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Research Article

MRI Semi-Quantitative Evaluation of Clinical Features of Cartilage Injury in Patients with Osteoarthritis

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This study aimed to investigate the correlation between magnetic resonance imaging (MRI) findings of articular cartilage and clinical symptoms in patients with osteoarthritis (OA). Eighty patients with OA were selected as the study subjects (OA group) and 80 healthy subjects during the same period were also selected as the control group. All subjects underwent knee sagittal PDW-SPAIR, sagittal T1WI-aTSE, sagittal T2WI-TSE, coronal PDW-SPAIR, sagittal 3D-WATSc, and sagittal T2 mapping scans. Thereafter, all subjects underwent clinical assessment. The whole-organ MRI score (WORMS) was adopted for MRI examination and semiquantitative analysis, and the T2 value was calculated. The correlation among T2 value, WORMS, and Western Ontario and Mc Master University OA Index (WOMAC) was then compared and analyzed. The correlation coefficients between T2 values and WORMS in each sub-region of patients with OA were 0.8, 0.55, −0.038, 0.811, and 0.743; the correlation coefficients between WORMS and WOAMC were 0.66, 0.71, 0.46, and 0.88; and the correlation coefficients between T2 values and WOAMC were 0.483, 0.33, 0.282, and 0.636, respectively. There was a significant positive correlation between the results of MRI semiquantitative analysis and clinical symptoms as well as disease severity in patients with OA.

1. Introduction

Osteoarthritis (OA), also known as degenerative joint disease, is the most common form of arthritis [1]. The disease is characterized by slow onset and gradual aggravation, so its clinical manifestations are often relatively insidious and often easily overlooked [2]. Clinically, it is generally divided into two types: primary and secondary, and OA usually refers to primary, and the disease is most often diagnosed in middle-aged and elderly women [3]. In recent years, with the rapid development of medical technology, the pathology, physiology, and diagnosis of OA have been greatly developed, but there is no unified and accurate conclusion on its pathogenesis [4]. In recent years, the disease has gradually shown a tendency to be younger, and its incidence is also increasing with age, with an incidence of approximately 30% in people over 65 years of age [5]. With the increasing population of obesity and the elderly, its incidence is still rising, and the World Health Organization predicts that OA will become the fourth leading cause of disability in the next few years [6].

In recent years, articular cartilage lesions have become the focus of research on the pathogenesis and progression of OA. Numerous clinical studies have shown that the pathogenesis of OA generally starts from the lesions of articular cartilage, and wear degeneration, or even stripping defects of cartilage can occur in the early stages of the disease [7, 8]. However, the absence of nerve distribution in cartilage does not directly produce pain, which is also the main reason that the insidious clinical symptoms of OA are not easily detected [9]. Therefore, monitoring the lesions of articular cartilage is very important for the diagnosis and treatment of OA. An arthroscopic biopsy is considered the gold standard for the diagnosis of cartilage damage in clinical practice, but as a seminal examination, it has the following disadvantages: this examination is invasive; it can only show the articular cartilage surface but not the full thickness of cartilage, so there are limitations in the visual field, so it cannot be

routinely used in clinical practice [10, 11]. In contrast, magnetic resonance imaging (MRI) shows a higher resolution for soft tissues and has gradually received clinical attention as a noninvasive and radiation-free inspection method [12]. Especially in recent years, with the emergence of high-intensity MRI and the continuous improvement of relevant software and hardware, MRI can completely and clearly show the articular cartilage [13, 14]. The current MRI diagnosis of knee OA cartilage lesions shows that the pathological changes of an early OA are closely related to cartilage damage caused by inflammation at the cartilage molecular level [15–17]. However, there are still controversies about the study results of MRI manifestations and the clinical correlation of knee OA cartilage defects all over the world. For example, some scholars have explored the diagnostic value of the total knee MRI scores for knee OA and found that the whole-organ MRI score (WORMS) was positively correlated with Western Ontario and Mc Master University Osteoarthritis Index (WOMAC) score, indicating that the pain, stiffness, and function of patients with the knee OA can be explained by imaging, and multiple linear regression analysis has been confirmed [18, 19]. However, some scholars have accurately measured the T2 of cartilage in each area of the knee joint using T2 maps generated by MR sagittal T2 mapping imaging sequences and found that cartilage T2 values were increased and weight-bearing areas were significant in patients with OA, but there was no significant correlation between clinical scores and cartilage T2 changes in all subjects [20]. In summary, further studies and confirmation are needed regarding the correlation between MRI findings and clinical symptoms.

