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Article

Optimization of diagnosis and treatment of tendon diseases caused by athletic injury using computer ultrasound images based on cell responses to tendon injuries

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Abstract: The application effect of computer ultrasound images in the diagnosis of tendon diseases caused by athletic injuries and the efficacy of optimized treatment plans were explored. One hundred and thirty-five patients with tendon diseases due to athletic injuries treated in a local tertiary hospital during the period of March 2021–September 2023 were selected as the study subjects, and they were separated into three groups of control group 1, control group 2 and research group by randomization method, with 45 patients in each group. Control group 1 was diagnosed using MRI (Magnetic Resonance Imaging); control group 2 used conventional diagnostic methods; the research group used computer ultrasound images for diagnosis. This study focused on observing the cellular responses to tendon injuries and how different diagnostic methods and treatment plans affect these responses. By comparing the specificity, sensitivity, accuracy of diagnoses, as well as the elastic modulus value, pain level, and satisfaction of tendons at different time periods after treatment among the three groups, we aimed to understand the role of computer ultrasound images in monitoring the cellular changes during the healing process. The average accuracy of the eight diagnoses in the research group (97.78%) was significantly greater than that of control group 1 (84.999%) and control group 2 (72.223%), and the difference was statistically significant ($p < 0.05$). On the 40th day of treatment, the elastic modulus of the tendons of the research group patients reached 169.8 kPa; the control group 1 was 141.1 kPa; the control group 2 was 133.5 kPa. The elastic modulus of the tendons of the research group was significantly greater than that of the control groups 1 and 2, and the difference was statistically significant ($p < 0.05$). The use of computer ultrasound images for diagnosis has high specificity and sensitivity, which is beneficial for improving the accuracy of tendon disease diagnosis and provides valuable insights into the cellular responses during tendon injury and recovery. At the same time, its application in the treatment of tendon diseases is beneficial for improving tendon elasticity, shortening the recovery cycle of tendon elasticity, and shortening the patient's pain cycle. Overall, computer ultrasound images have a significant role in clinical diagnosis and treatment by providing a window into the cellular world of tendon injuries. Its application in clinical diagnosis and treatment has a good effect.

Keywords: diagnosis of tendon diseases; computer ultrasound images; cellular response; athletic injuries; tendon treatment plans

1. Introduction

Muscle tendon injury caused by exercise is a common health problem [1]. Tendons are a type of connective tissue between bones and muscles in the human body, which is extremely important for the movement and stability of the human body [2,3]. If overused or due to incorrect movement posture, it may lead to tendon disease, which, once left untreated, can cause significant harm to the body. Recently, as science and technology continue to progress, computer ultrasound imaging technology has been increasingly applied in the medical field, opening up new avenues for the diagnosis and treatment of athletic injuries [4,5]. Ultrasound can penetrate the skin and muscles without damage, displaying the condition of deep tissues such as tendons [6]. Through computer ultrasound images, doctors can make more accurate judgments on the shape, thickness, and movement status of tendons, thereby improving the accuracy of diagnosis. This article explores the value of computer ultrasound images in the diagnosis and treatment optimization of tendon diseases caused by athletic injuries. Through discussion and empirical research, more evidence is provided for the application of computer ultrasound images in clinical diagnosis. At the same time, it is applied in the optimization of treatment plans for tendon diseases caused by athletic injuries, improving the efficacy of tendon diseases, shortening the rehabilitation cycle, allowing sports players to receive more accurate health monitoring and prevention, and better ensuring their sports health.

Tendons play a crucial role in the human body. However, tendons may also be injured or diseased, which can lead to pain and dysfunction [7,8]. In order to better diagnose tendon diseases, many scholars have conducted research on it. In order to evaluate the diagnostic performance of ultrasound on calcium pyrophosphate deposition at the levels of meniscus, hyaline cartilage, tendons, and knee joint synovial fluid, Lee K-A examined it and pointed out that ultrasound showed better diagnostic ability than conventional radiography in diagnosing calcium pyrophosphate deposition, with excellent reliability. The combined evaluation of meniscus, hyaline cartilage, and tendons showed the best diagnostic accuracy [9]. Via Alessio Giai studied the incidence of calcaneal tendon insertion calcification tendinosis and the percentage of symptomatic patients in the general population, and pointed out that the incidence rate of calcaneal tendon insertion calcification tendinosis increases with age, and the incidence rate of diabetes and hypothyroidism patients is significantly higher [10]. Regarding the value of ultrasound in the diagnosis and treatment of rheumatologists, Khudayberdiyevich Ziyadullayev Shukhrat discussed the possibility of using ultrasound elastography to diagnose tendon injuries in hypercholesterolemia, and stated that ultrasound elastography may soon enter clinical practice as a first-line diagnostic method for detecting biomechanical changes in tendons, muscles, and ligaments and evaluating treatment effectiveness [11]. To analyze and compare the diagnostic value and interpretation of six established clinical trials for infraspinatus tendon tears, and evaluate their ability to distinguish between partial and full layer tear of the infraspinatus tendon, Sgroi Mirco found through clinical trials that the descending sign and anti lateral rotation test can accurately diagnose infraspinatus tendon tears alone, while the combination of the two tests can improve diagnostic value [12]. These scholars' research on the diagnosis and treatment of tendon diseases can improve their diagnostic accuracy and enrich diagnostic methods and methods, but also has deficiencies. Although some scholars' research has already involved ultrasound, there has been no in-depth discussion on the diagnosis of tendon diseases in athletic injuries using computer ultrasound images, which leads to many uncertainties in the accuracy and therapeutic value of tendon diagnosis in the field of sports medicine.

Recently, progress in the diagnosis of athletic injury diseases has mainly been achieved through the updating of imaging and ultrasound equipment, as well as new research and exploration by doctors based on new diagnostic equipment [13,14]. Therefore, some scholars have explored the value of ultrasound images in athletic injuries. With the advancement of technology, the ability to accurately diagnose athletic injuries with ultrasound is improving. Robotti Guido evaluated the gender differences in athletic injuries and stated that ultrasound can display tissue structure using two-dimensional grayscale images. Ultrasound examination is the preferred imaging method for dynamically studying soft tissue lesions. Understanding the specific gender of injuries and injury mechanisms is crucial for evaluating appropriate diagnostic and treatment guidelines for phenotypic differences between men and women in both professional and amateur sports [15]. Medical imaging plays an increasingly crucial role in the early diagnosis and treatment of athletic injuries, and management decisions after injuries increasingly rely on imaging examination results. Jyoti Rajeev discussed a range of imaging options available in the clinical environment of athletic injuries to achieve optimal results, and delved into the role of each imaging mode and image guidance program in athletes' early recovery activities. He also summarized the commonly used imaging modes in athletic injury clinical practice, including the relative advantages of selecting the correct imaging mode [16]. Scholars' research on ultrasound and athletic injury can provide certain theoretical support for this study. However, because of its wide research scope, which focuses on the entire athletic injury and its mechanism, without a detailed exploration of the diagnosis and treatment of tendon diseases caused by athletic injuries, the research does not have great practical value and is difficult to accurately diagnose tendon diseases caused by athletic injuries, which is not conducive to the optimization of treatment plans.

