REVIEW ARTICLE

Diagnostic value of ultrasonography in knee osteoarthritis: A systematic review

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Background: Knee osteoarthritis (KOA) is the most expected diagnosis for an arthropathy that causes discomfort and disability in older adults. Radiography is frequently used to assess patients with KOA and there have been few prior research evaluating the diagnostic efficacy of ultrasonography (US). The current study sought to assess the diagnostic efficacy of the US in identifying various characteristics of KOA in the scientific literature. **Materials and Methods:** This study was conducted following the Preferred Reporting Items for Systematic Reviews and Meta Analyses statement. A systematic search in PubMed, Web of Science, Scopus, and Embase databases was completed in March 2023. This study focused on the diagnostic value of US in KOA, including sensitivity, specificity, positive predictive value, and negative predictive value. The quality assessment was conducted using the Joanna Briggs Institute critical appraisal tools. **Results:** Out of 552 records of database searches, finally, two studies met this systematic review's eligibility criteria and were included in the study. Both of the included studies were cross sectional studies. US demonstrated remarkable sensitivity with adequate specificity for the detection of radiographic knee OA; however, it was found not to be an appropriate method for the detection of early KOA. **Conclusion:** This study as the first systematic review aims to evaluate the diagnostic performance of US in detecting KOA. These findings shed light on the importance of investigating the different US features in the evaluation of KOA to reach appropriate sensitivity and specificity in the diagnosis

Key words: Knee, osteoarthritis, systematic review, ultrasonography

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INTRODUCTION

Osteoarthritis (OA) is a common and disabling chronic musculoskeletal disease worldwide, imposing heavy social and economic burdens on patients and health-care systems.[1] So far, nearly 400 million people around the world have lived with OA.[2] As the most common site of clinical OA, knee osteoarthritis (KOA) is the most expected diagnosis for an arthropathy that causes discomfort and disability in older adults.[3,4] With advancing age, KOA becomes more common in adults.[4,5] Gender, obesity, knee injuries, and a family history of KOA are additional risk factors.[6] The global prevalence of KOA is about 16% in individuals aged 15 and older, and 23% in individuals aged 40 and older.[7] Results of epidemiological studies reported an increase of 2.88-fold in the prevalence of KOA between 1990 and 2019,[8] which shed light on the importance of timely diagnosis and management approaches in suspected patients. KOA patients often suffer from decreased self-care ability and even final disability due to stiffness, joint pain, and limited mobility. The total prevalence of KOA among the population over 40 years old in China is 17.0%, among which the prevalence rate of men is 12.3%, and that of women is 22.2%, both of which are higher than the world average.[9] OA impacts

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the quality of life both physically and mentally.[10] In radiographic investigations, about 25% of the population over the age of 55 exhibit KOA signs.[11,12] In addition to radiography, another diagnostic tool that is frequently used in some clinics to clarify various aspects of KOA is ultrasonography (US), which is a cost-efficient, simple to use, convenient, and radiation-free method.[13] Although radiography is frequently used to assess patients with KOA, there have been few prior research evaluating the diagnostic efficacy of US. As a result, the current study sought to assess the diagnostic efficacy of the US in identifying various characteristics of KOA in the scientific literature. This study focused on the diagnostic value of US in KOA, including sensitivity, specificity, positive predictive value, and negative predictive value (NPV).

METHODS

This systematic review was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) statement.[14]

Eligibility criteria

This study focused on the diagnostic value of the US in KOA. Animal studies, conference abstracts, non-English papers, reviews, editorials, commentaries, and letters were excluded from the study.

