Original Article
Characteristics of musculoskeletal ultrasound versus X-ray in their differential diagnosis of knee osteoarthritis

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Abstract: Objective: To explore the diagnostic value of musculoskeletal ultrasound (MSUS) versus X-ray for knee osteoarthritis (KOA). Methods: Fifty patients diagnosed (57 knees) with KOA by arthroscopy were collected in our study. Additionally, fifty age- and gender-matched healthy volunteers undergoing a physical examination during the same period were recruited as controls. All the healthy volunteers had no symptoms and imaging findings of KOA. All the subjects were examined by MSUS and X-ray. The diagnostic efficacy of the two imaging meathods was analyzed separately to evaluate the diagnostic value of MSUS and X-ray in patients with KOA. Results: The detection rate of KOA by MSUS was higher than that by X-ray (P<0.05). MSUS achieved a sensitivity of 92.98%, specificity of 78.95%, and accuracy of 89.17% in the diagnosis of KOA, while X-ray achieved a sensitivity of 73.28%, specificity of 58.94%, and accuracy of 63.69%; which indicated that the diagnostic efficacy of MSUS was higher than that of X-ray (P<0.05). Compared with X-ray, there was a higher diagnostic accordance rate and a lower misdiagnosis rate with MSUS (P<0.05). Conclusion: MSUS achieved a higher sensitivity, specificity, and accuracy in the diagnosis of KOA than X-ray.

Keywords: Musculoskeletal ultrasound, knee osteoarthritis, synovial inflammation, cartilage tissue

Introduction

Knee osteoarthritis (KOA) is a common orthopedic disease, and the main clinical manifestation is knee pain [1, 2]. As a typical joint disease, the development and progression of KOA can significantly limit the mobility of the patient's knee joints [3-5]. KOA is caused by the imbalance between subchondral bone tissue and cartilage tissue under biological or mechanical factors, leading to synovitis or pain induced by spasmodic contraction. As a common chronic disease, KOA seriously threatens the patient's health and quality of life [6-8]. In recent years, the incidence of KOA in China has been high, and as such it has attracted extensive attention from experts and scholars. Timely and accurate diagnosis in the early stages of KOA is of great significance to the clinical treatment and prognosis of patients. X-ray and musculoskeletal ultrasound (MSUS) are common imaging modalities for KOA that are currently used in clinic. However, X-ray has several limitations, such as certain errors in the clinical diagnosis and an insufficient accuracy to reflect the location and condition of lesions [9]. MSUS which is mainly imaged by a high-frequency probe is easy to operate and non-invasive. This study aimed to explore the clinical diagnostic value of MSUS and X-ray in KOA.

Materials and methods

General information

Fifty patients (57 knees) diagnosed with KOA by arthroscopy in the Qionghai Hospital of Traditional Chinese Medicine from November 2018 to November 2019 were collected in our

study, with 23 males and 27 females. The patients were aged from 43 to 76 years, and their mean age was (60.4±12.5) years. The course of disease ranged from 5 months to 18 months with a mean course of (11.8±5.2) months. Additionally, fifty age- and gender-matched healthy volunteers undergoing a physical examination during the same period were recruited as the controls including 23 males and 27 females. The volunteers were aged from 43 to 75 years with a mean age of (59.3±12.6) years. All the healthy volunteers had no symptoms and imaging findings of KOA. This study was approved by the Ethics Committee of Qionghai Hospital of Traditional Chinese Medicine, and all the patients signed the informed consent.

Inclusion and exclusion criteria

Inclusion criteria: All patients met the diagnostic criteria for KOA established by Chinese Medical Association and the diagnosis was confirmed by arthroscopy in the Qionghai Hospital of Traditional Chinese Medicine [10]. Exclusion criteria: Patients with incomplete medical records; patients complicated with metabolic osteopathy and acute trauma; patients who received correlative treatment; patients with communication disorders. All patients and respective families agreed to participate in this study and signed the informed consent.

Methods

MSUS and X-ray: All patients were examined by MSUS and X-ray.

MSUS: Examinations were performed using the L12-5 and L17-5 ultrasonic probes with a frequency of 6-18 Hz. The patient was placed in the semi-recumbent position with the lower limbs exposed and the knee joints flexed at 30°. Then ultrasonic scanning of lateral and medial sides of the knee joint and bilateral sides of the patella was performed in the longitudinal and transverse sections to observe the synovial thickness and patellar bursal effusion. The knee joint morphology of the patient was observed with the knee joints flexed at 60°. In the prone position, longitudinal and transverse scanning of the popliteal fossa was performed to observe the morphology of cartilage surface, echogenicity and popliteal cyst for the posterior

portion of the sesamoid condyle. The diagnostic criteria of KOA were as follows: the presence of knee joint effusion and synovitis which were confirmed by MSUS examination; the positive floating patella test; the synovial thickness of the knee joint was greater than 2 mm according to the Walther grading criteria [11]. The diagnosis was made by two senior physicians of the Department of Ultrasound with a consensus decision.

