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The Role of Ultrasound Assessment in Achilles Tendon Pathology

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Abstract

Background: Tendons are connective tissues that transmit the force produced by muscle to bone and also prevent muscle damage by acting as shock absorbers. The Achilles tendon is the single largest, thickest and strongest tendon in the human body that transmit the force of powerful calf muscles to foot facilitating walking and running. This has long been known as a site susceptible to disabling injury. Forces up to 12 times bodyweight may arise during sporting activity. US performed with high-resolution linear-array probes has become increasingly important in the assessment of ligaments and tendons around the ankle because it is low cost, fast, readily available, and free of ionizing radiation.

Aim of the Work: To provide an overview of clinical applications of ultrasound in assessment of pathological Achilles tendons. And to demonstrate the role of ultrasound in diagnosis of Achilles tendon pathology after clinical diagnosis.

Patients and Methods: This study is a prospective study, it was conducted in Radiology Department at Ain-Shams University Hospitals (El-Demerdash) from September 2018 till March 2019. It included 20 patients who were referred from the orthopedics, sports medicine and physical medicine outpatients.

Results: In our study US was capable of detecting almost all Achilles tendon abnormalities with high accuracy. The main noticeable limitation was the assessment of the bone marrow. In our study, the sensitivity, specificity and accuracy for US for Achilles tendon were 100%, 75% and 95% respectively. Both US and MRI are used in the evaluation of superficial structures, such as tendons and ligaments. The choice between US and MRI in such evaluations is determined by availability, referring physician preference, and the experience of the radiologist because in many settings accuracies can be similar.

Conclusion: Ultrasonography is an accurate and sensitive modality in evaluation of the Achilles tendon, it and can be used either as primary tool of investigation or as complementary tool with MRI and even in some cases may be used as a final method of diagnosis without need for further correlation with any other imaging techniques.

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Key Words: *Ultrasound – Achilles tendon – Ultrasonography – MRI.*

Introduction

TENDONS are connective tissues that transmit the force produced by muscle to bone and also prevent muscle damage by acting as shock absorbers. The Achilles tendon is the single largest, thickest and strongest tendon in the human body that transmit the force of powerful calf muscles to foot facilitating walking and running **[1]**.

Achilles tendon disorders are among the more frequent maladies encountered in sports medicine. They are not only common but has shown enormous rise in incidence over the past three decades. They are commonly associated with overuse injuries and can affect quality of movement leading to thickening, vascularisation and hypoechogenicity of the diseased tendon **[2]**.

The various types of overuse tendon injuries include tendinopathies, peritendinitis and tendon rupture. Increased tendon thickness is the most commonly mentioned indicator of tendinopathies **[1]**.

US performed with high-resolution linear-array probes has become increasingly important in the assessment of ligaments and tendons around the ankle because it is low cost, fast, readily available, and free of ionizing radiation **[3]**.

US can provide a detailed depiction of normal anatomic structures and is effective for evaluating ligament integrity. In addition, US allows the performance of dynamic maneuvers, which may contribute to increased visibility of normal ligaments and improved detection of tears. It can facilitate accurate identification, localization and differentiation between synovial, tendinous and entheseal inflammation as well as joint, bursal and soft tissue fluid collection **[2,3]**.

Patients and Methods

Study setting:

This study was a prospective study, it was conducted in Radiology Department at Ain-Shams University Hospitals (El-Demerdash) from September 2018 till March 2019. It included 20 patients who were referred from the orthopedics, sports medicine and physical medicine outpatients, their age ranging from 17 to 60 years (13 males and 7 females).

Inclusion criteria:

The patients complained of acute posterior ankle pain, heel pain that might be induced by exercise specially with running, while some patients complained of continuous chronic pain even with walking as well as stiffness and limitation of movement in daily activities.

Patients were clinically diagnosed with Achilles tendon pathology, both sexes were included, all age groups were included.