To better study the application effect of computer ultrasound images in the diagnosis and treatment of tendon diseases caused by athletic injuries, this article analyzed the process of diagnosing tendon diseases using computer ultrasound images. Through empirical research, it has been found that using computer ultrasound for the diagnosis of tendon diseases is more effective, with higher specificity and sensitivity. Applying it to the treatment of tendon diseases is more conducive to alleviating patient pain, promoting the recovery of tendon elasticity, and thus improving patient satisfaction with treatment. Compared with the traditional diagnostic and therapeutic methods, the novelty of this paper's approach is that it focuses on the actual value of computerized ultrasound images and introduces them into the optimization of diagnostic and therapeutic plans for tendon diseases, which helps to improve the diagnostic and therapeutic effects and the prognosis, promotes the recovery of the patients, and provides more guarantees for the patients' athletic health.

2. Diagnosis process of tendon diseases caused by athletic injuries based on computer ultrasound images

Using ultrasound technology, computer ultrasound scans are performed on suspected tendon injuries in athletes to obtain corresponding ultrasound images. These images can cover static muscle and tendon structures, as well as dynamic muscle activity. The image dataset of tendon disease injuries is shown in **Figure 1**.

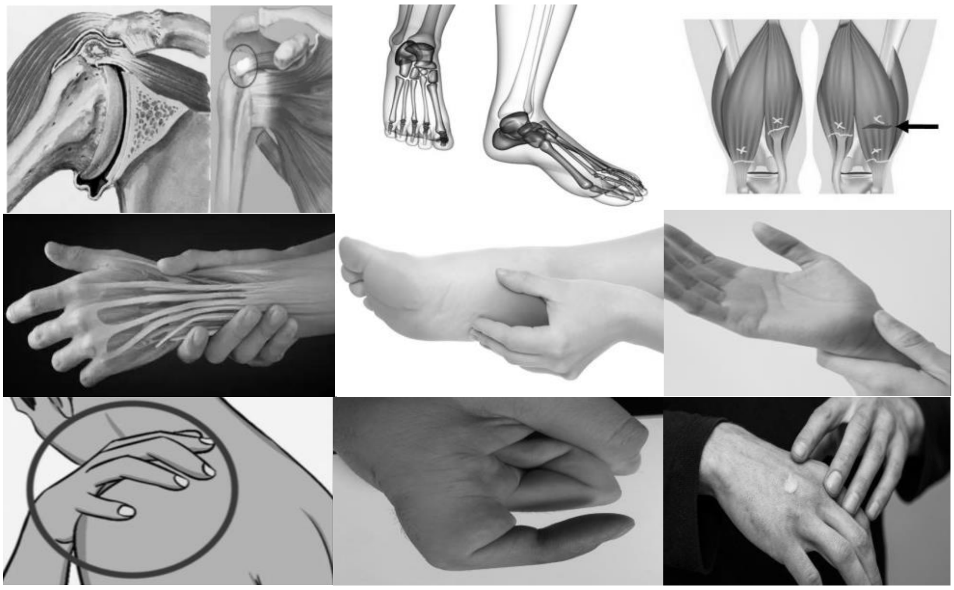


Figure 1. Image dataset of tendon disease injuries.

On the basis of the above, computer image processing technology is used to process and analyze ultrasound images. Ultrasound imaging is a two-dimensional or three-dimensional imaging method that displays human organs through ultrasound [17,18]. In ultrasound image processing, coherent light sources and associated detectors simultaneously act on objects with similar wavelengths to ultrasound, causing the ultrasound beam to scatter, resulting in shot noise [19]. Among them, the mathematical model of images contaminated by shot noise can be expressed as:

$$\mathrm{g}(m,n) = a(m,n)p(m,n) \tag{1}$$

among them: $a(m,n)$ unknown real images to be restored;

$\mathrm{g}(m,n)$ actual observed images contaminated by noise;

m,n -pixel spatial position.

Due to the presence of additional noise generated by sensors or similar objects in ultrasound images, the noise model is usually expressed as:

$$\mathrm{g}(m,n) = a(m,n)p_j(m,n) + p_i(m,n) \tag{2}$$

among them: $p_j(m,n)$ multiplicative shot noise;

$p_i(m,n)$ additive noise.

Computer image processing technology has been adopted to denoise and analyze ultrasound images. In commonly used image denoising algorithms, the window shape and size of median filtering have a significant impact on the filtering results [20]. Wiener filtering is a typical linear smoothing filtering method with good local adaptability [21,22]. Wiener filtering, median filtering, and other methods are mainly used for image additive noise, especially for suppressing salt and pepper noise [23]. However, due to the fact that ultrasound images are mostly multiplicative noise and are closely related to organizational structure, traditional median filtering, Wiener filtering, and other algorithms can easily blur image details and cannot effectively eliminate multiplicative speckle closely related to the signal, resulting in poor noise reduction effect.

Because additive noise is much smaller than multiplicative noise, the impact of additive noise can be taken into account when processing ultrasound images, and the model in Equation (1) can be used instead. In order to distinguish between shot noise $p(m,n)$ and actual image $a(m,n)$, the multiplicative noise in the ultrasound image is converted into additive noise. The two sides of Equation (1) are logarithmically calculated, and the Equation is:

$$\tilde{g}(m,n) = \tilde{a}(m,n)\tilde{p}(m,n) \tag{3}$$

Assuming that the transformed variable $\tilde{p}\,(m,n)$ follows a Gaussian distribution of $M\,(0,\theta^2)$, which is both independent and distributed, and is also independent of $\tilde{g}\,(m,n)$, the Equation can be obtained:

$$V_g = V_a + V_p \tag{4}$$

among them: V_g wavelet coefficient containing noise;

V_a wavelet coefficient of the original image;

V_p wavelet coefficient of noise.

In the multiscale decomposition process, $\tilde{g}(m,n) \in x_0 \subset K^2(T^2)$, the wavelet coefficients can be approximated and expressed through a finite subspace, namely:

$$\begin{aligned} x_0 = x_1 \oplus f_1 \oplus w_1 \oplus c_1 = x_2 \oplus f_2 \oplus w_2 \oplus c_2 \oplus f_1 \oplus w_1 \oplus c_1 = \cdots \\ = x_i \oplus f_i \oplus w_i \oplus c_i \cdots f_1 \oplus w_1 \oplus c_1 \end{aligned} \tag{5}$$

$\{x_n\}(n \in S)$ is the scale space; $\{f_n\}$, $\{w_n\}$, and $\{c_n\}$ are wavelet spaces with scale space n, and there are:

$$x_{i-1} = x_i \oplus f_i \oplus w_i \oplus c_i \tag{6}$$

$i = 0,1,2,\cdots,M-1$; x_i is the low-frequency subspace of x_{i-1}, and f_i, w_i, and c_i are the high-frequency subspaces of x_{i-1}, which are the horizontal detail coefficient, vertical detail coefficient, and diagonal detail coefficient.

In ultrasound image signals, the original image signal $\tilde{a}(m,n)$ is usually low-frequency or relatively stable, while the image signal $\tilde{p}(m,n)$ containing noise is usually high-frequency. Therefore, when denoising, the logarithmic signal $\tilde{g}(m,n)$ is first taken for wavelet decomposition. Since most of the noise exists in the high-frequency signal, Wiener filtering is performed on each high-frequency signal of f_i, w_i, and c_i. On this basis, the signal is reconstructed to eliminate noise.

