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Does Clinical Exam and Ultrasound Compare With MRI Findings When Assessing Tendon Approximation in Acute Achilles Tendon Tears? A Clinical Study

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ABSTRACT

The purpose of this study was to determine if clinical palpation and ultrasound determination of apposition compares with magnetic resonance imaging (MRI) findings in patients with an acute Achilles tendon rupture. A review of 18 consecutive patients presenting with an acute Achilles tendon tear was performed. All tears were diagnosed by clinical exam and confirmed by ultrasound. Ankles were then plantarflexed to a point where tendon apposition was achieved as determined by palpation and ultrasound. Dorsally based equinus splints were applied, and approximation was reconfirmed by palpation and ultrasound. MRI was performed on all patients for comparison to the exam/ultrasound for any residual gapping after splinting. Demographic and clinical comparisons were made between those with <0.5 cm and ≥ 0.5 cm of residual gapping found on MRI. Eighteen patients with acute Achilles tears were splinted at a mean of $41° \pm 11°$, with presumed, complete tendon approximation confirmed with palpation and ultrasound. Post-splinting MRI demonstrated that 9/18 (50%) of these patients had residual gapping at a mean of 2.2 ± 1 cm. Mean time to MRI from splinting was not different between those with gapping (1.3 ± 2 days) and those without (1.2 ± 1 days). No other clinical or demographic differences were observed between these groups. In conclusion, clinical exam and ultrasound did not routinely relate to MRI in assessing tendon approximation after splinting of an acute Achilles tendon tear. For surgeons who use approximation as a determination of nonoperative treatment, varying results can be obtained depending on the clinical utility used.

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Acute Achilles tendon tears are not uncommon in young, active people. Although operative repair has traditionally resulted in significantly fewer re-ruptures compared to cast immobilization in equinus, more recent data have suggested that nonoperative treatment with a progressive functional rehabilitation program can yield re-rupture rates statistically similar to that of operative intervention (1–4). Given the potential complications that can occur with surgery in this location of the lower extremity, previous studies have attempted to clarify which acute tears are most amenable to nonoperative treatment. Assuming that tendon apposition will enable the tendon to heal with the correct length, 2 previous studies used ultrasound to determine the position of plantar flexion needed for apposition (5,6). The accuracy and reliability of ultrasound in determining apposition have not been previously established. Magnetic resonance imaging (MRI) has been shown to be more accurate than ultrasound in determining tendon cross-sectional area; however, MRI and ultrasound have never been compared regarding gap assessment in acute tears (7,8). MRI has, however, been deemed the appropriate diagnostic tool in the setting of insufficient ultrasound findings. This would suggest that MRI could be used as a standard to which ultrasound evaluation could be compared (9).

To our knowledge, no studies have attempted to determine the reliability of clinical exam, ultrasound, and/or MRI in determining residual gapping after immobilization of an acute Achilles tendon rupture. The purpose of our study was to determine if clinical palpation and ultrasound determination of apposition compared with MRI findings in patients with an acute Achilles tendon rupture.

Patients and Methods

This was an institutional review board–approved retrospective review of 18 consecutive patients who presented to a military treatment facility from October 2014 to October 2015 with an acute Achilles tendon rupture. Only patients aged 18 to 65 years with

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acute tears were included. Patients were excluded if they had a previous diagnosis of Achilles tendinosis and/or tear. All patients were initially seen, evaluated, and splinted by an orthopedic surgery resident within 48 hours of injury, either in the emergency department or in the orthopedic clinic. Ultrasound measurements and dorsally based splinting with re-measurement were all performed with attending surgeon supervision in the orthopedic clinic within this same timeframe. Demographic factors, mechanism of injury, radiographic findings, clinical exam findings, ultrasound findings, MRI findings, time elapsed between diagnostic interventions, and the amount of splinted plantarflexion required to maintain apposition were noted.