Exclusion criteria:

- Patients with previous corticosteroids injection of the foot and ankle.
- Patients with previous surgery or fracture of the foot and ankle.

This study was conducted according to the guidelines of the Ethics Committee of our University and was approved by our institutional review board; all patients gave us written informed consent to be imaged in our study.

Study procedures:

All patients were subjected to the following:

- Informed consent from the patient or his guidance.
- Full history taking.
- Clinical evaluation.
- Explanation of the imaging procedure:
  - Real time high resolution ultrasonography.
  - Then complimentary MRI was done.

All scans were performed using the US scanner GE logic Pro7 with a high-resolution transducer after being clinically diagnosed and not oriented by the results of MRI of the ankle using (linear probe: 12MHz). The participants were examined in a prone position with the foot hanging over the edge of the bed in the longitudinal and transverse planes using conventional B-mode US. A standardized, preprogrammed scanning protocol (with optimized B-mode scanning parameters such as depth, frequency, focal zone and Doppler setting for perfusion) were used to ensure the consistency of the results obtained. The maximum Anteroposterior (AP) thickness and Cross-Sectional Area (CSA) of the Achilles tendon were measured in the transverse plane.

MRI examination technique:

- The examination done using Philips Intera 1.5 T (closed).
- Every patient lied supine with the ankle and foot in neutral position. No movement was allowed during examination by supporting the ankle using pads.
- The patients were examined by different pulse sequences including T1, T2, proton density, gradient echo and STIR. The examinations were done in different planes.

Statistical analysis:

Data was collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) Version 23. The quantitative data were presented as mean, standard deviations and ranges when parametric. Also qualitative variables were presented as number and percentages.

The comparison between groups regarding qualitative data was done by using Chi-square test.

Receiver Operating Characteristic curve (ROC) was used in the qualitative form to assess the sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and accuracy of U/S taking the MRI as a gold standard and also to assess the diagnostic accuracy of clinical findings taking the U/S as a gold standard.

Sensitivity: Probability that a test result will be positive when the disease is present (true positive rate, expressed as a percentage).

Specificity: Probability that a test result will be negative when the disease is not present.

Positive predictive value: Probability that the disease is present when the test is positive.

Negative predictive value: Probability that the disease is not present when the test is negative.

The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following:

- $p>0.05$: Non Significant (NS).
- $p<0.05$: Significant (S).
- $p<0.01$: Highly Significant (HS).

Results

This study comprised 20 patients, 13 males and 7 females, their age ranged from 17 to 67 years. Six subjects had acute posterior ankle pain and thirteen subject had chronic pain suggestive of Achilles tendon pathology while only one had no pain.

All subjects were clinically diagnosed with different Achilles tendon pathology. Ultrasonography was done as the main diagnostic imaging scan in this study then a complimentary MRI was done to confirm or exclude the findings of the US except one patient who had contraindication to MRI scan as he had a pace maker device.

After clinical examination 7 patients were diagnosed with tendinosis and 2 patients were diagnosed with complete tendon tear and confirmed later by US and MRI while the other 11 patients were wrongly diagnosed clinically (Table 1).

By US Achilles tendon pathology were detected in 17 cases (85%). There were no abnormalities detected in 3 patients, in 10 patients out of 17 one finding could be detected while in 6 patients 2 findings were depicted and only one patient showed 3 finding in US examination (Table 1).

MRI was done for 19 patients out of 20. MRI detected Achilles tendon pathology in 16 cases (80%). No abnormalities were detected in 3 patients. In 10 patients, one finding could be detected while 5 patients showed 2 findings and only one patient showed 3 findings (Table 1).

Table (1): Distribution of findings by clinical, U/S and MRI in the studied patients.

