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High-Resolution Ultrasonography Versus MRI in the Diagnosis of Achilles Tendon Lesions

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ABSTRACT

Achilles tendon lesions are commonly assessed using noninvasive imaging methods such as ultrasound and magnetic resonance imaging (MRI). Both techniques are well-established in diagnosing and evaluating the condition of the Achilles tendon. This prospective study aimed to compare the diagnostic efficacy of high-resolution ultrasonography and MRI in identifying Achilles tendon lesions. The focus was on understanding the respective strengths of each imaging modality in diagnosing different types of lesions, including tendinopathy, partial thickness tear, and full thickness tear. Twenty patients, aged between 23 and 63 years, participated in the study, presenting with symptoms ranging from posterior ankle pain to limited movement and swollen ankles. Ultrasonography, performed with patients in a prone position, examined the Achilles tendon from its musculotendinous junction to its calcaneal insertion. MRI, conducted with patients in a supine position, utilized axial and sagittal T1, T2-weighted images, STIR, and proton density. Among the 20 patients examined, diagnoses included eight cases of tendinopathy, five cases of partial thickness tear (one inconclusive by ultrasound), and seven cases of full thickness tear. The results indicate that ultrasound is comparable to MRI in diagnosing tendinopathy and full thickness tear. However, MRI demonstrates superiority in identifying partial thickness tears, while ultrasound excels in early enthesitis detection. Ultrasound emerges as a valuable complementary diagnostic tool for Achilles tendon lesions, demonstrating effectiveness comparable to MRI in certain aspects. While MRI outperforms in diagnosing partial thickness tears, ultrasound proves superior in the early detection of enthesitis.

INTRODUCTION

The Achilles tendon, a robust band of fibrous tissue connecting the calf muscles to the heel bone, plays a pivotal role in facilitating ambulation and overall lower limb functionality, despite its robust nature, the Achilles tendon is susceptible to various pathological conditions, ranging from acute injuries to chronic degenerative changes, timely and accurate diagnosis of Achilles tendon lesions is imperative for initiating appropriate therapeutic interventions and preventing long-term complications (Silbernagel *et al.*, 2020). In the realm of diagnostic imaging, both high-resolution ultrasonography (HRUS) and magnetic resonance imaging (MRI) have emerged as valuable tools for assessing Achilles tendon pathology, each offering distinct advantages and limitations (Gatz *et al.*, 2021).

Historically, conventional diagnostic methods, such as physical examination and plain radiography, provided limited insights into Achilles tendon pathologies, the advent of advanced imaging modalities has revolutionized the diagnostic landscape, enabling clinicians to delve deeper into the structural and functional aspects of the tendon (Dams *et al.*, 2017). High-resolution ultrasonography, characterized by its non-invasiveness, cost-effectiveness, and real-time capabilities, has gained widespread acceptance as an initial diagnostic tool for Achilles tendon disorders. HRUS allows for detailed visualization of the tendon's morphology, facilitating the identification of abnormalities such as tears, tendinopathy, and bursitis (Tang *et al.*, 2022).

Magnetic resonance imaging, with its unparalleled soft tissue contrast and three-dimensional capabilities, has become the gold standard for evaluating musculoskeletal pathologies, including Achilles tendon lesions (Shalabi, 2004). MRI provides a comprehensive assessment of the tendon's integrity, revealing subtle changes in signal intensity indicative of degeneration, inflammation, or ruptures, MRI allows for a holistic evaluation of the surrounding soft tissues, aiding in the identification of associated conditions and providing a broader context for clinical decision-making (Chang & Miller, 2009).

