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Original Article

Comparative analysis of magnetic resonance imaging in normal and osteoarthritis cartilage of the knee joint

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Abstract: Objective: To compare the characteristics of magnetic resonance imaging (MRI) in normal cartilage and osteoarthritis cartilage lesions of the knee. Methods: From March 2018 to December 2019, 50 patients with pathologically confirmed osteoarthritic cartilage lesions in our hospital were selected as the case group, and 50 patients with normal knee joints were used as the normal group. MRI examination of the knee was performed to observe changes in cartilage thickness and T2 values in 6 areas of the knee joint (lateral femoral condylar cartilage, medial femoral condylar cartilage, femoral trochlear, lateral tibial condylar cartilage, and medial tibial condyle). Results: In the normal group and the case group, no statistically apparent differences existed in cartilage thickness in the different parts of the knee joints at different ages (P>0.05), but the thickness of the medial femoral condyle, patella, and femoral cartilage in males was greater than that of females (P<0.05). No apparent differences existed in the thickness of cartilage in other parts of the knee between males and females (P>0.05). No apparent differences existed in T2 values of cartilage in different parts of knee joints at different ages and between genders (P>0.05). In comparison to the control group, the case group presented significantly less cartilage thickness in the 6 areas (P<0.05) and significantly higher T2 values of the 6 areas (P<0.05). Conclusion: MRI images revealed large differences between normal knee cartilage and osteoarthritis cartilage lesions, and it has a good evaluation value for distinguishing between different ages and genders between cartilage lesion cases and normal controls.

Keywords: Magnetic resonance imaging, normal cartilage, cartilage disease, osteoarthritis

Introduction

Knee articular cartilage is located at the trailing edge of the femur, tibia and patella. This cartalige is very important to maintain the normal movements of the knee joint. It can buffer the vibration and impact of the connected bone during movement and avoid joint damage [1]. When articular cartilage degenerates, it can cause secondary damage to bone, meniscus, and ligaments, leading to the occurrence of osteoarthritis (OA) [2]. The etiology and influencing factors of OA may be related to age, gender, physique and genetics. At present, the most commonly used imaging examinations of knee joints are X-ray and CT [3]. Although these two methods can display the bone structure of the knee joint well, they cannot directly display the articular cartilage, but by observing the joint space. The width determines the condition of articular cartilage. However, in addition to cartilage in the joint space, there are many other structures, such as the meniscus and ligaments, etc., and abnormal changes in subchondral bone mass can affect the true judgment of joint space [4]. Magnetic resonance imaging (MRI), a relatively new medical imaging technology, does not cause any harm to the human body and has high resolution. It can perform arbitrary plane imaging or use 3D sequences to reconstruct arbitrary plane images [5]. MRI is a non-invasive technique which can also provide things like comprehensive, multi-parametric information on brain anatomy, function and metabolism [6]. MRI can improve the accuracy of diagnosis of various diseases, such as patients with suspected multiple sclerosis, prostate cancer patients, patients with orthopedic implants, and evaluate peripheral artery disease [7-10] MRI can measure the thickness

Table 1. General information for the two groups [n (%)]

General information	Case group (n=50)	Normal group (n=50)	X^2	P
Age			0.050	0.975
<30	10 (20.0)	10 (20.0)		
30-50	21 (42.0)	20 (40.0)		
>50	19 (28.0)	20 (40.0)		
Gender			0.160	0.689
male	25 (50.0)	23 (46.0)		
female	25 (50.0)	27 (54.0)		
BMI (kg/m^2)			0.161	0.688
<25	28 (56.0)	26 (52.0)		
≥25	22 (44.0)	24 (48.0)		

of cartilage in different directions [11], through the changes of thickness and detection signals to evaluate the different states of the cartilage internal environment, and accurately reflect the pathological changes in the biochemical components of the earliest changes in cartilage in OA [12, 13]. Therefore, this article used MRI technology to compare the OA cartilage lesions of different ages and genders and recorded the differences in normal and diseased cartilage, providing a valuable reference for future clinical diagnosis.

Materials and methods

Clinical information

Fifty patients with OA cartilage disease diagnosed in our hospital were enrolled from March 2018 to December 2019 as the case group. Inclusion criteria: ① All patients were confirmed by biopsy or surgical pathological diagnosis. ② The patients had clinical manifestations such as joint pain, swelling, stiffness, or reduced mobility when they were admitted to the hospital. Some patients had symptoms of articular noose and bone friction sound. ③ Complete clinical data. Exclusion criteria: ① Previous and recent knee joint history of major trauma, infectious or surgical history. ② Congenital or acquired deformity of the knee joint. ③ Previously used drugs that have a history of chronic diseases that affect cartilage. ④ There had ferromagnetic implants such as pacemakers in the body. ⑤ Patients with poor compliance.