X-ray: The patient was placed in the upright position, and examination of the knee joint in the lesion side including anteroposterior and lateral radiographs was performed. The radiographs of axial patella profiles were performed with the knee joints flexed at 30°, 60°, 90° respectively.

MSUS findings: The meniscal lesions, inflammation of infrapatellar fat pad, and joint effusion were observed with a 10-MHz ultrasound probe.

Radiographic findings: The radiographic findings of the knee joint of the patients were evaluated by the K-L grading standard which was divided into five grades: Grade 0, Grade I, Grade II, Grade III, and Grade IV [12]. A higher grade indicates a more serious condition. Grade 0 signifies no abnormal findings in the radiograph. Grade I signifies possible osteophytes in the joint. Grade II, III and IV signifies mild, moderate and severe osteopathy in the knee joint, respectively. Grade II means the patient suffers from KOA.

Evaluation of diagnostic value: The comparison was performed separately for sensitivity, specificity, accuracy, coincidence rate, and misdiagnosis rate in the diagnosis of KOA by MSUS and X-ray. The arthroscopic results were considered as the gold standard. Sensitivity = a/(a+d) * 100%. Specificity = c/(c + b) * 100%. Accuracy = (a + c)/total number of cases * 100%. (a: true positive; b: false positive; c: true negative; d: false negative).

Statistical analysis

SPSS 21.0 software was used for statistical analysis. The measurement data were expressed as mean ± standard deviation ($\bar{x}$ ± sd), and the independent sample t test was used for the comparison between groups. The enu-

Table 1. Comparison of general data between healthy volunteers and patients with KOA

	Healthy volunteers	Patients with KOA	χ^2	P
Number of samples	50	50		
Gender (male/female)	23/27	23/27	0.000	1.000
Average age (years)	59.3±12.6	60.4±12.5	0.438	0.662
Course of disease (months)		11.8±5.2		
BMI (kg/m^2)	22.36±2.27	21.98±2.19	0.852	0.396
High blood pressure	12	13	0.053	0.817
Type 2 diabetes	8	10	0.271	0.603
Hyperlipidemia	12	11	0.056	0.812
Obesity	6	7	0.088	0.766

Note: KOA: knee osteoarthritis; BMI: body mass index.

Table 2. Comparison of detection rates (%)

	MSUS	X-ray	χ^2	P
Number of knees	57	57		
Meniscal lesion	27 (47.37)	16 (28.07)	4.518	0.034
Inflammation of infrapatellar fat pad	32 (56.14)	21 (36.84)	4.267	0.039
Joint effusion	36 (63.16)	25 (43.86)	4.267	0.039
Synovial hyperplasia	31 (54.39)	19 (33.33)	5.130	0.024
Patellar ligament lesion	33 (57.89)	22 (38.60)	4.251	0.039

Note: MSUS: musculoskeletal ultrasound.

meration data were expressed as percentage (%), and χ^2 test was used for the comparison between groups. The diagnostic accuracy was compared by paired chi-square test between the two diagnostic methods. P<0.05 was considered statistically significant.

Results

Comparison of general data between healthy volunteers and patients with KOA

As shown in **Table 1**, there was no significant difference in sex ratio, mean age, body mass index (BMI), and comorbid diseases between healthy volunteers and patients with KOA (P>0.05).

Imaging manifestations of MSUS and X-ray

The MSUS images of knee joints of patients were collected and analyzed by senior physicians of the Department of Ultrasound. There were 31 knee joints that were classified as synovial hyperplasia, 31 knees classified as inflammation of the infrapatellar fat pad, 27 knees classified as meniscus disease, 36 knees classified as joint effusion, and 33 knees

classified as patellar ligament disease. The incidence of soft tissue injury around the knee joint is high in patients with KOA, which is an important factor in the development of KOA.

Anteroposterior and lateral radiographs of the knee joint of patients were graded according to K-L grading standard and compiled by senior chief physicians of the Department of Orthopedics. There were 12 knees assigned at grade I, 31 knees at Grade II, and 14 knees at Grade III.