Despite the advantages offered by both HRUS and MRI, the choice between these imaging modalities in the diagnosis of Achilles tendon lesions remains a subject of debate, several factors, including availability, cost, patient preferences, and the specific clinical scenario, influence the selection of the most appropriate imaging technique (Dams *et al.*, 2017). The comparative diagnostic accuracy of HRUS and MRI in detecting Achilles tendon lesions has been a topic of interest among researchers and clinicians (Gatz *et al.*, 2021). Existing literature highlights the sensitivity and specificity of HRUS in detecting Achilles tendon pathologies, emphasizing its utility as a first-line imaging modality, the real-time imaging capabilities of HRUS enable dynamic assessments of the tendon during various ankle movements, providing valuable functional information (Dams *et al.*, 2017).

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MRI underscore its ability to provide high-resolution cross-sectional images, aiding in the precise localization and characterization of Achilles tendon lesions, the multiplanar imaging capabilities of MRI offer a comprehensive view of the tendon, enabling the identification of subtle changes that may be missed on ultrasonography, the drawbacks of MRI, including higher costs, longer imaging times, and contraindications for certain patients, have fueled the ongoing discourse on the most judicious use of this modality in routine clinical practice (Szaro *et al.*, 2021).

LITERATURE REVIEW

Gross Anatomy of the Achilles Tendon

The Achilles tendon, renowned as the body's most substantial tendon, is a robust connective tissue structure crucial for lower limb biomechanics, which originates from the convergence of the gastrocnemius and soleus muscles in the calf, forming a tendon that inserts into the calcaneus, and composed primarily of collagen fibers arranged hierarchically, the Achilles tendon endows the ankle joint with strength and elasticity essential for activities like walking, running, and jumping, its histological composition contributes to the tendon's ability to withstand considerable tensile forces while accommodating the dynamic movements of the ankle (Freedman *et al.*, 2014). High-resolution ultrasonography (HRUS) and magnetic resonance imaging (MRI) serve as invaluable tools in delineating the gross anatomy of the Achilles tendon. HRUS, utilizing a high-frequency transducer, provides real-time images with exceptional spatial resolution, allowing for dynamic assessments during ankle movements, study by Khan *et al.* (2003) have emphasized HRUS's capability to capture subtle alterations in the tendon's contour during plantarflexion and dorsiflexion, providing insights into its functional dynamics (Khan *et al.*, 2003). MRI, with its superior soft tissue contrast and multiplanar imaging capabilities, excels in offering detailed cross-sectional views of the Achilles tendon's structure. This imaging modality provides a comprehensive assessment of the tendon's integrity, enabling the identification of subtle changes indicative of degeneration, inflammation, or ruptures, study by Szaro *et al.* (2021) underscores MRI's ability to precisely visualize the different components of the tendon, aiding in the identification of partial tears and complete ruptures (Szaro *et al.*, 2021).

Understanding the gross anatomy of the Achilles tendon is fundamental for interpreting imaging findings accurately, both HRUS and MRI contribute significantly to this understanding, providing clinicians with a detailed insight into the structural nuances of the tendon, as we navigate through the comparative analysis of HRUS and MRI in diagnosing Achilles tendon lesions, this foundational knowledge of the tendon's gross anatomy will play a pivotal role in contextualizing the diagnostic capabilities of these imaging modalities (Pierre-Jerome *et al.*, 2010).

Pathology of Achilles Lesions

Achilles tendon lesions encompass a spectrum of pathological conditions, each presenting unique challenges in diagnosis and treatment, Tendinopathy, characterized by degenerative changes within the tendon without complete rupture, is a common affliction associated with pain, swelling, and functional impairment, High-resolution ultrasonography (HRUS) and magnetic resonance imaging (MRI) have proven instrumental in detecting early signs of tendinopathy (Ferguson *et al.*, 2019).

HRUS, with its high spatial resolution, enables the identification of hypoechoic areas within the tendon, indicative of intratendinous degeneration, the real-time imaging capabilities of HRUS facilitate dynamic assessments, allowing clinicians to visualize alterations in the tendon's structure during movement. Conversely, MRI's ability to capture alterations in signal intensity aids in the early diagnosis of tendinopathy, providing valuable information for timely intervention (Hodgson *et al.*, 2012).