The patients with OA were selected as the study subjects, and the clinical and MRI evaluations of the patients and the correlation between them were analyzed to provide a reference and basis for the treatment and diagnosis of related diseases in clinical practice.

2. Research Methods

2.1. Study Subjects. Eighty patients with OA in the hospital from February 2019 to March 2020 were selected as the study subjects and included in the OA group. Two chief physicians selected the study subjects according to the diagnostic criteria for the knee OA in the 2007 *Guidelines for the Diagnosis and Treatment of Osteoarthritis*. Another 80 healthy subjects during the same period were also selected as the control group. Inclusion criteria: patients who meet the diagnostic criteria of knee OA; patients who have no history of trauma surgery, tumor, or rheumatoid arthritis; patients without claustrophobia and other diseases not suitable for MRI examination. The informed consent was obtained from patients and this study was approved by the ethics committee of the hospital.

Inclusion criteria were as follows: no clinical manifestations related to knee OA; no immediate family members with rheumatic immune disease or another medical history; no history of knee surgery, or trauma; and people with normal medical examination results. Exclusion criteria were as follows: patients with the WOMAC index higher than that of grade II; patients with significant trauma; and patients with a history of surgery.

2.2. MRI Examination Method. Examination equipment: 3.0 T superconducting magnetic resonance; coil: 8-channel knee coil postprocessing workstation: MR Workspace 2.6.3.5 workstation.

Preparation before examination: the contraindications of MRI examination were investigated and the patients were instructed to keep the knee joint still as much as possible during the examination. All subjects rested for 30 minutes before the MRI examination.

Scanning method: the ear plug was used and the patient was in the supine position with the feet advanced and the lower limbs straight. The knee of the examined side was placed in the 8-channel knee coil so that the coil center was directly opposite to the knee, and sponge pads were added to the knee of examined side and feet to make the patient's position comfortable. Sagittal PDW-SPAIR, sagittal T1WI-aTSE, sagittal T2WI-TSE, coronal PDW-SPAIR, sagittal 3D-WATSc, and sagittal T2 mapping were performed, respectively.

Scanning parameters: [sagittal PAW-SPAIR] TR = 3,484 ms, TE = 30 ms, FOV160 × 160 mm, matrix 176 × 135, NEX = 2, layer thickness: 4 mm, interslice distance: 0.4 mm, number of layers: 18, scanning time: 2 min and 12 s; [sagittal T1WI-aTSE] TR = 633 ms, TE = 20 ms, FOV 160 × 160 mm, matrix 224 × 181, NEX = 2, layer thickness: 4 mm, interlayer distance: 0.4 mm, number of layers: 18, scanning time: 139 s; [sagittal T2WI-TSE] TR = 3,890 ms, TE = 100 ms, FOV 160 × 160 mm, matrix 212 × 161, NEX = 2, layer thickness: 4 mm, interlayer distance: 0.4 mm, number of layers: 18, scanning time: 2 min and 20 s; [coronal PAW-SPAIR] TR = 3,329 ms, TE = 25 ms, FOV 160 × 160 mm, matrix 356 × 285, NEX = 2, layer thickness: 3 mm, interlayer distance: 0.3 mm, number of layers: 18, scanning time: 166 s; [sagittal 3D-WATSc] TR = 20 ms, TE = 5.1 ms, FOV 160 × 160 mm, matrix 320 × 319, NEX = 2, layer thickness: 1.5 mm, interlayer distance: 0 mm, number of layers: 18, scanning time: 4 min and 26 s; [Sagittal T2 mapping] TR = 2,000 ms, TE = 13, 26, 39, 52, 65, 78 ms, FOV 160 × 160 mm, matrix 268 × 266, NEX = 1, layer thickness: 2.5 mm, interlayer distance: 0.25 mm, number of layers: 12*6, scanning time: 672 s.

2.3. Clinical Evaluation. All subjects filled in the WOMAC score form carefully under the guidance of orthopedic surgeons, which was required to be completed within 5 to 10 minutes. The WOMAC is currently the most widely used assessment tool for knee or hip arthritis in clinical practice. The severity and therapeutic effect of the patient are evaluated based on the patient's relevant symptoms and signs. The evaluation contents include three aspects: pain, stiffness, and joint function, and include a total number of 24 items, 5 pain items, 2 stiffness items, and 17 joint function items. Each item includes 5 scoring points (0: normal, 1: mild, 2: moderate, 3: severe, 4: very severe).