Diagnosis was made by physical exam by an orthopedic resident and confirmed by an attending orthopedic surgeon. Positive findings for an acute rupture included palpable defects, asymmetric Thompson's squeeze testing, and an asymmetric Matle's test (Fig. 1). All patients who presented were evaluated with plain radiographs to ensure that there were no other associated injuries. After a clinical diagnosis was established, all patients' affected extremities were plantarflexed until the tendon was approximated as determined by palpation. An ultrasound was then performed in the clinic to confirm tendon approximation in coronal and sagittal planes, and adjustments were made to confirm approximation with this modality (Fig. 2). Ultrasound was performed by the resident under the direct supervision of the staff surgeon on call. The degree of plantarflexion needed to obtain this approximation with a standard goniometer was noted. With this technique, all patients' gapping measurements after clinical exam and ultrasound were set at a value of "0 cm." Holding this degree of plantarflexion, the ankle was immobilized in a dorsally based plaster splint. Palpation and ultrasound was again performed to reaffirm approximation to 0 cm of gapping (Fig. 3). Patients were then sent for MRI studies with the splint in place to determine if approximation had been achieved/maintained. MRI studies were read by fellowship-trained musculoskeletal radiologists, and measurements of gapping were made using the PACS Software (Synapse, Fujifilm, Japan). Patients with gapping <0.5 cm were considered approximated, whereas patients with gapping ≥0.5 cm were considered to have positive gapping, as per the study by Kotnis et al (6). Additional analyses (similar to those described above) were performed for patients with >1.0 cm of gapping and also for patients with >2.0 cm of gapping. Patients were counseled by attending surgeons regarding operative or nonoperative intervention independent of the study findings with an accelerated rehabilitation program, as per the study institution's protocol.

Power analyses were conducted a priori to define needed sample size minima. Analyses showed that a minimum of 18 cases would be required to statistically verify that a minimum of 20% of clinicians preferring to have the diagnostic feedback was significantly greater than non (i.e., 0%) or neutrality. Levels for the power analysis were set at 0.80. Statistical analysis was performed with the chi-square test, Fisher's exact test, and paired Student's *t* test to determine if any differences in the study variables existed between patients with gapping and patients without gapping. Analyses were performed by a biostatistician. No external funding was received.

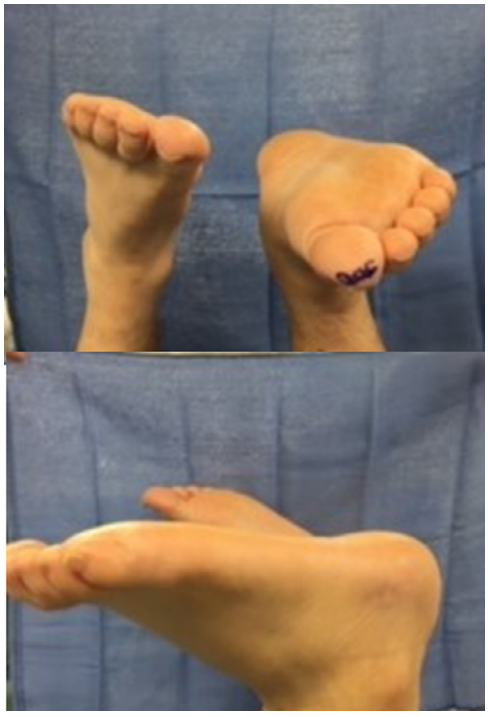

Fig. 1. Preoperative photo demonstrating a positive Matle's test on the right, indicating an Achilles tendon tear.

Results

Eighteen consecutive patients were identified over the 1-year study period. Their mean age was 36 ± 7.2 (range 24 to 50) years; 16/18 (89%) were men; and 13/18 (72%) were right sided ruptures. All injuries occurred from an athletic event, with basketball being the most common (Table 1). Radiographs were read as abnormal by a staff radiologist in 11/18 (61%) patients. Mean equinus angle of splinting at which exam and ultrasound suggested approximation was 41° ± 11° (range 20° to 55°). MRI was obtained at a mean of 1.3 ± 2 days (range 0 to 5 days) after evaluation/splinting. Nine of 18 (50%) patients demonstrated persistent gapping on MRI at a mean of 2.2 ± 1 cm (range 0.5 to 3.4 cm). The mean time to MRI from splinting in patients with persistent gapping (≥0.5 cm) was 1.3 ± 2 days (range 0 to 5 days), whereas the