During the same period, 50 volunteers with normal knee joints were collected as the normal group. All volunteers had no history of high-intensity sports training and lived a normal life. All patients provided written informed consent prior to participation. This study was approved by the ethics committee of the hospital. Records of the patients age, gender and BMI were made in both groups. In the case group, there were 10 patients aged <30 years old, 21 patients aged 30-50 years, 19 patients aged >50 years old; and 25 males and 25 females; 28 patients with BMI <25 kg/m^2, 22 patients with BMI ≥25 kg/m^2. In the normal group, there were 10 patients aged <30 years old, 20 patients aged 30-50 years, 20 patients aged >50 years old; 23 males and 27 females; 26 patients with BMI <25 kg/m^2, and 24 patients with BMI ≥25 kg/m^2. The difference in general data between the two groups was not statistically significant (P>0.05) shown in **Table 1**.

MRI scan

3.0T superconducting magnetic resonance imaging system (MAGNETOM Skyra) was used to scan patients. Scanning position: supine position, advanced foot, straight knee, while relaxed. Preparation before scanning: sit for 10 minutes to avoid weight-bearing on the knees and vigorous activities. Metal objects worn by the patient were removed. The examiner clarified that the patient has no contraindications for MRI examination. Scanning sequence: sagittal T2. Mapping sequence: TR1600 ms, TE113.8 ms, TE227.6 ms, TE341.4 ms, TE455.2 ms, FOV160×160 mm, resolution 384×384, layer thickness 3.5 mm, layer spacing 0.7 mm, pixel volume 0.4×0.4×3.5 mm^3.

Image analysis

T2: Mapping generates pseudo-color images automatically by the software that comes with the scan, and transmits all MR scanned images to Siemens Syngo Via VB10B processing workstation.

Measurement of cartilage thickness and cartilage relaxation time

We chose six measurement areas: lateral femoral condyle cartilage, medial femoral con-

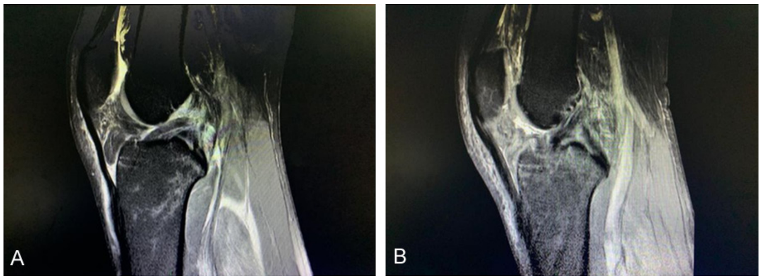

Figure 1. Magnetic resonance imaging in osteoarthritis cartilage (A) and normal cartilage of knee joint (B).

dyle cartilage, cartilage at the anterior femoral and patellar cartilage (femoral block), lateral tibial condyle cartilage, and medial condyle cartilage. When measuring the thickness, we took the thickest point of cartilage in each area as the measuring point. Measurement method: The image is magnified 5 times simultaneously to make the cartilage measurement of the region of interest (ROI) more accurate; used a circular or irregular shape to measure approximately similar ROIs, measured three times for each part, and took the average value. When measuring the T2 mapping value of cartilage, we selected the ROI as close to the inside of the cartilage as possible, avoiding the pixels with obvious abnormal colors formed by the fluid in the joint cavity on the boundary, the subcordicular cortex, etc., and measured three times for each part, and took the average.

Observation index

The difference in cartilage thickness and T2 mapping value between different age and genders in the case group and normal group was compared.

Statistical processing

SPSS 23.0 was adopted for statistical analysis. The quantitative data was described mean ± standard deviation. t test and analysis of variance were adopted for comparison between groups and multiple-group comparison, respectively. t test is mainly used for normally distributed data with small sample size and unknown population standard deviation. The t-test uses t-distribution theory to infer the probability of the difference, so as to compare whether the two averages are significantly different. The count data is represented by [n (%)], using chi-square (χ^2) test. The application of the chi-square test in the statistical inference of categorical data includes: the chi-square test for comparing two rates or two component ratios; the chi-square test for comparing multiple rates or multiple component ratios and the correlation analysis of categorical data, etc. The statistic of the chi-square test is the chi-square value. The larger the chi-square value, the more obvious the difference between the actual frequency and the theoretical frequency. $P<0.05$ indicates a significant difference.