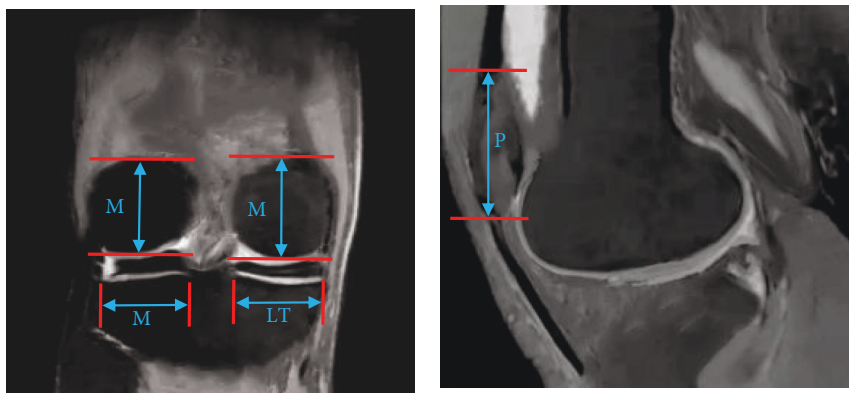


Figure 1: Knee cartilage partition method.

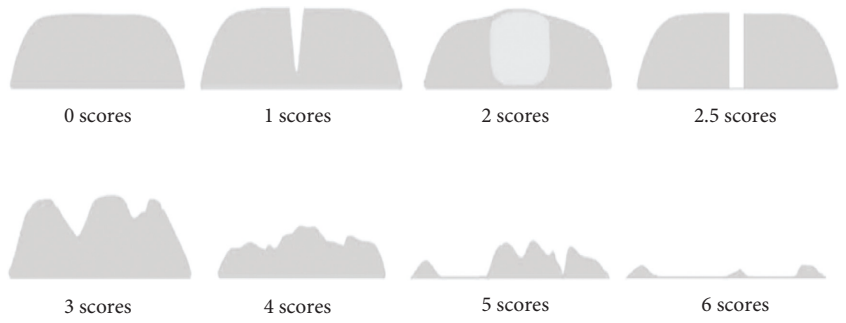


Figure 2: WORMS 8-point scoring for cartilage morphology.

Table 1: Comparison of general data between the two groups.

	Mean age	Gender (males/females)	Knee distribution	BMI	Course (month)
OA group ($n = 80$)	52.3 ± 11.2	48/32	41/39	22.3 ± 9.3	11.3 ± 4.6
Control group ($n = 80$)	51.1 ± 9.9	50/30	38/42	23.1 ± 11.02	10.08 ± 5.11
P	0.43	0.88	0.93	0.547	0.635

2.4. MRI Assessment. Before the MRI evaluation, it is necessary to reconstruct the coronal, sagittal, and axial images of the knee joint with the sagittal 3D-WATSc sequence image using the MPR multiplanar reconstruction group. WORMS was used to divide the knee cartilage into five subregions: medial region of femoral (MF), lateral region of femoral (LF), medial region of the tibia (MT), lateral region of the tibia (LT), and patella (P) (Figure 1).

MRI evaluation of cartilage morphology: according to 0–6 scores of WORMS 8 scoring points, the cartilage morphology in each sub-region of the knee joint was scored: 0: normal; 1: normal cartilage thickness but enhanced T2WI signal; 2: partial cartilage defects; 2.5: full-thickness cartilage defect; 3: multiple regional partial cartilage defects; 4: diffuse partial cartilage defect; 5: multi-regional full-thickness cartilage defect; 6: diffuse full-thickness cartilage defect. The specific scoring is shown in Figure 2.

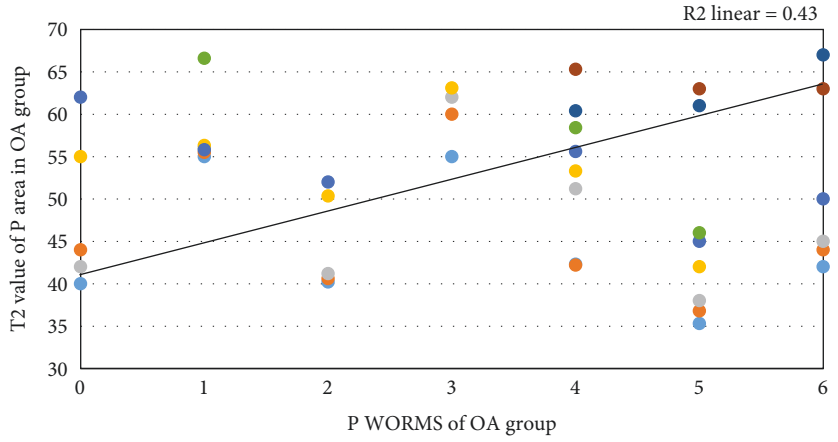
According to the WORMS scores of each sub-regional cartilage of the patients, the sub-regional cartilage was divided into 0 and 1 scores as mild (OA1) group, and 2–3 scores as moderate (OA2) group. 4–6 scores as severe (OA3) group, and healthy control group as H group.