Partial tears, representing an intermediate stage between tendinopathy and complete ruptures, pose diagnostic challenges due to their variable presentations, HRUS, with its dynamic imaging capabilities, can reveal disruptions in the tendon's continuity during ankle movement, aiding in the identification of partial tears, MRI's multiplanar imaging, offering detailed cross-sectional views, facilitates precise localization and characterization of partial tears, contributing to comprehensive diagnostic insights (Maffulli *et al.*, 2011).

Complete ruptures, often associated with sudden forceful activities, require prompt and accurate diagnosis for appropriate management HRUS, with its real-time imaging capabilities, visualizes complete disruption of the tendon fibers, enabling immediate identification of ruptures(ElMaraghy *et al.*, 2008). MRI, with its ability to capture the extent of soft tissue damage and evaluate associated injuries, plays a crucial role in planning surgical interventions and predicting postoperative outcomes (Nunna *et al.*, 2023).

The nuanced capabilities of HRUS and MRI in delineating the pathology of Achilles tendon lesions contribute to their complementary roles in clinical practice, as we delve into the comparative analysis of these imaging modalities, understanding their efficacy in capturing the diverse manifestations of Achilles tendon pathology becomes imperative for informed decision-making in the diagnostic and therapeutic landscape (Aström *et al.*, 1996).

Technique for Imaging the Achilles Tendon

The diagnostic efficacy of imaging modalities in assessing Achilles tendon lesions is intricately tied to the techniques employed during examinations, both high-resolution ultrasonography (HRUS) and magnetic resonance imaging (MRI) have established protocols, each offering unique advantages in capturing the structural and pathological nuances of the Achilles tendon (Dams *et al.*, 2017).

HRUS involves the use of a high-frequency transducer, typically ranging between 7-18 MHz, to obtain detailed real-time images of the tendon. Patient positioning is crucial, often in a prone or supine stance, allowing easy access to the posterior aspect of the ankle. Dynamic imaging, including ankle plantarflexion and dorsiflexion, enhances the assessment by providing insights into the tendon's response to stress. Doppler ultrasound can be incorporated to evaluate vascularity, aiding in distinguishing between inflammatory and degenerative conditions (Corvino *et al.*, 2022).

MRI utilizes a strong magnetic field and radiofrequency pulses to generate detailed images. Various sequences, such as T1-weighted, T2-weighted, and fat-suppressed sequences, offer different contrasts for a comprehensive assessment. The patient is positioned feet-first in the MRI scanner, with the ankle typically in a neutral position. Administration of gadolinium-based contrast agents may enhance the visualization of vascularity and inflammatory changes within the tendon (Schmidt & Payne, 2015).

Comparative studies, such as that conducted by Alahmari *et al.* (2022), underscore the importance of standardized protocols in ensuring reliable results from both HRUS and MRI. Meticulous attention to patient positioning, imaging parameters, and the incorporation of dynamic assessments optimizes the diagnostic potential of these modalities (Alahmari *et al.*, 2022).

Understanding the nuances of imaging techniques is pivotal for clinicians aiming to leverage the strengths of HRUS and MRI in diagnosing Achilles tendon lesions, as we navigate through the comparative analysis, recognizing the impact of these techniques on diagnostic accuracy will contribute to a comprehensive understanding of the respective roles of HRUS and MRI in the clinical management of Achilles tendon pathologies (Reiman *et al.*, 2014).

This study aims to assess the diagnostic efficacy of high-resolution ultrasonography versus MRI in detecting Achilles tendon lmodality, providing valuable insights to optimize the diagnostic approach for identifying and characterizing Achilles tendon pathology.