Results

The thickness of cartilage in different parts of the knee joints of the normal group and case group was different between different ages

MRI in normal cartilage of the knee joint the and Osteoarthritic cartilage is shown in **Figure 1**. In the normal group, no statistically apparent difference existed in the thickness of cartilage in different parts of the knee joint at different ages ($P>0.05$). In the case group, no statistically apparent difference existed in the thickness of cartilage in various parts of the knee joints at different ages ($P>0.05$). However, the thickness of the lateral femoral condyle, medial femoral condyle, patella, femoral trochlear, lateral tibial condyle, and the case group showed significantly less medial tibial condyle cartilage vs. the control group ($P<0.05$) shown in **Table 2**.

Differences of cartilage thickness in different parts of knee joints between the normal and case groups in different genders

In the normal group, the thickness of the medial femoral condyle, patella, and femoral trochlear cartilage was greater in males than that in females ($P<0.05$). In the case group, the thickness of the medial femoral condyle, patella, and femoral trochlear cartilage of males was greater than that of females ($P<0.05$). In comparison to the control group, the case group showed thinner cartilage thickness in each part of the knee joints of the male and female cases ($P<0.05$) as shown in **Table 3** and **Figure 2**.

Table 2. Thickness of cartilage at various parts of knee joints in the normal and case groups between different ages (mm, $\bar{x} \pm s$)

	Normal group			Case group		
	<30 years old	30~50 years oldr	>50 years old	<30 years old	30~50 years old	>50 years old
Lateral femoral condyle	1.93±0.32	1.95±0.31	1.87±0.35	1.42±0.25[a]	1.43±0.26[b]	1.40±0.25[c]
Medial femoral condyle	1.84±0.33	1.82±0.41	1.79±0.37	1.21±0.18[a]	1.19±0.16[b]	1.15±0.15[c]
patella	3.17±0.65	3.44±0.58	3.24±0.60	2.42±0.28[a]	2.53±0.31[b]	2.38±0.27[c]
Femoral block	3.65±0.71	3.46±0.66	3.13±0.68	2.52±0.33[a]	2.50±0.31[b]	2.36±0.27[c]
Lateral tibial condyle	2.85±0.38	2.87±0.34	2.66±0.41	1.80±0.16[a]	1.82±0.21[b]	1.69±0.22[c]
Medial tibial condyle	2.21±0.22	2.23±0.20	2.19±0.24	1.13±0.18[a]	1.16±0.17[b]	1.21±0.16[c]

Note: a, P<0.05, compared with normal group <30 years old; b, P<0.05, compared with normal group 30-50 years old; c, P<0.05, compared with normal group >50 years old.

Table 3. Thickness of cartilage at various parts of knee joints in normal and case groups between different genders (mm, $\bar{x} \pm s$)

	Normal group		Case group	
	Male	Female	Male	Female
Lateral femoral condyle	1.98±0.31	1.85±0.35	1.46±0.21[a]	1.37±0.23[b]
Medial femoral condyle	1.96±0.32	1.66±0.41[*]	1.33±0.18[a]	1.03±0.19[b,*]
Patella	3.53±0.57	3.17±0.60[*]	2.53±0.27[a]	2.37±0.25[b,*]
Femoral block	3.66±0.65	3.08±0.62[*]	2.56±0.28[a]	2.34±0.26[b,*]
Lateral tibial condyle	2.87±0.34	2.70±0.37	1.80±0.21[a]	1.73±0.18[b]
Medial tibial condyle	2.26±0.22	2.16±0.20	1.18±0.15[a]	1.16±0.17[b]

Note: a, P<0.05, compared with the normal group-male; b, P<0.05, compared with the normal group-female; *, P<0.05, compared with the male.