Wiener filtering is an adaptive filter that has good denoising ability for Gaussian noise and can adjust the filtering results with changes in image area. When there are large changes in the area, the smoothing effect is better, but on the contrary, its smoothing effect is smaller [24,25]. To eliminate Gaussian noise, a Wiener filter is used to filter the wavelet coefficients in three directions at each scale. The results of computer ultrasound image denoising for tendon disease injuries are illustrated in **Figure 2**.

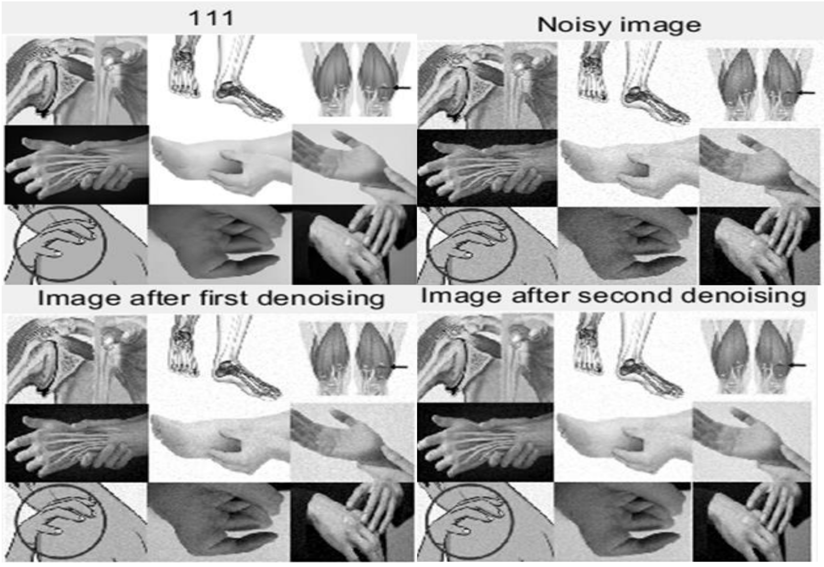


Figure 2. Results of computer ultrasound image denoising for tendon disease injuries.

Through the above operations, the processing of ultrasound images of tendon diseases can be achieved. Then, based on the obtained ultrasound images, the patient is diagnosed. Firstly, through high-definition images, the shape, structure, and motion trajectory of tendons can be accurately determined. Then, by quantitatively analyzing and measuring indicators such as tendon thickness, length, and elasticity, the degree of tendon injury and disease characteristics are determined. Afterwards, the movement status of the tendons is further observed, including the state of muscle contraction and relaxation, and the function and movement trajectory of the tendons are evaluated. Finally, based on the obtained ultrasound images and the type and severity of tendon disease, as well as the relevant information of the patient, a more personalized treatment plan is developed for the patient.

3. Evaluation of the diagnosis and treatment effect of tendon diseases using computer ultrasound images

3.1. Materials and methods

3.1.1. General information

One hundred and thirty-five patients with tendon diseases due to athletic injury treated in a local tertiary hospital during March 2021–September 2023 were selected for the study, including 96 males and 39 females. All patients were classified into three groups according to the randomization method, namely, control group 1, control group 2 and research group, with 45 patients in each group. Among them, control group 1 utilized MRI (Magnetic Resonance Imaging) diagnostic method, while control group 2 used conventional diagnostic method, and no other diagnosis was performed. The research group used computer ultrasound images for diagnosis. The comparison of age and gender data among the three groups of patients with tendon diseases caused by athletic injuries was not significant, and the difference was not statistically significant ($P > 0.05$). General information about the patients is displayed in **Table 1**.

Table 1. General information about the patients.

Order number	Content	Control group 1		Control group 2		Research group	
1	Age	15–49		14–50		15–51	
2	Average age	(25.21 ± 4.14)		(24.19 ± 5.26)		(24.58 ± 4.78)	
3	*P* value	0.531		0.712		0.653	
4	Gender	Man	Woman	Man	Woman	Man	Woman
5	Number of people	31	14	33	12	32	13
6	*P* value	2.121		2.365		2.426	
7	Body weight (kg)	(61.56 ± 14.89)		(62.13 ± 15.41)		(63.27 ± 14.68)	
8	*P* value	3.142		2.825		3.179	
9	Sex ratio	31/14		33/12		32/13	

The inclusion criteria include: 1) sunken surface of the tendon bursa; 2) poor continuity of tendons during passive movement. The exclusion criteria include: 1) patients with a history of joint surgery, 2) patients with trauma such as fractures, dislocations, and old flexor tendon rupture.

In this study, the researchers used randomization methods to select and assign patients. Simple randomization is used, and the sealed envelope method is used to ensure impartiality. The envelope contains the patient's grouping information. These envelopes are opened by people who are not involved in the study after the patient agrees and informs the grouping results. In order to maintain the impartiality of the analysis, data analysts work without knowing the details of the grouping. As soon as patients are enrolled in the group, they are assigned to control group 1, control group 2 or research group according to a preset random list. This process is handled by an automated system to reduce human operation. The study also adopted a double-blind design to ensure that neither the patient nor the medical staff knew the specific group of patients, and to avoid expected effects or behavioral deviations. In order to achieve double blindness, the research team used a similar-looking diagnostic process and relied on unsuspecting third-party professionals for diagnosis and evaluation. In addition, in order to ensure that the diagnostic report does not disclose grouping information, the study uses a unified report template to display only the diagnostic results. These measures work together to greatly reduce the bias in the research, ensure the reliability and authenticity of the results, and thus accurately reflect the actual effect of computer ultrasound images in the diagnosis and treatment of tendon diseases.

3.1.2. Methods

(1) Equipment preparation

In order to ensure the accuracy of the diagnosis of tendon diseases caused by sports injuries, a high-resolution computer ultrasound imaging system is needed. This system must contain a dedicated tendon diagnostic probe, the frequency of which can be adjusted between 10–14MHz to meet the imaging needs of different tendon sites and depths. According to the examination site and the patient's condition, the appropriate probe needs to be carefully selected. High-frequency probes can provide clearer images and help detect minor tendon problems, while low-frequency probes are suitable for deep tissue imaging. The system should be equipped with the latest diagnostic software, with image analysis, measurement and report generation functions. The software should allow doctors to process ultrasound images in real time, such as adjusting the contrast, enlarging the image, etc., in order to more accurately observe the tendon condition. At the same time, the software should be able to quickly generate diagnostic reports and improve work efficiency. The inspection room environment is critical to image quality. Keep quiet, control the indoor temperature and lighting, and ensure that doctors can work in a comfortable environment. Before the inspection, the ultrasonic equipment needs to be preheated and calibrated to ensure its best performance.