MRI measurement of the T2 value of each sub-region: sagittal T2 mapping sequence automatically generated the final T2 grayscale map by post-processing workstation, and manually delimited along the articular cartilage boundary on the T2 grayscale map. The T2 values of the five sub-regions of the knee joint were measured in turn. The T2 values of each region were measured three times and the average value was taken as the T2 value of each sub-region.

2.5. Statistical Analysis. The analysis of all data was completed by the SPSS 19.0 statistical software. Measurement data were expressed as (mean ± standard deviation), and the test method was an independent sample t-test. Enumeration data were expressed as frequency (percentage), and the test method was the chi-square test. $P < 0.05$ was considered statistically significant.

3. Results

3.1. General Data. The general data of patients in the two groups are shown in Table 1. It showed that the mean age of



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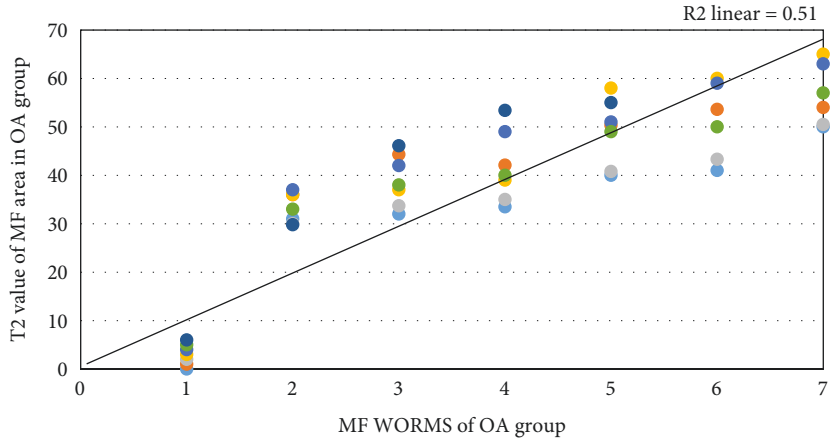

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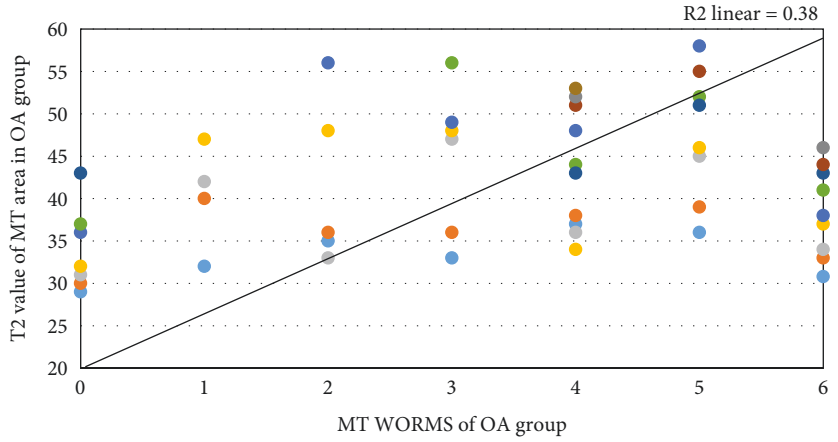