MATERIALS AND METHODS

Study Design

This prospective study includes 20 patients whose ages ranged from 23 to 63 years and for the duration of one year between December 2019 to December 2020. Sixteen patients complaining of posterior ankle pain, while in six patients had ankle swelling, three had limitation of movements with walking, four patients were involved in a car accident while two patients had sport-related trauma. All patients were subjected to history taking and clinical provisional diagnosis. 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 informed consent to be imaged in our study. Privacy and confidentiality of all patients data were guaranteed and there has been a code number for every patient file that includes all investigations. All data provision were monitored and used for scientific purpose only.

Inclusion and Exclusion Criteria

The inclusion criteria for this study encompassed both males and females without any age predilection. Participants were required to present with unilateral posterior ankle pain and have a history of ankle trauma or problems resulting from a motor car accident. In contrast, the exclusion criteria excluded claustrophobic individuals who were unable to undergo MRI scans.

Clinical Examination

Patients underwent a comprehensive clinical examination, involving detailed history-taking encompassing personal, operative, drug, and family history. Specific clinical tests, such as the Thompson test and hyperdorsiflexion sign, were conducted to evaluate Achilles tendon problems.

Imaging Modalities

Ultrasound Examination

Ultrasound Examination performed using a PHILIPS HD 11 instrument with a 7–10 MHz probe, ultrasound examinations included longitudinal and transverse scans. Thickness measurements were taken in the short axis image.

MRI Examination

MRI examination conducted on a GE MSOW 1.5 Tesla machine with standard circular extremity coils. Sequences included scout T1-weighted images, axial and sagittal T1-weighted images, axial and sagittal T2-weighted images with fat suppression, and sagittal short-tau inversion recovery (STIR) images.

Ethical Approval

Ethical considerations for this study involve obtaining approval from the local committees in the radiology department, college, and university prior to its commencement. It is ensured that there is no conflict of interest related to the study, authorship, and subsequent publication. Moreover, the privacy of patient data and study results is a paramount concern, with a commitment to maintaining confidentiality. Patients possess the right to maintain control over their information and have the assurance that their data will be handled with the utmost discretion and respect for their privacy.

Statistical Analysis

Statistical analysis was performed using the statistical package for the social sciences (SPSS). Patient characteristics were analysed using descriptive data. Diagnostic data were statistically described in terms of frequencies (number of cases) and percentages when appropriate

RESULTS

Table 1 shows the demographic data of the studied group. Age ranged from 23-63 years with a mean age of 41.667±9.99 years. Male cases were 16 (80.0%) while female cases were 4 (20.0%)

Table 1: Distribution of studied sample according to patient's demographic data

	Number	Percent
Age (years)		
≤30	2	10.0
>30	18	90.0
Range	23-63	
Mean±S.D.	**41.667±9.99**	
Sex		
Male	16	80.0
Female	4	20.0

Table 2 shows complain/history of the studied group and it show that 16 (80.0%) had Posterior ankle pain, 6 (30.0%) had swelling, 4 (20.0%) had motor car accident (MCA), 3(15.0%) had limitation of movement and 2(10.0%) had Sport-related trauma.

Table 2: Distribution of studied sample according to patient's Complain/History

Complain/History	Number	Percent
Posterior Ankle Pain	16	80.0
Swelling	6	30.0
Motor Car Accident (MCA)	4	20.0
Limitation of Movement	3	15.0
Sport-related Trauma	2	10.0

Table 3 shows leg side of the studied group show that 6 (30.0%) are affected in left side and 14 (70.0%) are affected in right side.

Table 3: Distribution of studied sample according to patient's leg side

Leg Side	Number	Percent
Leg Side	6	30.0
Left	14	70.0
Right	20	100

Table 4: Distribution of studied sample according to anatomic location of lesion

Anatomic location	Number	Percent
Anatomic location	13	65
Around the Mid Portion	7	35
Insertion Site	20	100

Table 4 shows that 7 (35.0%) of cases are affected at the insertion site of the tendon while 13 (65.0%) are affected in the mid portion of the tendon.