(2) Patient preparation

In order to ensure the accuracy of ultrasound imaging and improve the comfort of the patient during the examination, the patient needs to be guided to take the appropriate position according to the site of the tendon to be tested. For example, when examining the Achilles tendon, the patient should lie prone, with his feet hanging down and his feet lightly raised, with his toes facing up to clearly show the Achilles tendon and reduce interference. For shoulder tendons, etc., the patient may need to sit or lie on the side, depending on the doctor's judgment. Before the examination, the doctor will use an erasable pen to mark the position of the tendon on the patient's skin in order to quickly locate the probe to ensure the accuracy of the examination, while helping the patient understand the process and avoid misalignment. Patients need to take off their clothes and accessories in the inspection area to prevent them from interfering with the image or causing discomfort. The doctor will keep the skin in the examination area dry and clean, and clean it if necessary. In order to improve the image quality and reduce the reflection of sound waves on the skin, a couplant will be applied. It is a non-irritating gel that can fill the gap between the probe and the skin and ensure the effective conduction of sound waves. Through these preparations, we can perform ultrasound examinations more accurately.

(3) Detailed description of the operation steps

After turning on the power, turn on the power supply of the ultrasonic system smoothly, wait for the system self-test to complete and enter the main operation interface. According to the examination needs, select the most suitable mode for tendon diagnosis from the preset diagnosis mode. Next, adjust the system parameters, such as depth settings, to adapt to the depth of different tendons; adjust the gain to optimize the image contrast; adjust the dynamic range to show more image details. These settings are critical to subsequent image quality. After ensuring that the probe is clean, the doctor places it lightly on the tendon position marked on the patient's skin to keep the probe in close and stable contact with the skin to avoid air bubbles or voids affecting sound wave conduction and image clarity. As needed, the doctor will fine-tune the position of the probe to obtain the best imaging angle. In order to fully observe the tendons, the doctor will use two scanning methods, horizontal and vertical. Horizontal scanning helps to assess the width, morphology and relationship between the tendon and the surrounding tissue; vertical scanning clearly shows the length, thickness and internal fiber structure of the tendon. Combining the two methods, doctors can obtain more comprehensive and detailed tendon information. During the scan, the doctor will collect images in a dynamic and static state, respectively. Moving images show changes in tendon movement, such as elongation, shortening, and abnormal movement; still images provide morphological and structural information when the tendon is at rest. The performance of these different states helps doctors more accurately assess tendon health. During the examination, the doctor will adjust the probe position, angle and system parameters, such as depth, gain, dynamic range, etc., in a timely manner according to the image quality to ensure that the image is clear and accurate. These detailed adjustments can maximize the performance of the ultrasound imaging system and provide patients with more accurate diagnostic services.

(4) Image analysis

In the ultrasound image, we must first check the continuity of the tendon to see if it is complete, without interruption or deletion. Then, we need to see whether the thickness of the tendon is uniform. Too thick or too thin may be problematic. At the same time, we must carefully observe whether there are signs of fracture inside the tendon, such as the separation or misalignment of the fiber bundle. In addition, it is necessary to check for calcification foci around or inside the tendon. These calcification foci will appear as high echo areas on the ultrasound image, which may be the result of tendon degeneration or injury. Next, we need to look at the echo strength of the tendon, which is an important indicator for evaluating the texture of the tendon. Normal tendons should have a uniform echo of medium intensity under ultrasound. If the echo weakens, strengthens, or is unevenly distributed, it may indicate problems such as edema, inflammation, or fibrosis of the tendon. At the same time, be wary of abnormal echo areas, such as low echo or no echo areas, which may indicate fluid accumulation, hematoma, or necrosis inside the tendon. Finally, we need to observe the movement of the tendons when the patient is active and evaluate their functional status. Through dynamic ultrasound imaging, the morphological changes of tendons in motion can be seen in real time. We need to observe whether the tendon movement is smooth, whether there is caton or abnormal activity, in order to assess the integrity and coordination of its motor function. If there is obvious pain, restricted movement, or abnormal stress concentration, it may be a tendon injury or lesion, which requires timely diagnosis and treatment.

3.1.3. Diagnostic criteria

The results of diagnosing tendons can be divided into several categories. If the tendon structure is intact and there is no abnormality, inflammation or damage, it is “no damage.” If the tendon is inflamed or degenerated due to long-term stress or overuse, such as tendinitis, it is a “chronic injury.” When part of the fibers of the tendon are damaged, but the function remains, it may manifest as swelling, pain, or weakening of strength. This is “partial injury.” And if the tendon is completely or almost completely broken, which seriously affects function and is accompanied by severe pain, it is a “full-layer injury.” We also pay attention to the “sensitivity” and “specificity” of diagnosis. Sensitivity measures the proportion of people who are truly sick who are diagnosed, while specificity measures the proportion of people who are actually healthy who are correctly judged to be disease-free. The overall effect of diagnosis depends on “accuracy”, that is, the degree of conformity between the diagnosis and the actual situation. The treatment effect is divided into effective, effective and ineffective, depending on the degree of improvement of the patient’s condition. The "total efficiency" is to consider the ratio of effective and effective. After treatment, we pay attention to the "elastic modulus value of the tendon", which reflects the hardness and elasticity of the tendon. The higher the value, the better the tendon recovery, and the stronger the strength and toughness. At the same time, we also used the visual simulation scoring method to evaluate the "degree of pain", and the decrease in the score indicates that the pain is reduced. Finally, "patient satisfaction" is also very important, it reflects the actual improvement of treatment in the patient's life. These indicators are selected because they can comprehensively evaluate the effectiveness of diagnosis and treatment, which is critical to optimizing treatment options and improving the quality of life of patients.

3.1.4. Treatment methods

(1) Deepening of preliminary assessment

During the preliminary assessment, in addition to looking at the computerized ultrasound diagnosis results, we must also synthesize the patient's medical history, their symptom description, and physical examination to make a comprehensive assessment. In this way, we can more accurately judge the type of lesion, such as tearing, inflammation or degenerative changes, and at the same time, we can assess the severity of the lesion and predict the development and recovery of the disease. This comprehensive assessment can provide a more accurate basis for our follow-up treatment plan.

(2) Formulation and refinement of personalized treatment plans

When formulating a treatment plan, we have to consider the specific situation of the patient. For physical therapy, we need to refine the plan according to the patient's condition, tolerance and rehabilitation. For example, patients in the acute phase may need cold compresses to reduce swelling and pain, while patients in the chronic phase can use hot compresses or physiotherapy to help blood circulation and reduce inflammation. During the treatment process, we must also look at the effect regularly and adjust the plan at any time.

During drug treatment, pay attention to the side effects of the drug, and also consider whether the patient is allergic to certain drugs, as well as their liver and kidney function. When using non-steroidal anti-inflammatory drugs, control the dose and course of treatment to avoid adverse reactions. When treating with local closed injection, it is necessary to clarify the indications and contraindications to ensure that the treatment is safe and effective.

Rehabilitation training should also be personalized according to the patient's age, occupation and exercise habits. During training, pay attention to the patient's recovery and adjust the intensity and content of the training. At the same time, it is necessary to educate patients so that they can pay more attention to and actively participate in rehabilitation training.

For patients in need of surgical treatment, we must formulate a detailed surgical plan after evaluating the condition and the patient's physical condition. The operation should be refined to reduce damage to the surrounding tissues. After surgery, wound care and rehabilitation training should be strengthened to help patients quickly recover and rebuild their functions. At the same time, regular follow-up visits are required to assess the effect of the operation and the progress of rehabilitation.