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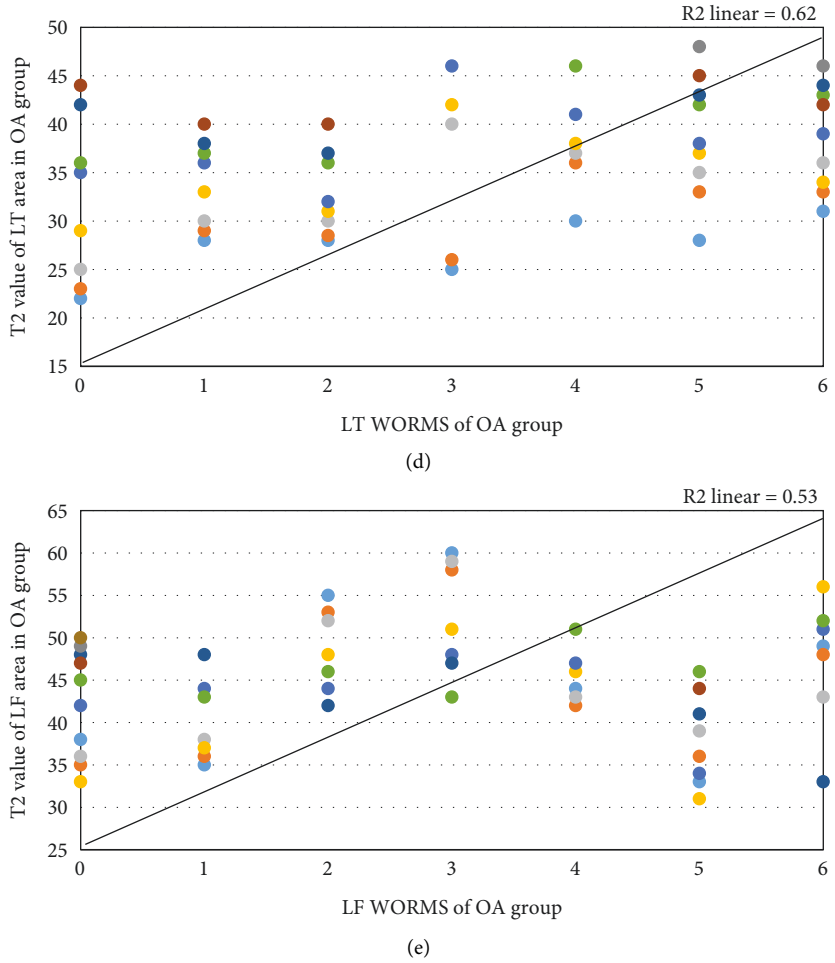


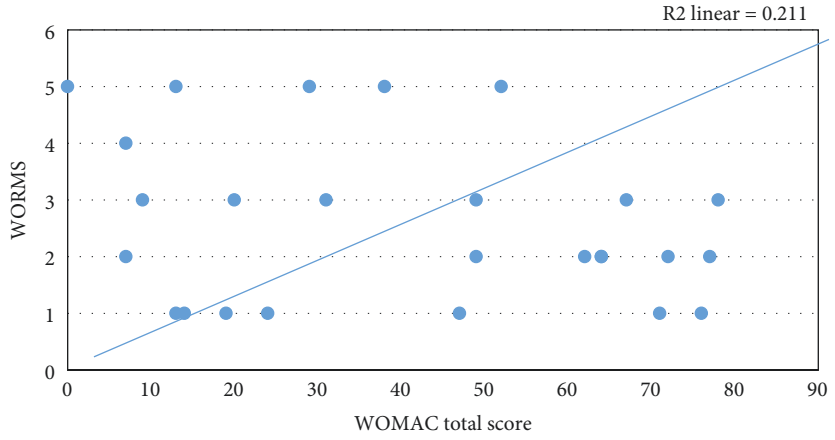
Figure 3: Scatterplot of correlation analysis between T2 values and WORMS in each sub-region of patients with OA. A : P; B : MF; C : MT; D : LT; E : LF. Each dot represented a case.

patients in the OA group was 52.3 ± 11.2 years old, 48/32 males/females, 41 right knees, and 39 left knees; the mean age of the population in the control group was 51.1 ± 9.9 years old, 50/30 males/females, 38 right knees, and 42 left knees. There was no significant difference in age, gender, and knee distribution between the two groups, $P < 0.05$.

3.2. Correlation Analysis between T2 Values and WORMS in Each Sub-Region of Patients with OA. The correlation analysis results between T2 values and WORMS in each sub-region of patients with OA are shown in Figure 3. Analysis of Figure 3 showed that in the OA group, the correlation coefficients between cartilage T2 values and WORMS were 0.8, 0.55, −0.038, 0.811, and 0.743 in the P, MF, MT, LT, and LF, respectively. The analysis showed that the T2 values of P, MF, MT, and LT were positively correlated with WORMS, and the T2 value of LF was not correlated with WORMS.

3.3. Correlation Analysis between Cartilage WORMS and WOAMC Scores in OA Group. The results of the correlation analysis between cartilage WORMS and WOAMC scores in the OA group are shown in Figure 4. The correlation coefficients between the cartilage WORMS score and the clinical WOAMC total score and each subdomain (pain, stiffness, joint function) score in the OA group were 0.66, 0.71, 0.46, and 0.88, respectively, indicating that cartilage WORMS was positively correlated with clinical WOAMC total score, pain score, stiffness score, and joint function score in the OA group. The correlation degree was divided into high correlation, moderate correlation, low correlation, and high correlation.