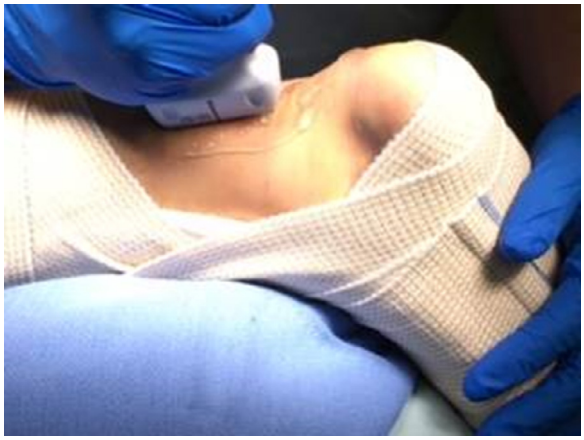

Fig. 3. Re-ultrasound and palpation after splinting to confirm approximation.

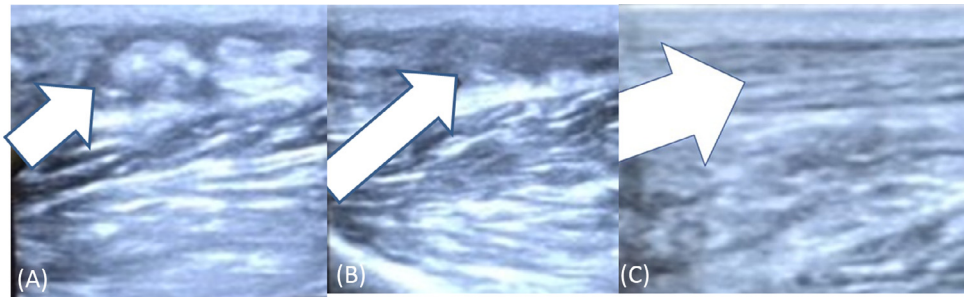

Fig. 2. Sagittal views of the Achilles tendon showing an acute tear (*A*) and reapproximation of a tear with plantarflexion (*B*). A sagittal ultrasound view of a normal tendon is given for comparison (*C*).

Table 1
Characteristics of patients presenting with acute Achilles tendon rupture

No.	Age	Sex	Mechanism	Side	US Degrees Plantarflexion (°)	MRI Read/Gap (cm)	Days to MRI
1	36	M	Running	R	30	0	3
2	41	M	Running	R	35	0	3
3	43	F	Soccer	R	35	2	3
4	41	M	Football	L	55	0	1
5	31	M	Basketball	L	40	1.5	4
6	31	M	Jumping	L	50	2	0
7	40	M	Football	R	40	0	0
8	27	M	Jumping	R	48	3.4	0
9	28	F	Basketball	R	20	3.4	0
10	43	M	Soccer	R	Not recorded	0	3
11	35	M	Basketball	R	Not recorded	0	0
12	36	M	Basketball	L	Not recorded	0	1
13	24	M	Football	R	51	0	0
14	25	M	Running	L	50	0	0
15	50	M	Volleyball	R	Not recorded	0.5	0
16	41	M	Weightlifting	R	55	1	0
17	40	M	Running	R	40	3	0
18	31	M	Basketball	R	30	3.4	5

Abbreviations: F, female; L, left; M, male; MRI, magnetic resonance imaging; R, right; US, ultrasound.

Table 2
Descriptive statistics for all patients and comparison of patients with (≥0.5 cm) and without (<0.5 cm) gapping

	All Patients	Gapping < 0.5 cm	Gapping ≥ 0.5cm	*p* Value
Number	18	8/18 (44%)	10/18 (56%)	
Age (years)	36 ± 7 (range 24 to 50)	36 ± 7 (range 24 to 43)	36 ± 8 (range 27 to 50)	>.96
Sex (M:F)	16:2	9:0	7:2	>.47
Laterality (R:L)	13:5	6:3	7:2	1.00
Plantarflexion (°)	41° ± 11° (range 20° to 55°)	44° ± 10° (range 30° to 55°).	40° ± 11° (range 20° to 55°).	>.72
Magnetic resonance imaging (MRI) gap (cm)*		0 ± 0 (range 0 to 0)	2 ± 1 (range 0.5 to 3.4)	
Time to MRI (days)†	1.3 ± 2 (range 0 to 5)	1.3 ± 2 (range 0 to 5)	1.2 ± 1 (range 0 to 3)	>.88

Abbreviations: M:F, male to female; MRI, magnetic resonance imaging; R:L, right to left.
* All patients were approximated by clinical exam and ultrasound prior to MRI with a presumed complete approximation at that time (0 cm).
† Time to MRI is based on the time of clinical exam and ultrasound being time mark "0."