3.1.5. Parameter setting

Depth setting: According to the anatomical depth and position of the tendon, we usually set the depth parameter between 5–15 cm. For shallower positions like hand tendons, we may need to set a shallower depth, while for deeper tendons such as the back of the thigh, we need to set a deeper depth.

Gain adjustment: When diagnosing tendon diseases, we need to adjust the gain to clearly show the subtle structure and boundaries of the tendon. It should be noted that too high a gain may cause the image to be overexposed and the details to disappear; while too low a gain may make the image too dim and difficult to recognize. Fine-tuning needs to be made according to the actual quality of the image to ensure that the tendon structure is clearly visible.

The optimization of the dynamic range helps us better capture the fine structure and movement state of the tendon, such as the arrangement of fibers inside the tendon, tiny calcification points, and morphological changes in movement. By adjusting the dynamic range, we can make the image much delicate and rich in layers.

In addition, the frequency selection of the probe: the frequency directly affects the resolution and penetration of the image. When diagnosing tendon diseases, we need to select the appropriate probe frequency based on the depth and location of the tendon. Generally speaking, the frequency of 10–14 MHz is suitable for most tendon examinations. High-frequency probes can provide finer images, but the penetration is slightly weaker; while low-frequency probes have strong penetration, but the resolution is lower. Therefore, comprehensive consideration is required when choosing.

Focus adjustment is also a key step in ensuring clear images. By adjusting the focus position, we can make the ultrasonic waves form the best focus at the tendon, thereby improving the resolution and contrast of the image, and making the tendon structure clearer.

The filtering settings cannot be ignored. Choosing the appropriate filtering mode can effectively reduce the noise interference in the image and make the tendon structure much prominent and clear. At the same time, the filtering settings also need to be adjusted according to the image quality and inspection requirements.

3.1.6. Statistical analysis

This study used SPSS 21.0, a powerful statistical analysis software, which is often used for data analysis in social sciences, medical research and other fields. We have adopted the following statistical methods: first, through data descriptive statistics, the average and standard deviation are used to show the central trend and dispersion of the data. Secondly, the *P*-value is used for hypothesis testing. The *P*-value can help us determine whether there is a significant difference between the research group and the control group. If the *P*-value is less than 0.05, it means that these differences are not just random, but statistically significant. Moreover, in order to compare the differences between different groups, we used an independent sample *t*-test. Finally, we also calculated a 95% confidence interval, which can help us estimate the true range of parameters and increase the reliability of the results. The calculation of this interval will take into account the average value, standard deviation and size of the sample, and the theory of *t* distribution or normal distribution will be used specifically. In general, these methods allow us to analyze the data more comprehensively and accurately, so as to draw more convincing conclusions.

3.2. Diagnostic results

3.2.1. Diagnosis outcomes of tendon injury

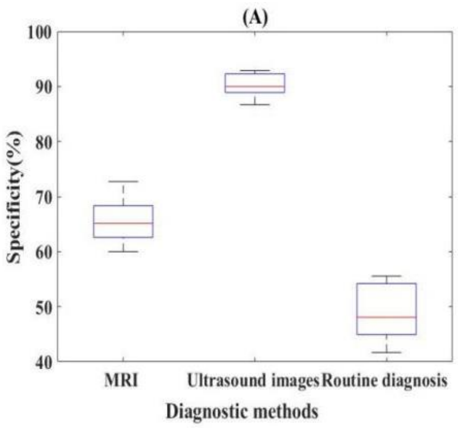
Tendon injury can be divided into non injury, chronic injury, partial injury, and full layer injury. By comparing different situations of tendon injury, the integrity and injury status of the tendon can be displayed, which is of great significance for the diagnosis and treatment of tendon diseases. This article summarized the results of 8 tendon diagnoses in three groups of patients, as presented in **Table 2**.

Table 2. Diagnosis results of 8 tendon injuries in three groups of patients.

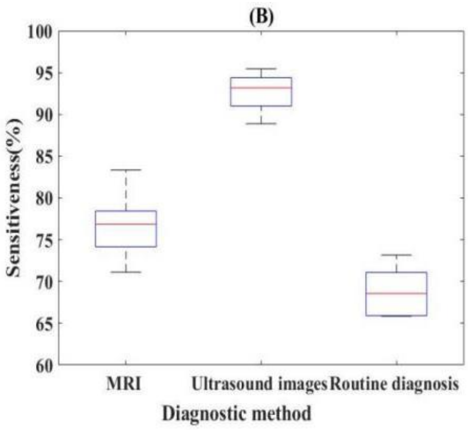
Frequency (control group 1)	No injury	Chronic injury	Partial injury	Full layer injury
1	6	21	15	3
2	8	13	18	6
3	7	11	22	5
4	9	14	14	8
5	10	16	18	1
6	9	13	19	4
7	7	16	17	5
8	9	18	16	2
Frequency (research group)	**No injury**	**Chronic injury**	**Partial injury**	**Full layer injury**
1	4	18	17	6
2	4	18	18	5
3	5	16	18	6
4	5	20	17	5
5	5	20	17	5
6	6	21	15	3
7	6	22	14	2
8	7	22	14	2
Frequency (control group 2)	**No injury**	**Chronic injury**	**Partial injury**	**Full layer injury**
1	3	25	16	1
2	6	19	15	5
3	7	22	12	4
4	9	25	8	3
5	6	22	13	4
6	9	17	15	4
7	7	20	16	2
8	9	20	13	3

From **Table 2**, it can be seen that there was a significant difference in the 8 diagnostic results between patients in control groups 1 and 2, and the changes in diagnostic results were unstable. The overall difference in the results of the eight diagnoses among the research group patients was relatively small, but compared to the first diagnosis, the number of cases with no injury increased at the eighth diagnosis, while the number of cases with full layer injury gradually decreased. This is because the patient's tendon injury has undergone varying degrees of changes due to different diagnostic times.

In addition, this article also analyzed the sensitivity and specificity of diagnosis for patients with tendon injuries. Among them, specificity is an essential indicator for evaluating diagnostic tests, and the higher the specificity, the less likely the patient is to be misdiagnosed or missed. Sensitivity refers to the proportion of samples that are actually positive and determined to be positive in diagnostic tests. It can help doctors capture early signals of tendon disease, timely intervention and treatment, and avoid worsening of the condition. It is a key criterion for accurate diagnosis of tendon disease. Therefore, this article counted the specificity and sensitivity of diagnosis in three groups of patients. The findings are illustrated as **Figure 3**.



(A) Diagnostic specificity results for three groups of patients.



(B) Diagnostic sensitivity results for three groups of patients.

Figure 3. Diagnostic specificity and sensitivity results for three groups of patients.

In **Figure 3A,B,** the horizontal axis represents the patient's diagnostic method; the vertical axis represents specificity and sensitivity, respectively.