3.4. Correlation between Cartilage T2 Value and WOAMC Scores in the OA Group. The results of the correlation analysis between the cartilage T2 value and the WOAMC scores in the OA group are shown in Figure 5. The correlation coefficients between the cartilage T2 value and the clinical WOAMC total score and each subdomain (pain, stiffness, joint function) scores in the OA group were 0.483, 0.33, 0.282, and 0.636, respectively, which indicated that the cartilage T2 value was positively correlated with the clinical WOAMC total score, pain score, stiffness score, and joint



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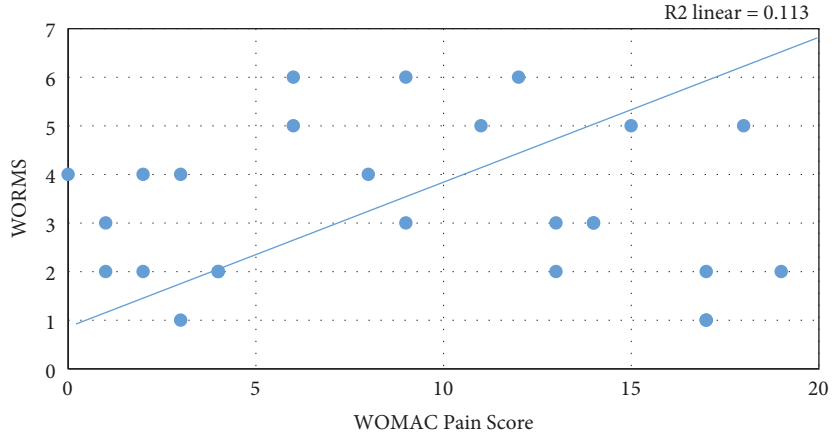

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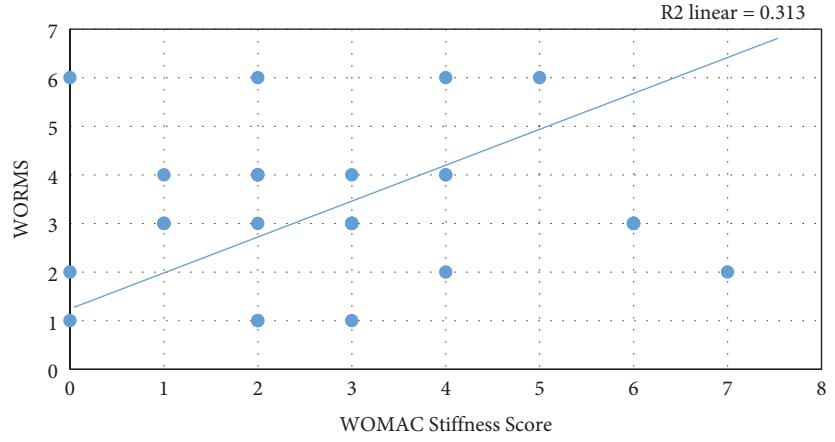

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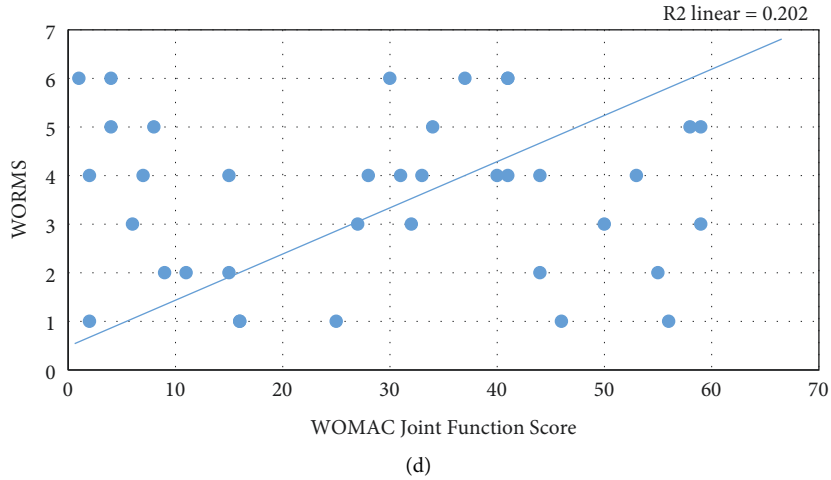

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Figure 4: Scatterplot of correlation analysis between cartilage WORMS and WOAMC scores in the OA group. (a) WOMAC total score; (b) WOMAC pain score; (c) WOMAC stiffness score; (d) WOMAC joint function score.

function score in the OA group, and the degree of correlation was divided into moderate correlation, low correlation, low correlation, and moderate correlation.