		No.	%
No. of findings by clinical	NAD	11	55.0
	One finding	9	45.0
No. of findigns by US	NAD	3	15.0
	One finding	10	50.0
	Two findings	6	30.0
	Three findings	1	5.0
No. of findings by MRI	NAD	4	20.0
	One finding	10	50.0
	Two findings	5	25.0
	Three findings	1	5.0

Based on the clinical diagnosis, 11 of the 20 patients were diagnosed as tendinosis only 7 (35%) were confirmed later by US and MRI and 2 patients were diagnosed as complete rupture and was confirmed by US and MRI (10%). Partial Achilles tendon rupture, peri-tendinitis, retrocalcaneal bursitis and xanthoma were not diagnosed clinically (55%).

Table (2): U/S findings among the studied patients.

US		No. (%)
Tendinosis	Negative	10 (50.0%)
	Positive	10 (50.0%)
Partial tear	Negative	17 (85.0%)
	Positive	3 (15.0%)
Complete tear	Negative	17 (85.0%)
	Positive	3 (15.0%)
Peri-tendinitis	Negative	18 (90.0%)
	Positive	2 (10.0%)
Retro-calcaneal bursitis	Negative	17 (85.0%)
	Positive	3 (15.0%)
Haglund's deformity	Negative	17 (85.0%)
	Positive	3 (15.0%)
Xanthoma	Negative	19 (95.0%)
	Positive	1 (5.0%)
Total	Negative	3 (15.0%)
	Positive	17 (85.0%)

Based on the ultrasound findings, 17 of the 20 cases were diagnosed with Achilles tendon pathology. 10 cases had tendinosis (50%) and 3 had partial tear (15%) and also 3 cases had complete Achilles tendon rupture (15%). Peri-tendinitis was noted in 2 patients (10%), 3 cases had retro-calcaneal bursitis (15%) and Haglund's deformity was depicted in 3 patients (15%) while only one case had Xanthoma (5%). On the other hand three cases had no significant Achilles tendon pathology (15%) (Table 2).

Table (3): MRI findings among the studied patients.

MRI		No. (%)
Tendinosis	Negative	10 (50.0%)
	Positive	10 (50.0%)
Partial tear	Negative	17 (85.0%)
	Positive	3 (15.0%)
Complete tear	Negative	17 (85.0%)
	Positive	3 (15.0%)
Peri-tendinitis	Negative	19 (95.0%)
	Positive	1 (5.0%)
Retro-calcaneal bursitis	Negative	18 (90.0%)
	Positive	2 (10.0%)
Haglund's deformity	Negative	17 (85.0%)
	Positive	3 (15.0%)
Xanthoma	Negative	19 (95.0%)
	Positive	1 (5.0%)
Total	Negative	4 (20.0%)
	Positive	16 (80.0%)

MRI confirmed tendinosis in 10 patients (50%), but revealed a partial rupture of the Achilles tendon in 3 cases (15%) and complete tear in 3 cases (15%). Only 1 patient was confirmed as peri-tendinitis (5%) while the other case that was diag-

nosed by US with peritendinitis couldn't be confirmed by MRI as he had a pace maker and he also had retro calcaneal bursitis. The other two cases that had retro calcaneal bursitis (10%) were confirmed by MRI and also three cases with Haglund's deformity (15%) as well as one case was confirmed to have Xanthoma (5%) (Table 3).

In comparison to US and also MRI, clinical diagnosis was poorly accurate. Partial tears, peritendinitis, retro-calcaneal bursitis and Haglund's deformity couldn't be diagnosed by only clinical examination (Table 4).

Table (4): Comparison between clinical and U/S findings.