From **Figure 3A,B,** it can be learned that the specificity and sensitivity of 8 diagnoses in control group 1 using MRI ranged from 60% to 72.73% and 71.11% to 83.33%, respectively; the research group of patients using computer ultrasound images had a specificity of 86.67% to 92.86% for 8 diagnoses, and a sensitivity of 88.89% to 95.45%; the specificity of 8 diagnoses in control group 2 using conventional diagnosis ranged from 41.67% to 55.56%, and the sensitivity ranged from 65.85% to 73.17%. From it, it can be seen that in the comparison of the specificity and sensitivity of the three groups of patients, the overall average specificity and sensitivity of the research group patients were significantly better than those of the control groups 1 and 2 patients, and the difference was statistically significant ($p < 0.05$). This indicates that computer ultrasound images can more accurately diagnose tendon diseases caused by athletic injuries, better assist doctors in capturing early signals of tendon diseases, and timely intervene and treat different tendon diseases to avoid worsening the condition, thereby better ensuring patient health, promoting better recovery, and playing an important role in subsequent treatment.

3.2.2. Overall diagnostic effect evaluation

Diagnostic accuracy is an important indicator for evaluating diagnostic effectiveness. This article summarized the accuracy results of 8 diagnoses for three groups of patients. The findings are illustrated as **Figure 4**.

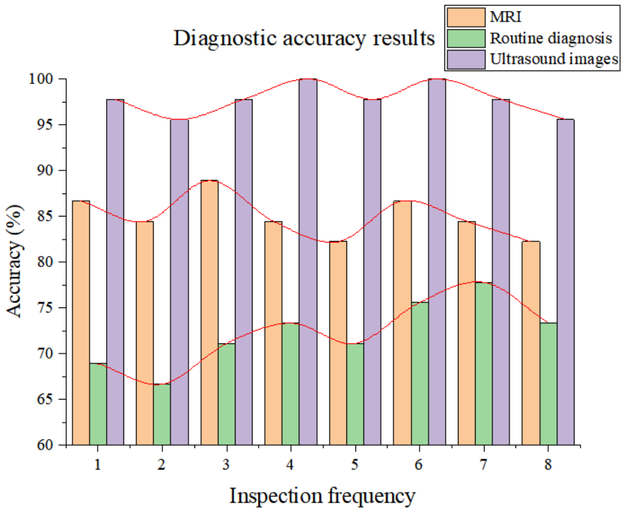


Figure 4. Comparison of accuracy results of 8 diagnoses among three groups of patients.

In **Figure 4**, the horizontal axis 1 to 8 indicates the number of diagnoses, and the vertical axis 60% to 100% indicates the accuracy of the diagnosis.

According to **Figure 4**, it can be learned that in the first diagnosis, the diagnostic accuracy of control group 1 using MRI was 86.67%; the diagnostic accuracy of control group 2 patients using conventional diagnosis was 68.89%; the diagnostic accuracy of the research group of patients using computer ultrasound images was 97.78%. In the fourth diagnosis, the diagnostic accuracy of control group 1 using MRI was 84.44%; the diagnostic accuracy of control group 2 patients using conventional diagnosis was 73.33%; the diagnostic accuracy of the research group of patients using computer ultrasound images was 100%. In the eighth diagnosis, the diagnostic accuracy of control group 1 using MRI was 82.22%; the diagnostic accuracy of control group 2 patients using conventional diagnosis was 73.33%; the diagnostic accuracy of the research group of patients using computer ultrasound images was 95.56%. From it, it can be learned that among the three groups of patients, the research group using computer ultrasound images had the highest diagnostic accuracy, followed by the control group 1 using MRI, and the control group 2 using conventional diagnostic methods had the lowest diagnostic accuracy. The average accuracy of eight diagnoses in control group 1 using MRI was approximately 84.999%; the average accuracy of eight diagnoses in control group 2 using conventional diagnosis was approximately 72.223%; the average accuracy rate of eight diagnoses for the research group of patients using computer ultrasound images was approximately 97.78%. From this, it can be learned that the overall accuracy of 8 diagnoses in the research group patients was significantly greater than that of control groups 1 and 2, with a statistically significant difference ($p < 0.05$).

In addition, this article also counted the effective rates of three sets of diagnoses. Diagnostic efficiency is one of the crucial indicators for evaluating the performance of computer ultrasound image processing systems. It can help doctors and researchers understand the accuracy and reliability of the system in diagnosing tendon diseases caused by athletic injuries. If the diagnostic effectiveness is high, then the system can be seen as an effective diagnostic tool to help doctors better diagnose and treat tendon diseases caused by athletic injuries. The diagnostic results of the three groups of patients are shown in **Table 3**.

Table 3. Diagnostic efficacy of three groups of patients.

Effect	Control group 1	Research group	Control group 2
Number of cases	45	45	45
Apparent effect	19	35	10
Effective	20	9	22
Invalid	6	1	13
Overall effective rate (%)	86.67%	97.78%	71.11%
P-value	0.012		0.008

According to **Table 3**, the overall diagnostic effective rate of patients in the research group reached 97.78%, while control group 1 only had 86.67% and control group 2 only had 71.11%. The overall diagnostic effective rate of the research group was significantly better than that of control groups 1 and 2, with significant differences between the groups and statistical significance ($p < 0.05$).

3.3. Treatment findings

Based on the diagnosis of tendon diseases, targeted treatment plans were developed. For patients with tendinitis, physical therapy, medication, and other methods were adopted; for patients with torn tendons, surgical treatment was required. Through computer image processing and analysis, the degree of disease and treatment effectiveness were accurately evaluated, thereby optimizing treatment plans. During the treatment process, the therapeutic effect can be evaluated through dynamic changes in ultrasound images. This article evaluated the treatment effect by measuring the elastic modulus of tendons and the degree of pain in three groups of patients, and calculated patient satisfaction.

3.3.1. Tendon elastic modulus value after treatment

Tendon elasticity can reflect the integrity and functional status of tendons. When evaluating the effectiveness of tendon treatment, the use of elasticity measuring instruments can understand the elasticity of the tendon and determine its degree of healing and functional recovery. This article tested the elastic modulus of tendons in three groups of patients at different times (taking the mean of the results). The results are illustrated in **Figure 5**.

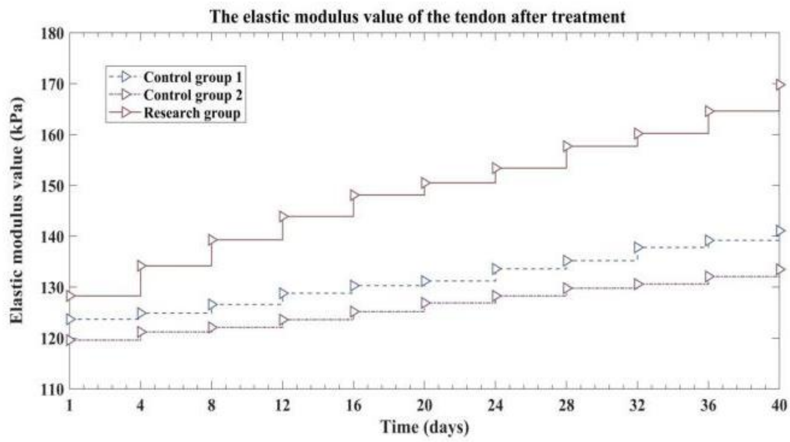


Figure 5. Comparison of tendon elastic modulus values among three groups of patients after treatment.