Table 5 shows USG Findings of the studied group and it show that 7 (35.0%) patients had full-thickness tear, 4 (20.0%) partial-thickness tear and 9 (45.0%) had tendinopathy.

Table 5: Distribution of studied sample according to patient's USG Findings

USG Findings	Number	Percent
Full thickness tear	7	35.0
Partial thickness tear	4	20.0
Tendinopathy	9	45.0
Total	**20**	**100**

Table 6 shows MRI Findings of the studied group and it shows that 7 (33.0%) patients had full-thickness tear while 5 (26.0%) patients had partial-thickness tear and 8 (41.0%) patients had tendinopathy.

Table 6: Distribution of studied sample according to patient's MRI Findings

MRI Findings	Number	Percent
Full thickness tear	7	33.0
Partial thickness tear	5	26.0
Tendinopathy	8	41.0
Total	**20**	**100**

Table 7 shows USG diagnosis of the studied group show that 17(85.0%) had retro calcaneal bursitis, 10(50.0%) had enthesophyte, 12(60.0%) had Increased Tendon Thickness, 4(20.0%) had Partial Tear, 7(30.0%) had Full Thickness Tear and 20(100.0%) had altered intrasubstance signal of tendon.

Table 7: Distribution of studied sample according to patient's USG diagnosis

USG diagnosis	Number	Percent
Retro Calcaneal Bursitis	17	85
Enthesophyte	10	50
Increased Tendon Thickness	12	60
Partial Tear	4	20
Full Thickness Tear	7	30
Altered Intrasubstance Signal	20	100

Table 8 shows MRI diagnosis of the studied group show that 17(85.0%) had retro calcaneal bursitis, 4(20.0%) had enthesophyte, 12(60.0%) had Increased Tendon Thickness, 5(25.0%) had Partial Tear, 7(30.0%) had Full Thickness Tear and 20(100.0%) had Altered Intrasubstance Signal.

Table 8: Distribution of studied sample according to patient's MRI diagnosis

MRI diagnosis	Number	Percent
Retro Calcaneal Bursitis	17	85
Enthesophyte	4	20
Increased Tendon Thickness	12	60
Partial Tear	5	25
Full Thickness Tear	7	30
Altered Intrasubstance Signal	20	100

Table 9: Kappa agreement test between the two methods according to patient's diagnosis

Diagnosis	USG		MRI	
	No.	%	No.	%
Retro Calcaneal Bursitis	17	85	17	85
Enthesophyte	10	50	4	20
Increased Tendon Thickness	12	60	12	60
Partial Tear	4	20	5	25
Full Thickness Tear	6	30	6	30
Altered Intrasubstance Signal	20	100	20	100
Kappa Agreement	0.923			

The kappa coefficient was used to assess the agreement between USG and MRI. The strength of agreement on diagnosis is considered as good (k=0.923), as shown in Table 9.

DISCUSSION

The Achilles tendon, the largest and strongest tendon in the human body, is frequently prone to injury due to increased participation in sports-related activities and overuse conditions (Alrashidi *et al.*, 2018). The diagnostic evaluation of Achilles tendon abnormalities involves various imaging techniques, including plain radiography, computed tomography (CT), ultrasonography (US), and magnetic resonance imaging (MRI) (Moretti *et al.*, 2020).

According to Nyssonen (2020), Plain radiography and CT are limited in their ability to assess avulsion fractures, Haglund's deformity, or other bony pathologies (Moretti *et al.*, 2020). On the other hand, high-resolution US, particularly when performed with linear-array probes, has become increasingly important due to its cost-effectiveness, speed, availability, and lack of ionizing radiation. US provides a detailed depiction of normal anatomical structures and is effective in evaluating tendon integrity. Its dynamic capabilities enhance visibility, aiding in the identification, localization, and differentiation of various inflammatory conditions (Sconfienza *et al.*, 2015). The Achilles tendon, with its fibrillar echotexture on US, consisting of densely packed longitudinally arranged collagen fibers, is highly sensitive to early diagnosis of enthesitis. Moreover, US is more cost-effective than MRI for this purpose (Mascarenhas, 2020). However, MRI, with its superior multiplanar capability and soft tissue contrast, plays a crucial role in diagnosing tendon injuries. It offers valuable insights into abnormalities in bones and soft tissues that may not be immediately evident in other imaging modalities (Elgohary *et al.*, 2017).