	Clinical No. (%)	U/S No. (%)	Test value*	*p*-value	Sig.
Tendinosis:					
Negative	13 (65.0%)	10 (50.0%)	0.921	0.337	NS
Positive	7 (35.0%)	10 (50.0%)			
Partial tear:					
Negative	20 (100.0%)	17 (85.0%)	3.243	0.072	NS
Positive	0 (0.0%)	3 (15.0%)			
Complete tear:					
Negative	18 (90.0%)	17 (85.0%)	0.229	0.632	NS
Positive	2 (10.0%)	3 (15.0%)			
Peri-tendinitis:					
Negative	20 (100.0%)	18 (90.0%)	2.105	0.147	NS
Positive	0 (0.0%)	2 (10.0%)			
Retro-calcaneal bursitis:		17 (85.0%)	3.243	0.072	NS
Negative	20 (100.0%)	3 (15.0%)			
Positive	0 (0.0%)				
Haglund's deformity:		17 (85.0%)	3.243	0.072	NS
Negative	20 (100.0%)	3 (15.0%)			
Positive	0 (0.0%)				
Xanthoma:					
Negative	20 (100.0%)	19 (95.0%)	1.026	0.311	NS
Positive	0 (0.0%)	1 (5.0%)			
Total:					
Negative	11 (55.0%)	3 (15.0%)	7.033	0.008	HS
Positive	9 (45.0%)	17 (85.0%)			

p-value >0.05: Non significant.
p-value <0.05: Significant.
p-value <0.01: Highly significant.
*: Chi-square test.

Correlating US results with MRI results were insignificant. Almost all findings that were noted by US had been confirmed later by MRI (Table 5).

In our study, the sensitivity, specificity and accuracy for US for Achilles tendon were 100%, 75% and 95% respectively (Table 6) that agrees with Hartgerink et al., [4] who found that ultrasonography is effective in differentiation of full versus partial thickness tears or tendinopathy, with a sensitivity, specificity and accuracy of 100%, 83% and 92% respectively.

Table (5): Comparison between U/S findings and MRI findings.

	U/S No. (%)	MRI No. (%)	Test value*	*p*-value	Sig.
Tendinosis:					
Negative	10 (50.0%)	10 (50.0%)	0.000	1.000	NS
Positive	10 (50.0%)	10 (50.0%)			
Partial tear:					
Negative	17 (85.0%)	17 (85.0%)	0.000	1.000	NS
Positive	3 (15.0%)	3 (15.0%)			
Complete tear:					
Negative	17 (85.0%)	17 (85.0%)	0.000	1.000	NS
Positive	3 (15.0%)	3 (15.0%)			
Peri-tendinitis:					
Negative	18 (90.0%)	19 (95.0%)	0.360	0.549	NS
Positive	2 (10.0%)	1 (5.0%)			
Retro-calcaneal bursitis:					
Negative	17 (85.0%)	18 (90.0%)	0.229	0.632	NS
Positive	3 (15.0%)	2 (10.0%)			
Haglund's deformity:					
Negative	17 (85.0%)	17 (85.0%)	0.000	1.000	NS
Positive	3 (15.0%)	3 (15.0%)			
Xanthoma:					
Negative	19 (95.0%)	19 (95.0%)	0.000	1.000	NS
Positive	1 (5.0%)	1 (5.0%)			
Total:					
Negative	3 (15.0%)	4 (20.0%)	0.173	0.677	NS
Positive	17 (85.0%)	16 (80.0%)			

p-value >0.05: Non significant.
p-value <0.05: Significant.
p-value <0.01: Highly significant.
*: Chi-square test.

Table (6): Diagnostic accuracy of U/S in prediction of MRI results as a gold standard.

	TP	TN	FP	FN	Sensitivity	Specificity	PPV	NPV	Accuracy
• Tendinosis	10	10	0	0	100	100	100	100	100
• Partial tear	3	17	0	0	100	100	100	100	100
• Complete tear	3	17	0	0	100	100	100	100	100
• Peri-tendinitis	1	18	1	0	100	94.7	50	100	95
• Retro-calcaneal bursitis	2	17	1	0	100	94.4	66.67	100	95
• Hagland deformity	3	17	0	0	100	100	100	100	100
• Xanthoma	1	19	0	0	100	100	100	100	100
Total	16	3	1	0	100	75.0	94.12	100	95.0

Table (7): Diagnostic accuracy of clinical (total) in prediction of U/S results as a gold standard.