Search strategies

A systematic search in PubMed, Web of Science, Scopus, and Embase databases was completed on March 2023, with the ("Osteoarthritis" [MeSH Terms] AND "Knee Joint" [MeSH Terms] AND "Ultrasonography" [MeSH Terms] AND "Diagnosis" [MeSH Terms]) OR (("Osteoarthritis" [Title/Abstract] OR "Osteoarthrosis" [Title/Abstract] OR "Osteoarthroses" [Title/Abstract] OR "Arthrosis" [Title/Abstract] OR "Arthroses" [Title/Abstract]) AND "Knee" [Title/Abstract] AND "Ultrasonography" [Title/Abstract] AND ("Diagnosis" [Title/Abstract] OR "detection" [Title/Abstract])) strategy in PubMed. Each article reference list was also scrutinized for comprehensive coverage of published studies.

Selection process and data extraction

The results of database searches were imported into the EndNote app and after removing duplicated studies, two investigators independently screened the articles based on title and abstract using the Rayyan.[15] After that, in the full-text step, potentially related studies were evaluated for inclusion. The demanded data were extracted using a predesigned table by one investigator and double-checked by two other investigators. Any discrepancies were resolved through debate or by the expert researcher's opinion.

Quality assessments

The methodological quality of the studies was evaluated using the Joanna Briggs Institute (JBI)'s critical appraisal tools.[16,17] The JBI critical appraisal tool assessed the randomized or consecutive inclusion of the participants in the study, avoiding case–control study design, appropriate eligibility criteria, interpretation of the results of reference and assessed test without previous knowledge, appropriate thresholds (which was not applicable in this study), gold standard reference test, the appropriate interval between reference and assessed tests, same reference standard, and inclusion of all patients in the final analysis as the sources of bias in diagnostic studies.

RESULTS

Search results and selection

Out of 552 records of database searches, finally, two studies met this systematic review's eligibility criteria and were included in the study. The details of the screening process are presented in Figure 1.

Characteristics of the studies

Both of the included studies were cross-sectional and were conducted in Argentina and Finland. The sample sizes were 322 (including 183 patients with KOA and 139 healthy controls) and 40, respectively. In Brom *et al.*'s[18] study, the reference test was radiological degenerative changes, and in Saarakkala *et al.*'s[19] study, it was arthroscopy findings. More details of the studies are presented in Table 1.

Risk of bias

Saarakkala *et al.*'s study did not report the intervals between the tests which may have biased their conclusion. The reference test of Brom *et al.*'s study was radiographic changes which cannot be considered a gold standard diagnostic method. There was no considerable risk of bias regarding the other aspects of the study.

Results of individual studies

Brom *et al.*, in the evaluation of 322 knees in patients complaining of unilateral or bilateral mechanical knee pain, reported that the presence of either osteophytes or the compromise of the femoral hyaline cartilage was most sensitive to detect OA (95%), with an NPV of 92% which approved the validity of US in detection of KOA in suspected patients. In this study, the US demonstrated an excellent sensitivity with adequate specificity for the detection of radiographic knee OA; however, the US was found not to be an appropriate method for the detection of early knee OA (without degenerative changes in radiography).[18]

Saarakkala *et al.*, in their study of 40 adult patients with knee pain, referred to knee arthroscopy, found that US findings