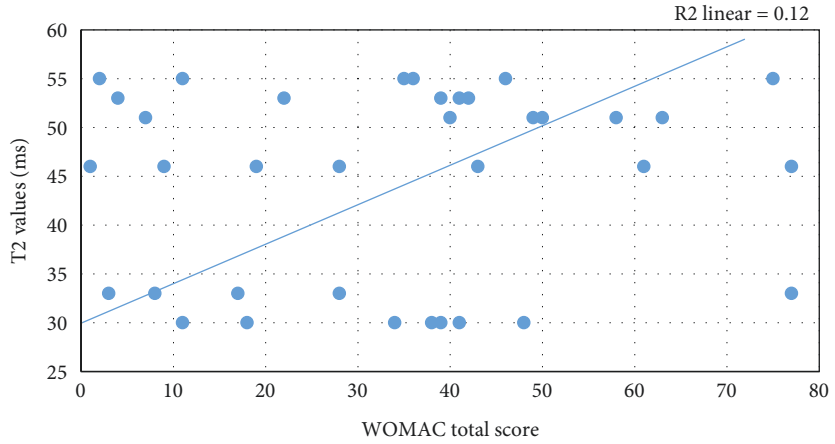
4. Discussion

The knee joint is composed of the lower end of the tibia, the upper segment of the tibia and fibula, and the patella, which carries 3/4 of the weight of the human body and is the most used sport's joint of the human body, so the probability of its lesions is also much higher than those of other joints [21]. Clinically, arthritis is generally divided into two types: primary and secondary. Primary degenerative arthritis mostly occurs in the elderly. The analysis of its etiology may be that the bones and joints of the elderly appear a certain degree of aging [22]. Secondary degenerative arthritis may occur at any age and is generally mainly caused by trauma, joint structure instability, and endocrine disorders [23]. Regardless of the type of degenerative arthritis, it can limit the patient's movement and seriously affect the patient's quality of life. The knee joint has hyaline cartilage between the tibia and femur in addition to internal components such as connective tissue and joint capsule. As a special connective tissue, when the human body moves, it will bear great gravity, absorb various mechanical oscillations and impacts at the same time, and it also has a more important linking effect, which will be transmitted to the underlying bone tissue, so it is highly susceptible to damage [24]. When OA occurs, the cartilage tissue becomes less transparent and the texture becomes hard, thus, further damaging the synovial tissue of the joint. This damage to articular cartilage is usually difficult to recover [25].

At present, there is no effective drug for the treatment of OA, and the main obstacle to the improvement of OA treatment is that there is no accurate and effective method for the examination of articular cartilage lesions. Photographs are a traditional method of examining OA, but their clinical application is limited because they cannot directly observe and evaluate cartilage changes [26]. In recent years, nuclear magnetic resonance technology has been continuously developed and advanced, and it has gradually become an effective method for the examination of OA [27]. MRI is mostly used to evaluate cartilage defects in the knee OA using WORMS. The results of relevant clinical studies have shown that WORMS has a high reliability for the detection of the occurrence of cartilage loss [28]. MR T2 mapping imaging is used to quantitatively analyze the changes in the tissue composition of articular cartilage by measuring T2 transverse relaxation time, to make a diagnosis for early cartilage lesions.

At present, the study results on the correlation between MRI findings of cartilage defects in the knee OA and clinical symptoms are inconsistent, and there is still great controversy. Some scholars have shown that the WOMAC score has no correlation with cartilage thickness and the degree of cartilage defect, and there is a significant correlation between cartilage thickness shown by MRI and the joint space width of the flat film [29]. Some scholars have studied the correlation between the degree of cartilage injury and knee joint pain, stiffness, and function WOMAC scores and found that the WOMAC scores of pain and function between different cartilage injury grades were statistically significant, while the WOMAC score of stiffness was not statistically significant [30]. There was no significant difference in WOMAC scores between the mild cartilage injury or normal group and the severe cartilage injury group [31].

WOMAC was used for clinical analysis of patients with OA, T2 mapping imaging sequence and WORMS were used for MRI analysis of patients, and the correlation among the three was analyzed. The results showed that T2 values in P, MF, MT, and LT were positively correlated with WORMS, while T2 value in LF was not correlated with WORMS; cartilage WORMS in the OA group was positively correlated with clinical WOAMC total score, pain score, stiffness score, and joint function score; cartilage T2 values in the OA group were positively correlated with the clinical WOAMC total