Clinical	Negative by U/S		Positive by U/S		Test value	*p*-value	Sig.
	No.	%	No.	%			
Negative	3	100.0	8	47.1	2.888	0.089	NS
Positive	0	0.0	9	52.9			

	TP	TN	FP	FN	Sensitivity	Specificity	PPV	NPV	Accuracy
Clinical (total)	9	3	0	8	52.9%	100.0%	100.0%	27.3%	60.0%

US is very useful in diagnosing Achilles tendon pathology as the clinical diagnosis without imaging is inconclusive its sensitivity, specificity and accuracy in our study was 52, 9%, 100% and 60% respectively (Table 7).

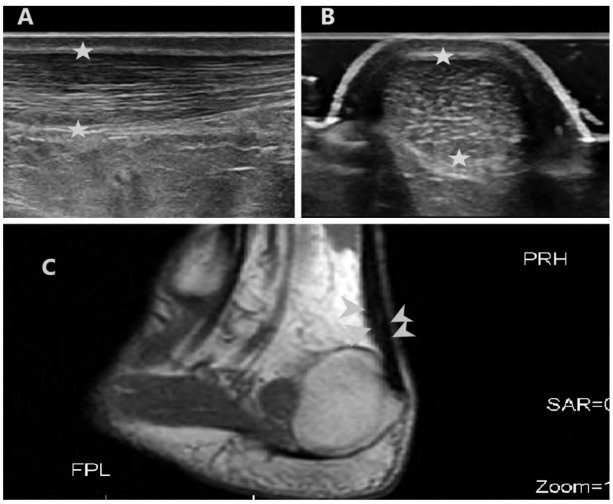

Fig. (1): Longitudinal (A) and transverse (B) US images of a 30 years old male patient, runner, suffers from chronic ankle pain, showing thickened AT (stars) with hypo-echogenicity and preserved fibers (C) T1 weighted MRI image showing thickened distal portion of the AT (arrows) with no course interruption denoting AT Tendinosis.

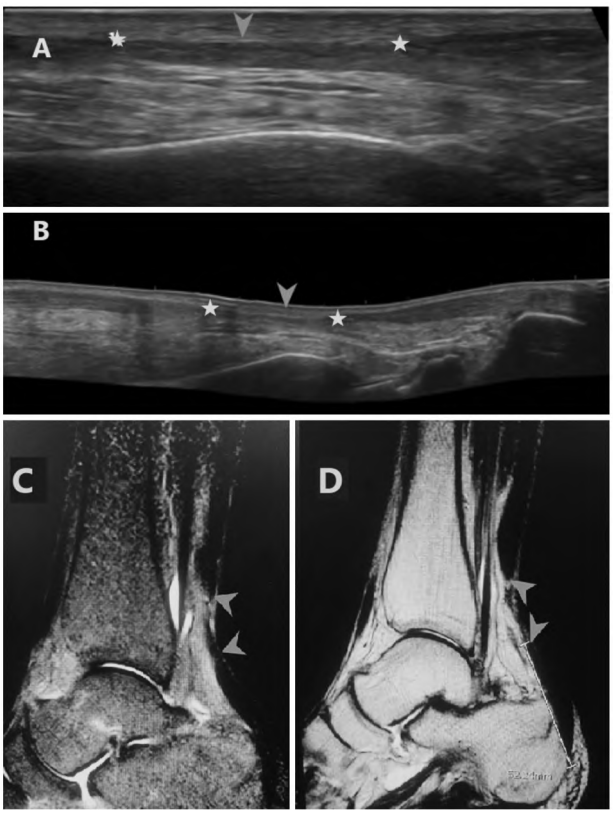

Fig. (2): Longitudinal (A) and panoramic (B) views of AT in A 40 years old male patient complains of acute ankle pain after twisting his ankle accidentally, AT showing full thickness tear of the mid segment (stars) with gapping (arrows), the cut edges are thickened with hypo-echoic texture. MRI, STIR-Sagittal (C) and T2WI sagittal (D) showing full thickness tear of the AT with gapping (arrows).