Comparison of detection rates

As shown in **Table 2**, the detection rate of clinical symptoms in patients with KOA by MSUS was significantly higher than that by X-ray (P<0.05).

Diagnostic value of MSUS and X-ray

As shown in **Table 3**, MSUS achieved a sensitivity of 92.98%, specificity of 78.95%, and accuracy of 89.17% in the diagnosis of KOA; while X-ray achieved a sensitivity of 73.28%, specificity of 58.94%, and accuracy of 63.69%, which indicated that the diagnostic efficacy of MSUS was higher than that of X-ray (P<0.05).

Comparison of diagnostic coincidence rate and misdiagnosis rate in the diagnosis of KOA by MSUS and X-ray

Compared with X-ray, there was a higher diagnostic accordance rate and a lower misdiagnosis rate in the diagnosis of KOA by MSUS (P<0.05). See **Table 4**.

X-ray image, MSUS image, and appearance of knee joint in patients with KOA

The imaging findings of X-ray as well as MSUS and the appearance of clinical signs of patients KOA were shown in **Figures 1**-**3**.

Table 3. Diagnostic value of ultrasound and x-ray of muscle bone

		+ (true positive)			- (true negative)		
		X-ray					
		+ (positive)	- (negative)	Total	+ (positive)	- (negative)	Total
MSUS	+ (positive)	53	4	57	3	97	100
	- (negative)	45	12	57	10	90	100
	Total	98	16	114	13	187	200
χ^2		4.653			4.031		
P		0.031			0.045		

Note: MSUS: musculoskeletal ultrasound.

Table 4. Comparison of diagnostic coincidence rate and misdiagnosis rate in the diagnosis of KOA by MSUS and X-ray n (%)

Examination method	Number of knees	Coincidence rate	Misdiagnosis rate
MSUS	57	53 (92.98)	4 (7.02)
X-ray	57	45 (78.95)	12 (21.05)
χ^2		4.653	4.653
P		0.031	0.031

Note: KOA: knee osteoarthritis; MSUS: musculoskeletal ultrasound.

Discussion

KOA is a chronic disease caused by injury of the articular soft tissue of the body, and its main site of occurrence is the cartilage [13, 14]. The early stage clinical symptoms of KOA are usually not obvious, so it is often easily overlooked [15, 16]. It can have a serious impact on the joint activity of patients after disease progression, leading to a decline in quality of life [17, 18]. Therefore, early diagnosis and intervention have a positive effect on the prognosis of patients. X-ray is the most important means of clinical examination which can reflect the knee joint bone structure. However, X-ray has some obvious shortcomings in clinical application. The radiographic appearance may not show a linear relationship with the clinical severity of patients, so there are certain diagnostic errors [19, 20]. Moreover, it is difficult to accurately diagnose the location of the lesion and clearly show the cartilage tissue. As an imaging technique with use of a high-frequency probe, MSUS has the advantages of being a simple operation, without injury to patients and little economic pressure; and as such it can be used to compensate for deficiencies of X-ray in the examination of patients with KOA [21, 22]. In our study, patients with KOA were examined by both X-ray and MSUS. The results showed the detection rate of KOA by MSUS was higher than that by X-ray, suggesting that MSUS can diagnose the knee joint lesions of patients with KOA more accurately and therefore it has a certain clinical application value.

The estimation of the severity of KOA is performed mainly according to K-L grading standard in clinic. Studies have shown that the incidence of the first three grades in the K-L grading is the highest in the diagnosis of KOA by MSUS and X-ray, so there is a relatively high detection rate [12]. MSUS is an ultrasonic examination method using a high-frequency probe of conventional ultrasonic equipment to examine human muscle, bone, and joints, and it can make up for the limitations of X-ray effectively [23]. According to related literature reports, the diagnosis of KOA is usually assisted by X-ray combined with MSUS currently [24]. Compared with X-ray, MSUS has no radiation damage and can realize real-time monitoring. Also, MSUS can better reflect the articular cartilage lesions and the vascular proliferation around the articular surface, which greatly improve the early diagnosis rate of KOA [25]. The results indicated MSUS had better diagnostic efficacy in the diagnosis of KOA and higher clinical application value compared with X-ray [26]. In our study, the diagnostic efficacy of X-ray and MSUS in the diagnosis of KOA was analyzed, and the results showed that the MSUS achieved a high diagnostic rate and efficacy in the diagnosis of KOA, indicating that MSUS can diagnose KOA more accurately, further reflecting the application value of MSUS in the clinical diagnosis of KOA.