The present study aimed to assess the role of high-resolution ultrasonography versus MRI in diagnosing Achilles tendon lesions. Inclusion criteria comprised 20 patients aged 23 to 63 years, presenting with ankle pain and, commonly, limitations in daily activities. The study noted a male predominance for Achilles lesions, aligning with findings from previous research (Nyyssönen, 2020).

The affected zone in the Achilles tendon was identified as the mid-portion, consistent with existing literature suggesting the zone of relative avascularity, located 2–6 cm from the calcaneal insertion, as commonly affected, Tendinopathy, particularly full or partial thickness tears, emerged as the most prevalent disorders in the study (Wong *et al.*, 2018).

Both US and MRI were utilized for diagnostic purposes, with tendinopathy diagnosed in eight cases through US. The study focused on the characteristic US and MRI findings for tendinopathy, partial thickness tear, and full thickness tear, including alterations in tendon morphology, echogenicity, and disruptions in tendon fibers (Hodgson *et al.*, 2012). The findings of the study align with existing literature on the diagnostic reliability of US in cases of tendinopathy, partial thickness tear, and full thickness tear. Ultrasound, with its dynamic and real-time capabilities, emerged as a valuable tool in primary clinics, offering advantages over static MRI, particularly in terms of cost-effectiveness and physiological movement visualization (Dong & Fessell, 2009). The diagnostic evaluation of Achilles tendon lesions requires a comprehensive understanding of the strengths and limitations of imaging modalities such as high-resolution US and MRI. These techniques play complementary roles, with specific advantages in different clinical scenarios. The study contributes valuable insights into the diagnostic accuracy of these imaging modalities, with implications for clinical practice and potential avenues for further research in the field (Dams *et al.*, 2017).

The Achilles tendon, considered the largest and strongest tendon in the human body, is frequently prone to injury due to increased participation in sports-related activities and overuse conditions (Alrashidi *et al.*, 2018). The diagnostic evaluation of Achilles tendon abnormalities involves various imaging techniques, including plain radiography, computed tomography (CT), ultrasonography (US), and magnetic resonance imaging (MRI) (Moretti *et al.*, 2020). Plain radiography and CT are limited in their ability to assess avulsion fractures, Haglund's deformity, or other bony pathologies (Nyyssönen, 2020). On the other hand, high-resolution US, particularly when performed with linear-array probes, has become increasingly important due to its cost-effectiveness, speed, availability, and lack of ionizing radiation. US provides a detailed depiction of normal anatomical structures and is effective in evaluating tendon integrity. Its dynamic capabilities

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CONCLUSION

In conclusion, the Achilles tendon, prone to injuries from sports activities, presents various conditions, and imaging modalities like MRI and ultrasound play crucial roles in diagnosis. While ultrasound is cost-effective and dynamic, MRI excels in assessing bone and soft tissue. Ultrasound complements MRI for tendinopathy and full-thickness tear diagnosis, but MRI proves superior for partial-thickness tears. The choice depends on clinical needs, with ultrasound excelling in early enthesitis detection.

Strengths and Limitations

The strength of this study is that the study contributes valuable insights into the diagnostic accuracy of high-resolution ultrasonography versus MRI in assessing Achilles tendon lesions, enhancing our understanding of their complementary roles in clinical practice. While the limitation is the study's sample size of 20 patients may limit generalizability, and further research with a larger cohort is warranted

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