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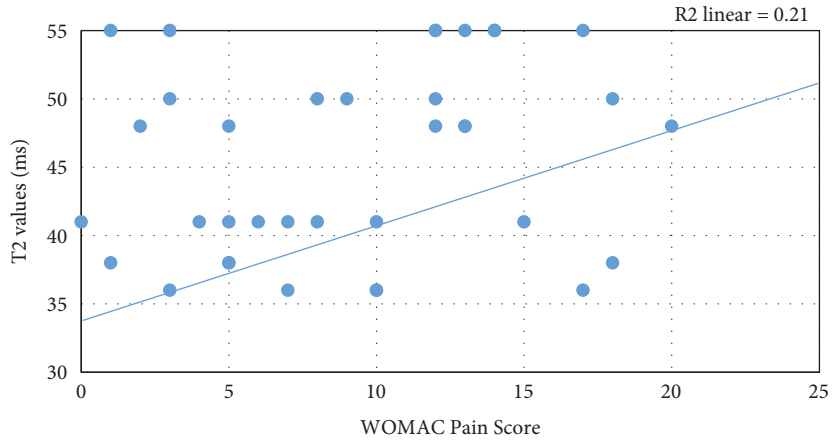

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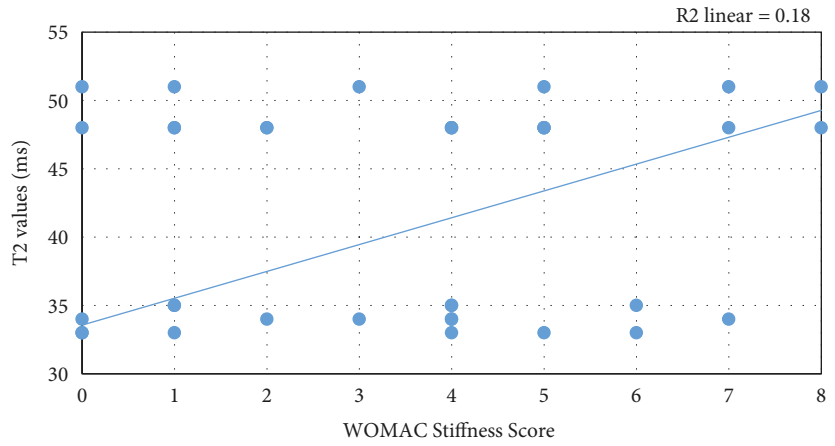

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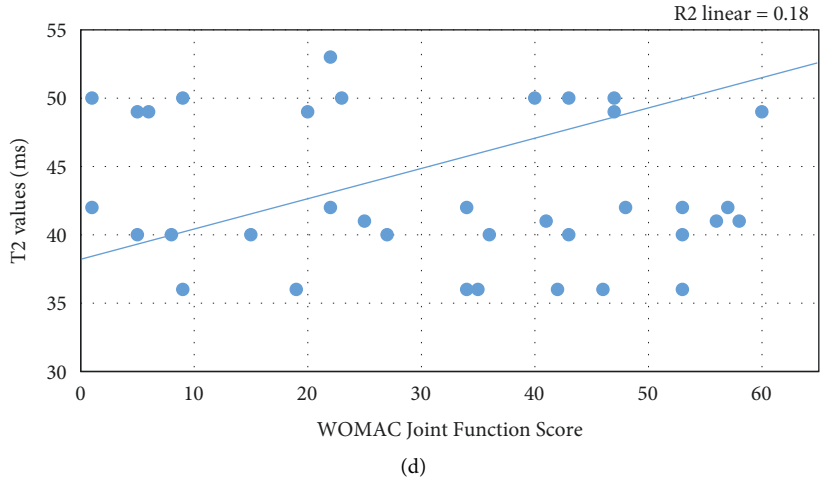

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Figure 5: Scatterplot of correlation analysis between cartilage T2 value and WOAMC score in the OA group. (a) WOMAC total score; (b) WOMAC pain score; (c) WOMAC stiffness score; (d) WOMAC joint function score.

score, pain score, stiffness score, and joint function score. There was a clear correlation between MRI findings and clinical symptoms in patients with OA, which is consistent with the results of some previous related studies.

5. Conclusion

Patients with OA were taken as the study subjects in this research, and WOMAC was utilized for clinical analysis of patients. T2 mapping imaging sequences and WORMS were used for MRI analysis of patients, and the correlation between the three was analyzed. A significant positive correlation was shown between the results of the MRI semi-quantitative analysis and the total WOAMC score. This indicated that MRI semi-quantitative analysis had a high clinical application value in the evaluation of clinical features of cartilage injury in patients with knee OA. But this work still had deficiencies. The cartilage WORMS score was somewhat subjective, and there was also a certain random error in the manual delimitation method for T2 value measurement. All of the above factors might lead to certain deviations in the research results. In the future study, the above-mentioned influencing factors would be avoided, and this issue would be further studied comprehensively and in-depth.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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