Discussion

It has been reported by Jacobson (2009) [5] that it has high significance in assessing soft tissue lesions found near metallic implants. Despite the improvement in CT and MRI in suppression of the metallic artifacts, yet US proved to be ideal in this entity as in the setting of presence of abscess or a tendon near a metallic plate or screw.

This work included 20 patients, with age ranging from 17 to 67 years. Thirteen patients complained of chronic ankle pain (65%), however acute pain and limitation of movement in daily activities and stiffness was also a common complaint, this is agreement with Berquist [6] who state that in most patients suffering from ankle lesions, pain is the most common and most annoying clinical presentation.

The Achilles tendon is the strongest, largest and thickest tendon in the body, but all literature agreed that it is the most commonly injured ankle tendon.

Most of the Achilles tendon sport injuries occur in males, mainly due to higher male participation in males. In agreement with Kvist (1994) [7] who reported that males are more affected when it comes to ankle injuries, males account for 65% of all injuries in our study.

The spectrum of Achilles tendinopathy varies between tendinosis, tendinitis, peritendinitis, and partial or complete tendon tears. MSK US plays a vital role in differentiating these underlying causes from each other.

In our study, US succeeded to classify Achilles injuries similar to MRI regarding tendinosis, partial tear, and complete tear as well as insertional and peritendinious paythology Similarly, Liffen [8] and Margetic et al., [9] reported that ultrasound has been used as a first-line approach for assessing Achilles tendon disorders and stated that it has 100% sensitive in detecting Achilles tendon injuries in 26 cases.

Ultrasound was done for all patients, we found that tendinosis was the most common Achilles pathology among our cases Fig. (1), this is in line with El-Liethy and Kamal [10] who stated that Tendinosis was the most encountered tendon pathology. We had ten patients out of 20 who were diagnosed with tendinosis by US and MRI.

In our study we depicted 2 cases of tendo Achilles peritendinitis and was readily detected by US but only one was confirmed by MRI as the other

case had a pace maker.those results were in line with Bianchi et al., [11] study in which they summarized the signs of tendinopathy in three main signs: Increased A-P diameter of the tendon in the zone of the abnormality 8-10mm, swollen edematous tendon with heterogeneous echogenicity (tendinosis), and fluid surrounding the tendon (peritendinosis).

In our study we were able to differentiate between partial tear and tendinosis, as we depicted 3 cases of partial tear by US and confirmed by MRI, although it was missed clinically.

This is in agreement with Margetic et al., [9] and Mansour and Jain [12] who stated that the use of either sonography or MRI had demontrated a high degree of differentiation in helping to distinguish partial thickness from tendinosis. However, this distinction may not be of great clinical importance since a partial thickness tear or tendinosis, in the absence of a full thickness tear, is usually treated with non-surgical means.

Full thickness tear was diagnosed in three cases depending on the presence of a lot of sonographic signs mainly presence of tendon gapping Fig. (2) that was found in the whole 3 cases, we studied the tendon retraction with the foot in neutral, dorsiflexion, and plantar flexion positions and we found out that it was increased with dorsiflexion position to be 1cm., this agreed with Hartgerink et al., [4], posterior acoustic shadow was seen in two patients, Kager fat herniation was also found in two patients. However in one of these three cases it was diagnosed as acute full thickness tear as a result of the presence of hypoechoic hematoma filling the tendon gap.

In our study three cases were diagnosed with retro-calcaneal bursitis and were readily detected by US but only 2 was confirmed by MRI as the other case had a pace maker.

Another three cases were diagnosed with Haglund's exostosis which is the prominent osseous protuberance at the postero-superior margin of the calcaneus [13].