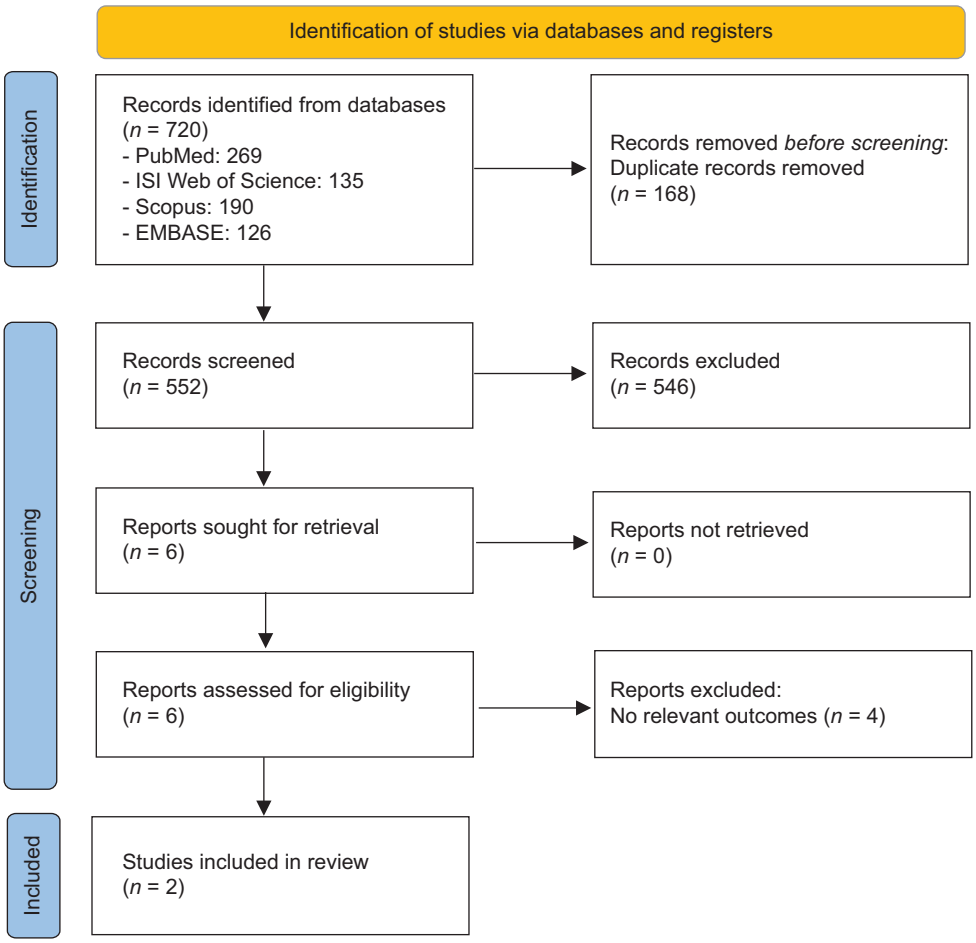

Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram[14]

are a strong indicator of arthroscopic degenerative changes of cartilage, depending on the site; however, the negative finding does not rule out degenerative changes. This study suggested the US a promising technique for screening degenerative changes in articular cartilage.[19]

DISCUSSION

This study aims to evaluate the diagnostic accuracy of US in patients with KOA. Based on the limited available evidence, the US is suggested as a promising method in the detection of KOA; however, the sensitivity and specificity of US changes in KOA patients are diverse between different sites and US features. In addition, the low level of NPV limited the clinical application of the US in detecting KOA. There is a need for future well-designed studies on this topic for a comprehensive conclusion in this regard.

The current gold standard diagnostic imaging modality for KOA is magnetic resonance imaging;[20] however, high cost and difficulty in employment, limited its application in clinical practice. Therefore, radiography is typically employed to determine the severity of the changes as an initial imaging test in patients suspected of KOA.[21] Marginal osteophytes, subchondral sclerosis, and a narrowing of the knee joint space are pathological alterations that can be seen on radiographs.[22] The mentioned limitations suggested a need for another applicable diagnostic imaging method in KOA.

The US is a noninvasive and free of ionizing radiation imaging examination of the joints which requires no special facility and in the knee joint, it can be used for visualizing the ligaments, cartilages, and some meniscal damages.[23] These advantages make the US a promising imaging method in the evaluation of knee injuries.[24,25] The diagnostic value of US in KOA was found to be appropriate. In an evaluation of the diagnostic accuracy of the US, Majidi *et al*. found the US a useful imaging modality in patients with KOA.[26] We also found sonography an applicable method for detecting the KOA. Operator dependency is a considerable disadvantage of the US which may limit the clinical significance of the findings of this study.