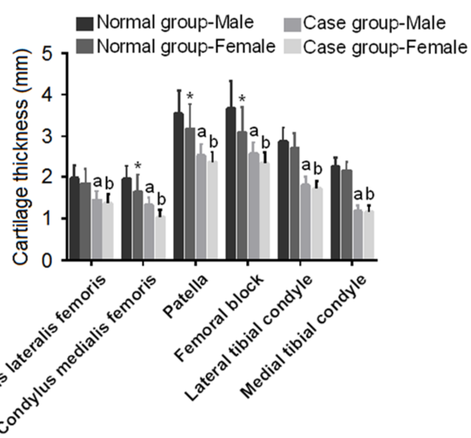

Figure 2. Thickness of cartilage at various parts of knee joint in normal group and case group. a, P<0.05, compared with the normal group-male; b, P<0.05, compared with the normal group-female; *, P<0.05, compared with the male.

Differences of cartilage T2 values in different parts of knee joints in the normal group and case group between different ages

In the normal group, no statistically apparent difference existed in the T2 value of cartilage in different parts of the knee joints at different ages (P>0.05). In the case group, no apparent difference existed in the T2 value of cartilage in different parts of the knee joints at different ages (P>0.05). However, by comparison with the control group, the case group showed significantly higher T2 values of the lateral femoral condyle, medial femoral condyle, patella, femoral trochlear, lateral tibial condyle, and medial tibial condyle cartilage (P<0.05) shown in **Table 4**.

Differences of cartilage T2 values in different parts of knee joints between the normal and case groups in different genders

In the normal group, no apparent difference existed in the T2 value of cartilage in different parts of the knee joint between different genders (P>0.05). In the case group, no statistically apparent difference existed in the T2 value of cartilage in different parts of the knee joint between different genders (P>0.05). However, in comparison to the control group, the case group showed significantly thicker cartilage in the knees of both males and females in the femoral condyle, medial femoral condyle, patella, femoral trochlear, lateral tibial condyle, and medial tibial condyle cartilage (P<0.05), as shown in **Table 5** and **Figure 3**.

Discussion

Related studies have shown that the thickness of the cartilage of the knee joint decreases sig-

Table 4. T2 values of cartilage at various parts of knee joints in normal and case groups between different ages (ms, $\bar{x} \pm s$)

	Normal group			Case group		
	<30 years old	30-50 years oldr	>50 years old	<30 years old	30-50 years old	>50 years old
Lateral femoral condyle	43.58±7.54	45.21±7.62	44.00±7.14	50.11±6.76[a]	51.39±6.37[b]	49.76±6.88[c]
Medial femoral condyle	45.21±7.11	44.37±7.08	47.66±7.25	50.61±6.69[a]	50.13±7.12[b]	52.94±6.58[c]
patella	39.64±6.10	40.61±6.08	42.00±6.34	47.32±5.82[a]	49.17±6.16[b]	49.13±6.07[c]
Femoral block	56.77±7.64	58.61±7.34	57.73±8.13	66.39±7.18[a]	67.31±7.24[b]	71.04±7.35[c]
Lateral tibial condyle	48.69±6.78	49.77±6.82	53.17±7.31	60.48±6.75[a]	61.88±6.83[b]	60.71±6.92[c]
Medial tibial condyle	48.37±6.69	48.98±6.59	49.27±6.75	54.82±6.46[a]	56.72±6.71[b]	58.89±6.76[c]

Note: a, P<0.05, compared with normal group <30 years old; b, P<0.05, compared with normal group 30-50 years old; c, P<0.05, compared with normal group >50 years old.

Table 5. T2 values of cartilage in various parts of the knee joints of normal and case groups between different genders (ms, $\bar{x} \pm s$)

	Normal group		Case group	
	Male	Female	Male	Female
Lateral femoral condyle	45.24±8.12	43.61±6.78	51.42±7.15[a]	49.61±6.24[b]
Medial femoral condyle	46.32±7.68	45.26±7.35	52.31±7.21[a]	50.82±6.76[b]
Patella	40.51±6.11	41.38±6.24	49.21±6.02[a]	48.39±6.12[b]
Femoral block	58.43±8.06	57.39±8.30	67.88±7.34[a]	69.21±7.41[b]
Lateral tibial condyle	50.24±7.23	51.38±7.34	62.13±7.10[a]	60.18±7.06[b]
Medial tibial condyle	48.67±6.88	49.27±6.37	56.22±6.57[a]	58.11±6.82[b]

Note: a, P<0.05, compared with normal group-male; b, P<0.05, compared with normal group-female.