In **Figure 5**, the horizontal axis is the different time periods after treatment, and the vertical axis is the elastic modulus value of the tendon, in kilopascal (kPa).

From **Figure 5**, it can be seen that on the first day after treatment, the elastic modulus value of the tendon in control group 1 using MRI was 123.7 kPa; the elastic modulus value of the tendon in control group 2 using conventional diagnosis was 119.6 kPa; the research group of patients diagnosed using computer ultrasound images had a tendon elastic modulus value of 128.3 kPa. There was no significant difference in the elastic modulus of tendons between the research group and control groups 1 and 2 on the first day after treatment, and the difference was not statistically significant ($p > 0.05$). On the 20th day after treatment, the elastic modulus value of the tendons in control group 1 using MRI was 131.2 kPa, while in control group 2 using conventional diagnosis, the elastic modulus value of the tendons was 126.9 kPa. The elastic modulus value of the tendons in the research group diagnosed using computer ultrasound images was 150.5 kPa. The elastic modulus of tendons in the research group patients was significantly better on the 20th day after treatment compared to control groups 1 and 2, with a statistically significant difference ($p < 0.05$). On the 40th day after treatment, the elastic modulus value of the tendons in control group 1 using MRI was 141.1 kPa, while in control group 2 using conventional diagnosis, the elastic modulus value of the tendons was 133.5 kPa. The elastic modulus value of the tendons in the research group diagnosed using computer ultrasound images was 169.8 kPa. It can be seen that on the 40th day after treatment, the tendon elastic modulus value of the research group patients was significantly greater than that of control groups 1 and 2, with a statistically significant difference ($p < 0.05$). This suggests that using computer ultrasound images for diagnosis and treatment is beneficial for faster recovery of tendon function and promotes tendon healing.

3.3.2. Posttreatment tendon pain score results

Pain is one of the common symptoms of tendinosis. Assessing the degree of pain after treatment can help to gain a more intuitive understanding of the treatment effect. The tendon pain score refers to the visual simulation scoring method. Among them, a score of 0 represents no pain; a score of 1–3 represents mild pain; a score of 4–6 represents moderate pain; a score of 7–10 represents the degree of severe pain (the results are averaged). This article summarized the tendon pain scores of each group of patients at different time periods after treatment. The findings are illustrated as **Figure 6**.

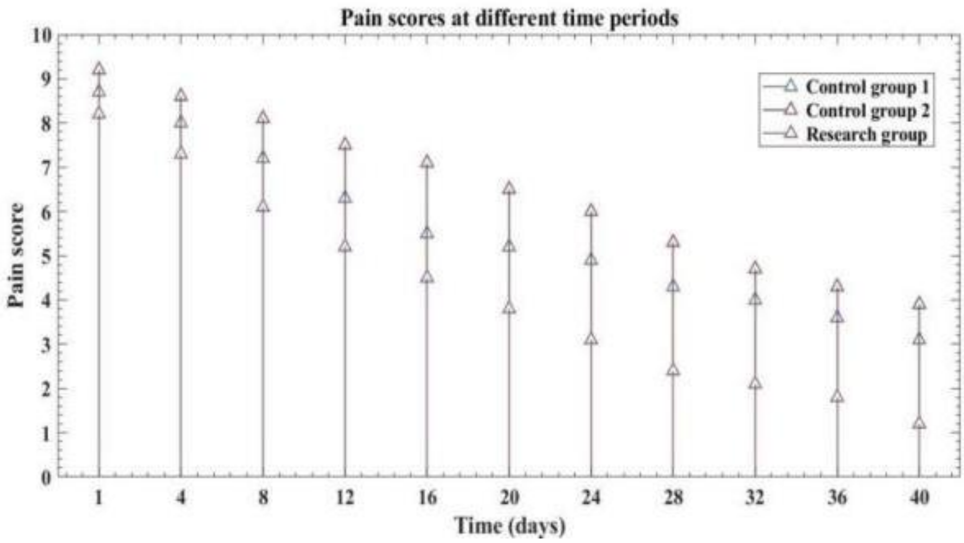


Figure 6. Comparison of tendon pain scores at different time periods after treatment among three groups of patients.

In **Figure 6**, the horizontal axis shows the different time periods after treatment, and the vertical axis shows the tendon pain score results.

As **Figure 6**, it can be learned that on the first day after treatment, the tendon pain score of control group 1 using MRI was 8.7 points, while the tendon pain score of control group 2 using conventional diagnosis was 9.2 points. The tendon pain score of research group patients using computer ultrasound imaging diagnosis was 8.2 points. It can be seen that on the first day after treatment, the tendons of the three groups of patients were in a severe pain state, and there was no significant difference in their initial pain scores after treatment, with no statistically significant difference ($p > 0.05$). On the 40th day after treatment, the tendon pain score of control group 1 using MRI was 3.1 points; the tendon pain score of control group 2 using conventional diagnosis was 3.9 points; the research group of patients diagnosed with computer ultrasound images had a tendon pain score of 1.2. On the 40th day after treatment, the tendon pain of the research group patients was already in a mild pain state and gradually approaching a painless state. The time required for pain relief in patients in the research group was significantly shorter than that in patients in control groups 1 and 2, with a statistically significant difference ($p < 0.05$). From this, it can be learned that using computer ultrasound images for the treatment of tendon diseases can better help patients alleviate pain and alleviate their pain, and has clinical value.

Finally, this article also counted the satisfaction of each group of patients with treatment. The results are described as **Table 4**.

Table 4. Comparison of treatment satisfaction among patients in each group.

Satisfaction level	Control group 1	Research group	Control group 2
Satisfaction	57.78%	88.89%	33.33%
P-value	0.037	0.008	
Same as	33.33%	8.89%	46.67%
P-value	0.041	0.032	
Dissatisfied	8.89%	2.22%	20%
P-value	0.052	0.046	

From **Table 4**, it can be learned that the proportion of patients in the research group who were satisfied with tendon treatment was significantly better than that of control groups 1 and 2, while the proportion of patients with average treatment satisfaction was significantly lower than that of control groups 1 and 2. In addition, there was no significant difference in the proportion of people who were dissatisfied with treatment between the research group and control group 1 ($p > 0.05$), but there was a significant difference compared to control group 2, with statistical significance ($p < 0.05$). This suggests that the satisfaction of patients in the research group who used computer ultrasound images to treat tendon diseases caused by athletic injuries is higher, and this method has more clinical value.

4. Discussion

Tendon lesions caused by athletic injuries are a common type of sports related disease in clinical practice. Among them, tendinitis, tendon rupture, and tenosynovitis are common tendon diseases [26,27]. Tenonitis refers to the excessive pulling or overuse of tendons during exercise, resulting in symptoms such as inflammation, swelling, and pain of the tendons [28]. This situation is more common among athletes, housewives, etc. Tendon rupture is mainly caused by trauma or external force, which causes the muscles to not contract and stretch normally, resulting in symptoms such as pain, swelling, and limited joint activity [29]. This situation is mainly caused by external injuries, sudden excessive force, long-term chronic wear, and other reasons. Synovial swelling, pain, and limited joint activity are mainly caused by synovial damage or inflammatory stimulation between tendons and joint capsules.