An evaluation of the rheumatologist's choices regarding the diagnostic management and therapy of nontraumatic knee pain found that the US did not significantly modify the clinical management of the patients.[27] On the other hand,

Table 1: The details of characteristics and findings of the included studies

Study	Study design	Setting	Inclusion criteria	Sample size KOA	Sample size HC	Age	Male to female ratio	Severity of KOA	Control group	Reference test	Feature	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
Brom *et al*., 2020[18]	Cross-sectional	Buenos Aires, Argentina	Complaining of unilateral or bilateral mechanical knee pain	183	139	64±17	1:3	KL1 (*n*: 34), KL2 (*n*: 20), KL3 (*n*: 115), KL4 (*n*: 14)	Absence of radiological degenerative changes (KL0)	Radiographic degenerative changes	Femoral hyaline cartilage involvement	90 (86–95)	75 (68–83)	84 (79–89)	85 (78–91)
											Osteophytes	82 (77–88)	86 (80–92)	89 (84–94)	78 (71–84)
											Femoral hyaline cartilage involvement or US osteophytes	95 (92–98)	76 (69–83)	85 (80–90)	92 (87–97)
											Femoral hyaline cartilage and US osteophytes	75 (68–81)	94 (89–97.5)	94 (89–97.6)	74 (67–80)
Saarakkala *et al*., 2012[19]	Cross-sectional	Finland	Knee pain	40		52	5:3	Noye's Grading Scale	Arthroscopy negative	Arthroscopy (gold standard)	Femoral sulcus area	54.3 (36.9–70.8)	100 (46.3–100)	100 (79.1–100)	23.8 (9.1–47.5)
											Femoral medial condyle	83.3 (66.5–93)	50.0 (9.2–90.8)	93.8 (77.8–98.9)	25.0 (4.5–64.4)
											Femoral lateral condyle	51.9 (32.4–70.8)	84.6 (53.6–97.3)	87.5 (60.4–97.8)	45.8 (26.2–66.8)

KL=Kellgren-Lawrence; CI=Confidence interval; KOA=Knee osteoarthritis; HC=Healthy control; PPV=Positive predictive value; NPV=Negative predictive value; US=Ultrasonography

results from a multicenter study in Latin America reported that the US increases the accuracy of musculoskeletal clinical examination and can influence the diagnosis and management in rheumatologic centers.[28] We found the US an appropriate evaluation method in patients suspected of KOA, which suggested contemplating the US in the clinical setting.

Murakami *et al*. suggested the gap of the medial radial displacement between the standing and supine positions in the US, a feature predicting the onset of radiographic knee OA.[24] The medial radial displacement of the medial meniscus was previously suggested as a marker for the progression of OA.[29] The reliability of the US in the diagnosis of KOA is also evaluated in different stages of the disease.[30,31] Eşen *et al*. also reported US is a more reliable method than clinical examination during the acute exacerbation of KOA.[32]

Regarding US features, in Brom *et al*.'s study,[18] femoral hyaline cartilage involvement or osteophytes was reported as the most sensitive feature, whereas observation of both of the mentioned changes showed the greatest specificity between the investigated features. Femoral medial condyle involvement was reported as the most sensitive and involvement of the medial sulcus area were reported as the most specific feature in Saarakkala *et al*.'s study.[19] Furthermore, in a large population-based study, medial osteophyte changes were reported as an associated factor with knee symptom scores, which suggests it is an informative finding, at the earlier phase of KOA.[33] These findings shed light on the importance of investigating the different US features in the evaluation of KOA to reach appropriate sensitivity and specificity in the diagnosis.

This study as the first review aims to evaluate the diagnostic performance of the US in detecting KOA. The systematic approach of the study and appropriate coverage of all published studies were the main strengths of this study. Limitations such as the circumscribed number of included studies make this study's findings inconclusive which suggested future studies on this topic.

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Conflicts of interest

There are no conflicts of interest.

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