In conclusion, the examination of patients with KOA by MSUS can better reflect the pathological changes of soft tissue and more accurately locate the lesions. Therefore, MSUS can be
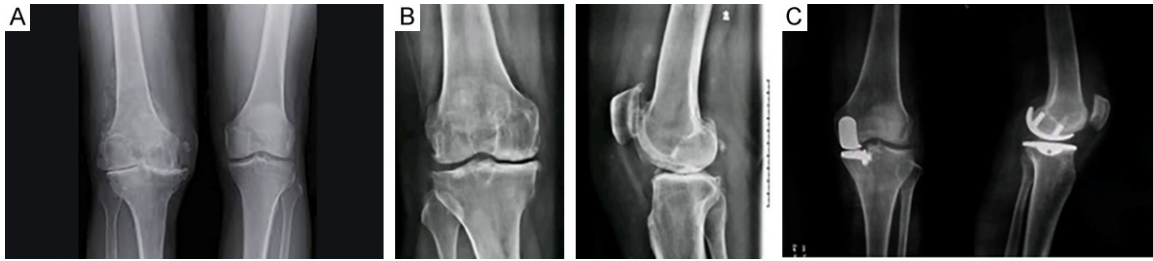
Figure 1. X-ray images of KOA patients. A. KOA in right limb normal knee joint in left limb; B. Normal X-ray; C. KOA in both limbs. KOA: knee osteoarthritis.
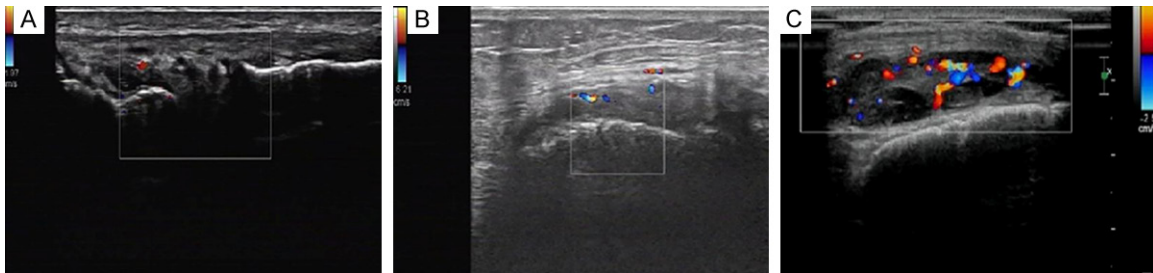

Figure 2. MSUS images of KOA. A. Degenerative lesions of meniscus; B. Synovial hyperplasia; C. Patellar bursal effusion with hyperplasia. KOA: knee osteoarthritis; MSUS: musculoskeletal ultrasound.
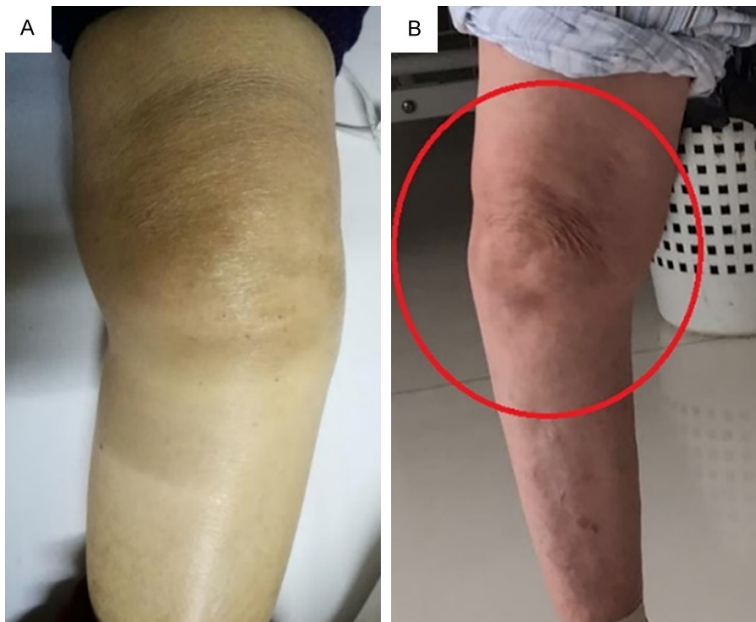

Figure 3. Appearance of knee joint in patients with KOA. The figure showed the deformed (A) and twisted knee joint (B). KOA: knee osteoarthritis.

used for diagnosis when the radiographic appearance is not obvious, and it has a high clinical application value.

Disclosure of conflict of interest

None.

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