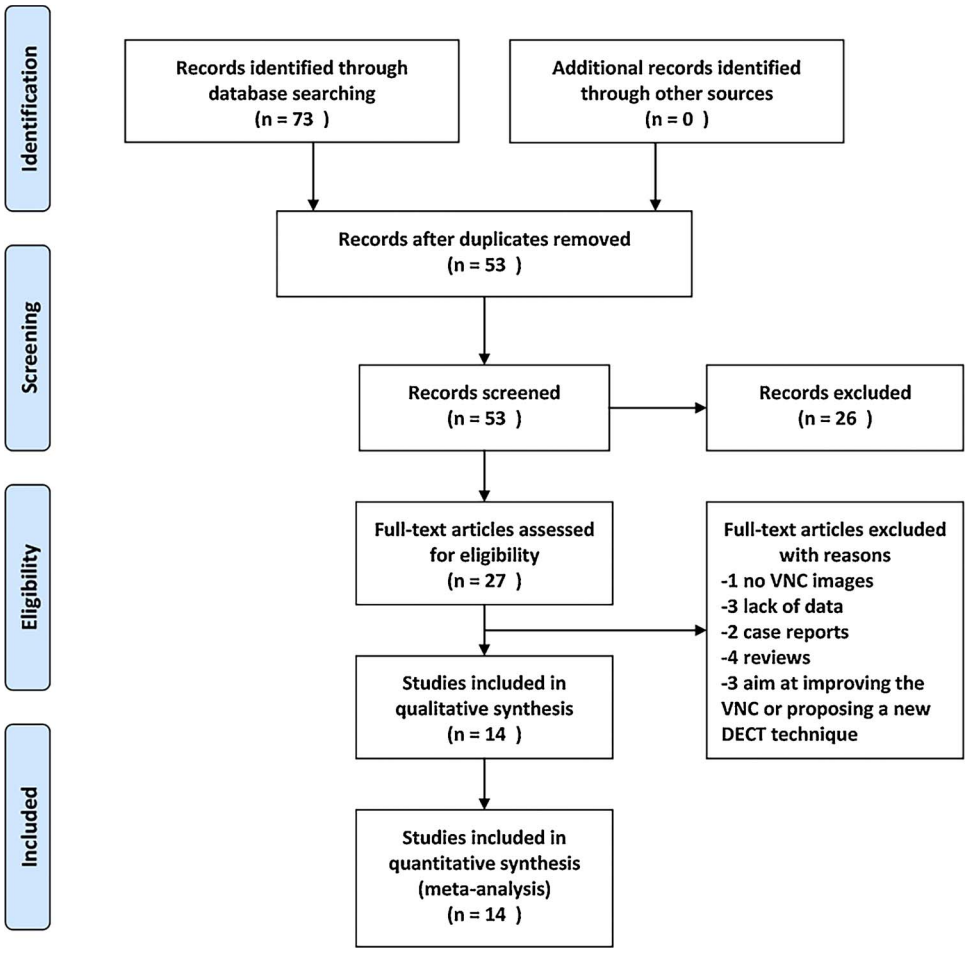

Fig. 1. Flow diagram showing selection of 14 articles.

Table 1
Characteristics of 14 studies included in this meta-analysis.

author	nation	design	CT(kv)	regions	position	sample	standard	P (M/F)
Diekhoff et al. [4]	Germany	pro	135/80	14	vertebra	fracture	MRI	9(3/6)
Bierry et al. [12]	France	pro	140/80	185	vertebra	both	MRI	20(4/16)
Reddy et al. [13]	Canada	retro	140/100	25	hip	both	follow-up	25(7/18)
Karaca et al. [14]	Turkey	pro	140/80	209	vertebra	both	MRI	23(5/18)
Wang et al. [7]	Taiwan	pro	140/100	112	vertebra	both	MRI	63(17/46)
Kaup et al. [15]	Germany	retro	140/80	114	vertebra	fracture	MRI	49(21/28)
Kellock et al. [16]	Canada	retro	140/100	118	hip	both	follow-up	118(40/78)
Petritsch et al. [17]	Germany	pro	150/90	163	vertebra	both	MRI	22(9/13)
Bao et al. [18]	China	pro	140/80	154	knee	No fracture	MRI	21(4/13)
Huang et al. [19]	China	pro	140/80	138	vertebra	both	MRI	42(19/23)
Tu et al. [20]	China	pro	140/80	253	ankle	both	MRI	11(5/6)
Guggenberger et al. [21]	Switzerland	pro	140/80	292	ankle	both	MRI	30(15/15)
Pache et al. [22]	Germany	pro	140/80	236	knee	both	MRI	21(16/5)
Cao et al. [23]	China	pro	140/80	384	knee	both	MRI	32(24/8)

Regions and bone partitions were used by authors to better analyse BME.
standard = the reference standard; P (M/F) = ratio of male to female patients.

2.2. Inclusion and exclusion criteria

We included original articles that included (1) DECT to detect BME in trauma patients; (2) VNC images; (3) sufficient raw data to complete a 2 × 2 contingency table; (4) MRI or follow-up as the reference standard. Articles were excluded if they (1) presented overlapping data (in those cases, the study with the most cases was chosen); (2) included only abstracts, animal experiments, reviews, proceedings, case reports, letters, or commentaries; or (3) had more than four “unclear” or “no” results in the quality assessment.