Table 3
Probability of the null between the clinical exam/ultrasound and magnetic resonance imaging (MRI) in measuring the gap

Group	Ultrasound/Clinical Exam*	MRI
Number (n)	18	18
Mean gap (cm)	0 ± 0	1.1 ± 1.4
Standard error of difference	0.0	0.33
P	<.0030	
95% confidence interval	1.12 (0.44 to 1.81)	
T	3.44	

* Presumed gap measured was 0 cm for all patients with direct visualization of the tendon ends under ultrasound as well as with palpation of the diminishing tendon gap with clinical exam.

average in patients with approximation was 1.2 ± 1 days (range 0 to 3 days). This was not statistically significant (p >.88). The groups were not different with regard to age, sex, laterality, or degrees plantarflexion (Table 2). A comparison of the probability of the null was made between the methods of measuring the gap between ultrasound/clinical exam and MRI using a presumed complete apposition with ultrasound and clinical exam set at a universal gap distance of 0.0 cm. A significant difference was observed between the 2 methods of measurement (Table 3).

Sex (p > .47), increasing age (p > .32), laterality (p = 1.00), increasing days to MRI (p > .31), and mechanism of injury (p > .53) were not associated with persistent gapping. Stratifying patients by increasing degrees of required plantarflexion into groups (20° to 39°, 40° to 49°, and 50° to 59°) was not associated with persistent gapping (p > .72). A negative correlation was found between the gap distance on MRI and the degree of plantarflexion (correlation = −0.51, p = .031) (Fig. 4). The 2 patients with the largest gap distance (3.4 cm) had the lowest degree of plantarflexion when splinted (20° and 30°).

A gap distance >1 cm was considered to be outside of acceptable parameters for nonoperative management due to concern that the tendon would heal in an elongated position. Seven of 18 (39%) patients were outside of "acceptable" parameters for nonoperative intervention. Sex (p > .12), increasing age (p >.71), laterality (p >.54), increasing days to MRI (p > .32), increasing degrees of plantarflexion (as stratified earlier) (p >.44), and mechanism of injury (p > .82) were not associated with persistent gapping. Similar results were found with a maximum gap distance >2 cm, 4/18 (22%) patients with neither gender (p > .41), increasing age (p > .62), laterality (p > .24), increasing days to MRI (p > .22), increasing degrees of plantarflexion (as stratified earlier) (p > .33), and mechanism of injury (p > .32), all of which had an association with persistent gapping.

Discussion

In this retrospective series of patients with an acute Achilles tendon tear, where tendon reapproximation by clinical exam and ultrasound was attempted, half of the patients demonstrated persistent gapping ≥0.5 cm on exam with MRI despite presumed approximation after splinting with clinical palpation and ultrasound. Although it is possible that the gap occurred after the patients left the clinic, all patients received a secondary exam and ultrasound with a splint in place to confirm apposition with these modalities. It is possible that the tendon ends could slowly retract after a period of immobilization or with muscle belly contracture. Interestingly, the group of patients who received

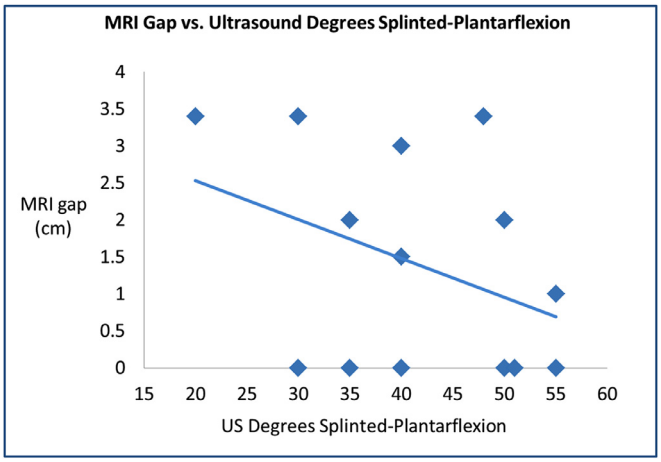

Fig. 4. Degrees of splinted plantarflexion required to observe tendon apposition on ultrasound compared with the gap present on magnetic resonance imaging.

their MRI the same day as the in-clinic exam/ultrasound demonstrated no difference in gapping when compared to those who had to wait at least a day to receive their MRI. This would contradict the speculation that muscle contracture could alter gapping measurements with an exam/ultrasound.