One case was diagnosed with xanthoma which are painless soft tissue masses occurring most commonly at the distal one-third of the tendon and are usually bilateral and symmetrical [8]. This is in line with Gurgenidze et al., [14] who stated that US can be used as the criterion standard not only in traumatic injuries of the foot but also in the diagnosis of inflammatory diseases and conditions, such as soft tissue masses, and that the management of further radiologic examination decisions should be given in light of US findings.

In our study, the sensitivity, specificity and accuracy for US for Achilles tendon were 100%, 75% and 95% respectively (Table 7) which coincident with Hartgerink et al., [4] who found that US is effective in differentiation of full versus partial thickness tears or tendinopathy, with a sensitivity, specificity and accuracy of 100%, 83% and 92% respectively.

US is very useful in diagnosing Achilles tendon pathology as the clinical diagnosis without imaging is inconclusive, its sensitivity, specificity and accuracy in our study was 52, 9%, 100% and 60% respectively (Table 7).

This is in contrast with Garras et al., [15] who stated that clinicians should rely primarily on the history and physical examination and have heightened awareness of a potential Achilles lesions based on the mechanism of injury for accurate diagnosis and management and reserve imaging for ambiguous presentations.

We should mention that our study had few limitations such as:

- The sample size wasn't enough to demonstrate all Achilles pathology causing ankle pain.
- The subjects were evaluated by one radiologist without confirmation of inter-observer agreement.
- No correlation with operative data depending only on MRI.

However, US could accurately diagnose a good number of cases of Achilles tendon abnormality. Our results showed that sensitivity of US was (100%) which was higher than specificity or better positive than negative with overall accuracy of (95%).

Although it remains operator dependent, yet the implementation of standardized protocols will minimize this pitfall and allow the presence of professional ultrasonographers. In comparison to other imaging modalities especially MRI, it is cheap, rapid, less invasive and with no risk of ionizing radiation if compared to plain radiography and CT.

Conclusion:

In Conclusion, US is an accurate and sensitive modality in evaluation of the Achilles tendon, it and can be used either as primary tool of investigation or as complementary tool with MRI and even in some cases may be used as a final method

of diagnosis without need for further correlation with any other imaging techniques.

US provides a good alternative to other modalities, such as MRI, for diagnosing Achilles tendon pathology. It can be used as first step scan, and if negative and the patient is still complaining; complementary MRI should be done. If US findings are positive and are going with the patient clinical diagnosis; no further investigation is needed.

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دور الموجات فوق الصوتية فى تقييم إختلال وظائف وتر آخيل

يتعرض وتر آخيل للإصابة غالباً نتيجة الإستخدام المفرض آو التعرض للإصابة المباشرة وتتناول هذه الدراسة دور الموجات فوق الصوتية فى تشخيص الإصابات المختلفة فى وتر آخيل.

تتميز الموجات فوق الصوتية بآنها الآكثر آماناً وتوافراً وآيضاً من آدق وسائل التشخيص بالآشعة حيث يمكن القيام بالفحص فى وقت قياسى وبوضع مريح للمريض كما يوفر تقييم ديناميكى للوتر والمنطقة المحيطة به ومقارنته بالقدم الآخرى الغير مصابة ودون التعرض لخطر التعرض للإشعاع المضر.

شملت هذه الدراسة ٢٠ مرض تتراوح آعمارهم بين ١٧ و٧٠ عاماً وآجريت خلال الفترة بين سبتمبر ٢٠١٨ ومارس ٢٠١٩. تم فحص هؤلاء المرضى إكلينيكياً فى عيادات العظام والعلاج الطبيعى وعيادات الطب الرياضى ثم تم الفحص بواسطة الموجات فوق الصوتية كما تم فحصهم بالرنين المغناطيسى لاحقاً لتآكيد النتائج.

فى هذه الدراسة كان الفحص بالموجات الصوتية قادراً على تشخيص جميع إصابات وتر آخيل وبدقة عالية آكثر دقة وحساسية من الفحص الإعتماد على الفحص الإكلينيكى وحده وكانت النتائج متماثلة تقريباً مع نتائج فحص الرنين المغناطيسى.