Computer ultrasound imaging is the use of high-frequency sound waves and computer processing technology to convert the echo signals generated by various tissues in the body into images for doctors to diagnose and analyze [30]. This method converts the spatial distribution of ultrasound echo signals into a pixel matrix representing a certain tissue or organ. Based on the strength and spatial distribution characteristics of the echo signal, corresponding grayscale or color processing is performed on each pixel to better reflect the acoustic characteristics of various tissues and organs. Compared with conventional ultrasound, computer ultrasound imaging has the advantages of high clarity, high resolution, high sensitivity and specificity, and can provide more accurate and detailed image information for ultrasound imaging. Ultrasound computer images can not only diagnose lesions, but also monitor therapeutic effects and determine the progression of the condition.

This study has found that computer ultrasound images have high sensitivity and specificity in the diagnosis of tendon injuries, especially in the diagnosis of partial tear of the supraspinatus tendon, which has its unique advantages. The development of computer ultrasound diagnosis technology relies on its portable and repeatable detection methods. Unlike MRI, computer ultrasound can dynamically scan tendon injuries and perform multiple repeated scans of the injured area. In addition, computer ultrasound examination can scan multiple postures of the upper limbs, making it easier to observe and examine changes in limb posture. The thinning of tendons is caused by joint site collision syndrome. Most of the cases studied in this article show thickened tearing injuries of the tendons, accompanied by hypertrophic synovial hyperplasia. Excessive proliferation of the joint synovium can affect ultrasound diagnosis, thereby affecting the judgment of tendon thickening. The computer ultrasound images, with their ultrasound dynamic gradient compression method, can effectively distinguish between normal and abnormal joints and joints with tendon defects.

This paper discusses the application of computerized ultrasound images in the diagnosis and treatment of tendon diseases. Compared with MRI and conventional methods, computerized ultrasound images have significant advantages in diagnostic accuracy and contribute to faster recovery of tendon elasticity in patients. This result has a positive impact on clinical practice in many ways and is in stark contrast to traditional treatment methods. Compared with traditional MRI, computerized ULTRASOUND image examination is faster, economical and convenient. It is suitable for real-time monitoring of tendon injuries, especially for emergency assessment and follow-up of sports injuries. In addition, the technology can more accurately locate tendon injuries and provide strong support for personalized treatment options, thereby improving the targeted treatment, avoiding waste of resources, and improving the efficacy. Studies have also shown that this technology can significantly improve tendon elasticity, speed up the rehabilitation process, and help patients return to normal activities faster. Through precise diagnosis and treatment optimization, computerized ultrasound imaging technology is expected to solve the problem of tendon injury more thoroughly, reduce the risk of recurrence, maintain patient health, and improve the quality of life. In addition, the technology also reduces the burden on the medical system, reduces hospitalization, follow-up and unnecessary treatment costs, and has a positive impact on public health economics. The popularization of computerized ultrasound image technology has promoted the progress of tendon disease research in the field of sports medicine, provided the direction and basis for the subsequent research and development of new diagnostic technologies and treatment methods, and promoted the overall development of the discipline.

Computerized ultrasound imaging technology has shown significant advantages in the diagnosis of tendon diseases caused by sports injuries. Compared with MRI and conventional diagnosis, its diagnostic accuracy rate is higher, reaching 97.78%, and it is more specific and sensitive to tendon injury. The technology can be dynamically monitored and scanned multiple times. It is suitable for different limb postures, which is conducive to observing tendon changes, and is especially good at diagnosing partial tears such as supramedial tendons. After treatment, the elastic modulus of the tendons of the patients in the research group was significantly improved, the pain was reduced, and the satisfaction was high, indicating that it has great potential in optimizing treatment options, accelerating rehabilitation, and improving the quality of life of patients. Computerized ultrasound image technology, with its noninvasive, immediate, low cost and high efficiency, has a wide range of applications, not only for professional athletes, but also for the majority of sports enthusiasts and people in need of tendon health management. It is expected to become the preferred tool for the diagnosis and treatment of tendon diseases in the future, especially in primary medical care and sports field real-time evaluation, it shows broad application prospects.

Computerized ultrasound images have significant advantages in the diagnosis and treatment of tendon diseases, especially in improving the accuracy of diagnosis, treatment effect and patient satisfaction. But medical technology always has limitations and potential side effects. Although its images are clear and high-resolution, the diagnostic ability of deep tissue damage may not be as good as MRI and other technologies. Ultrasonic images may also be disturbed by noise. Although image processing techniques have improved the quality, they still face challenges in complex anatomical structures or high-noise environments. In addition, the quality and interpretation of ultrasonic images are highly dependent on the skills of the operator, which may lead to unstable diagnostic results. Although the specificity and sensitivity of computerized ultrasound images are high, there is still a risk of misdiagnosis in some cases. At the same time, the popularization of technology, equipment costs and training requirements also limit its wide application. Nevertheless, the accuracy rate of computerized ultrasound images in the diagnosis of tendon diseases is still significantly higher than that of traditional methods, which helps to detect and treat problems in a timely manner. The increase in the elastic modulus value of the tendon after treatment shows that this technique can accelerate the recovery of the tendon and shorten the rehabilitation period. Patient satisfaction is high, and it shows that technology has a positive impact on improving patient comfort and trust. However, it is necessary to pay attention to the limitations of its deep diagnosis and the potential risk of misdiagnosis, and combine other imaging examinations or clinical manifestations to avoid missed diagnosis or misdiagnosis. At the same time, professional technical personnel and continuous technical training are required to maintain the quality of diagnosis.

5. Conclusions

With the widespread promotion of the current concept of national fitness and people’s attention to sports, tendon diseases caused by athletic injuries are also common. How to better diagnose and optimize treatment plans for tendon diseases caused by athletic injuries is the focus of current research. The theme of this article was to apply computer ultrasound images to diagnose and optimize treatment plans for tendon diseases caused by athletic injuries. Firstly, the background of the study was outlined, and then the strengths and weaknesses of previous scholars’ studies were summarized. Afterwards, the process of diagnosing tendon diseases using computer ultrasound images was analyzed in detail, and the processing of computer ultrasound images was emphasized. Finally, the effectiveness of computer ultrasound images in the diagnosis and treatment of tendon diseases was verified through empirical research. The research results showed that the diagnostic accuracy of tendon diseases in the research group using computer ultrasound images was significantly better than that in the control group 1 using MRI and control group 2 using conventional diagnosis. At the same time, the tendon elastic modulus of the research group patients after treatment was significantly greater than that in the control groups 1 and 2, with a statistically significant difference ($p < 0.05$), and the treatment effect was significantly improved. However, there are some shortcomings in this study. Computerized ultrasound imaging technology has significant benefits for the diagnosis and treatment of tendon diseases caused by sports injuries, and can improve diagnostic accuracy, rehabilitation speed and patient satisfaction. However, its limitations such as limited depth imaging, strong operational dependence, and insufficient popularity also need to be paid attention to. In the future, it is necessary to explore the effects of this technology on different tendon injuries and populations, combine AI and machine learning to improve the intelligence and accuracy of diagnosis, and conduct long-term follow-up to evaluate its impact on patients' long-term recovery and quality of life, with a view to bringing greater impact to sports medicine.

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