Ultrasound has been universally established as a useful diagnostic tool in the evaluation of both acute and chronic Achilles tendon pathology (9). It mitigates the high cost of MRI and allows for dynamic exam. Its reliability, however, appears to correlate with the operator, and it is not as effective for differentiating partial tear from focal tendinosis (9). MRI has been shown to be more accurate than ultrasound in determining tendon cross-sectional area; however, MRI and ultrasound have never been compared regarding gap assessment in acute tears (7,8). Even so, MRI is the radiologic study of choice when clinical exam or ultrasound is unobtainable or inconclusive (9). Considering these findings, we determined that MRI would be a reliable study to use as a standard for comparison of residual gapping to our clinical exam and ultrasound evaluations.

In 2006, Kotnis et al (6) evaluated 125 patients with acute Achilles tendon tears. To determine which tears were amenable to nonoperative versus operative intervention, they arbitrarily chose gapping >0.5 cm as measured by ultrasound as a cutoff. With their dynamic technique, measurements were taken at the maximal amount of plantarflexion allowable as determined by the patients' pain. Ultrasounds were performed by technicians. Patients with gapping ≥ 0.5 cm received operative intervention, whereas those with less received nonoperative treatment in a cast. Using this algorithm, they found no significant differences in re-rupture rates (3.4% nonoperative vs 1.5% operative) or complications rates.

In 2006, Hufner et al (5) reported on 125 patients with acute Achilles tendon tears. Patients were evaluated with ultrasound by surgeons at 0° and 20° of plantarflexion to determine tendon apposition. Patients with a gap <1 cm when at neutral or those with obliteration of their gap to 0 cm after splinting in plantarflexion to 20° were considered adequate candidates for nonoperative intervention with cast immobilization. Patients who did not meet these criteria underwent operative intervention. These measurements and cutoffs were chosen arbitrarily. Using this algorithm, they had 73.5% good to excellent results over all patients, with a 6.4% re-rupture rate.

Although both algorithms in the above studies were successful in allocating operative versus nonoperative intervention of acute Achilles tendon ruptures, there are no data to definitively suggest a specific measurement of gapping that can aid in such. Willits et al (4) prospectively evaluated 144 patients with acute Achilles tears, randomizing them to operative and nonoperative intervention with the same accelerated rehabilitation program. They found that acceptable and clinically similar results can be achieved with nonoperative intervention as compared to operative intervention. They did not consider tendon gapping in their study, suggesting that perhaps the gap is not as relevant in the setting of an accelerated rehabilitation program with nonoperative intervention.

We recognize that the findings in our study are represented by a small patient population and are retrospective in nature. Although a distinct number measurement cannot be suggested with our findings, this study may imply that if a surgeon should choose to use gapping as a guide to operative/nonoperative intervention, it should be noted that different clinical utilities can provide varying results in determining tendon reapproximation after splinting. Over 50% of the patients who were presumably reapproximated after splinting as determined by exam/ultrasound were found to demonstrate no approximation on MRI. We also recognize that the ultrasound and exams were performed by resident surgeons; however, all cases were directly supervised by an attending physician. An in-clinic ultrasound is a relatively straightforward exam that can be performed after minimal training by a certified ultrasound technician. This approach was also used by Hufner et al (5) in their study, and the use of a trained ultrasound technician does not appear to be routinely needed for these injuries/purposes.

In conclusion, we present a series of patients who received a clinical exam, ultrasound, and MRI after an acute Achilles tendon tear. We found that using clinical exam and ultrasound as tools to assess tendon apposition was not comparable to the same patients' MRI findings. One half of the patients demonstrated persistent gapping on MRI after presumed approximation on exam/ultrasound. For surgeons who use gapping measurements as a determination for operative versus nonoperative intervention, varying results can be achieved depending on the clinical utility. Further studies are warranted to determine if gapping measurements correlate with outcomes after operative or nonoperative intervention for acute Achilles tendon tears, as well as to determine whether a specific amount of gapping is tolerable for nonoperative intervention.

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