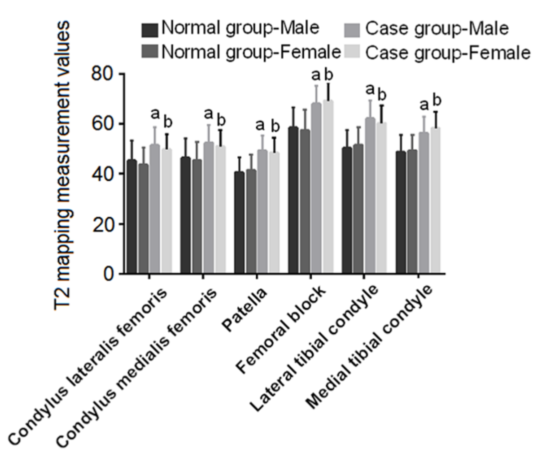

Figure 3. T2 mapping measurement values of cartilage in different parts of knee joint in normal group and case group. a, P<0.05, compared with normal group-male; b, P<0.05, compared with normal group-female.

nificantly with age, and the thickness of the medial femoral condyle and medial cartilage of the tibia decreases most obviously, but the trend of cartilage thickness with age in different regions is not completely consistent [14]. In this article, although the thickness of the knee joint femoral cartilage in different age groups (<30-year old group, 30-50-year old group, >50-year old group) showed a downward trend, there was no significant difference between different ages. Perhaps this result is related to the sample size. This article compares the thickness of the cartilage at 6 different areas in the knee joints between men and women. The results show that regardless of being in the case group or the normal group, the thickness of the medial femoral condyle, patella, and femoral trochlear cartilage in males is greater than that of females (P<0.05). No significant differences existed in other parts of the knee (P>0.05). Analysis of the possible reasons is that men exercise more than women. The loss of cartilage in women after menopause is higher, and the cartilage damage will increase with time [15]. In comparison to the normal group, the case group showed less cartilage thickness of each part of the knee joint cartilage in this study (P<0.05). Multiple studies have shown that [16, 17] the average cartilage thickness of osteoarthritis patients is lower than that of healthy people.

T2 mapping is one of the earliest MR cartilage physiology imaging techniques. It is widely used clinically [18, 19], but there is no unified opinion on its diagnostic value. T2 mapping is affected by the content of water molecules in cartilage [20]. The spatial distribution of T2 value in normal articular cartilage has the characteristic of decreasing from the surface of cartilage to the subchondral bone. This paper compares the measured values of T2 mapping of knee joint cartilage in men and women of different parts. The results show that in 6 different cartilage areas, no statistically apparent difference existed between males and females in the knee joint cartilage T2 values (P>0.05). Studies have shown that T2 relaxation time and cartilage thickness are the same, and men have higher relaxation time values than women [14]. However, there are also studies that show that there is no difference between male and female cartilage T2 values excluding the influence of BMI [21], which is consistent with the results of this study, suggesting that male and female cartilage collagen alignment directions and collagen content may be consistent with gender and T2 value. There is no difference in the changes. At present, the research results of knee joint cartilage T2 values reported in relevant literature are inconsistent with age changes. Shiraj S et al. [22] studied the spatial variation of patellar cartilage T2 values in immature and mature bones. The results showed that in the T2 between the two the value space varies. However, Wirth W et al. [21] believed that there was no relationship between age and changes in the T2 value of the knee cartilage. This study compared the differences in T2 mapping values of cartilage in different parts of the knee joints of the three age groups. Results exhibited that there were no statistical differences in the measured T2 mapping values between the three age groups in the six different cartilage regions. In comparison to the normal group, the case group presented higher cartilage T2 values of the six areas of the knee joint in this study (P<0.05). The reason may be the destruction of the collagen network structure in the articular cartilage and the change in the arrangement of collagen fibers, the increased permeability of water, and the fracture of the collagen network causes the accumulated proteoglycan to spread out and expose more anions, which further increases the water content in cartilage which increases with the T2 value of cartilage [23, 24].

In summary, the thickness of cartilage in the patellar cartilage, femoral trochlear and medial femoral condyle of men is greater than that of women. With age, only the femoral trochlear tends to become thinner. The biochemical imaging index T2 mapping value of cartilage in the same part of the knee and joint of different genders and different ages has no obvious change rule. The T2 mapping value of patients with osteoarthritis cartilage of the knee joint was significantly changed compared with normal patients. Therefore, this study believes that when imaging cartilage of the knee, T2 mapping sequence can be selected for scanning to observe whether the cartilage has a lesion. However, there are still shortcomings in this study, that is, the sample size is small, and the results may have certain deviations. In later study, we will increase the sample size to verify the accuracy of the experimental results.

Disclosure of conflict of interest

None.

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