

Clinical Outcomes and Ultrasonic Evaluation of Percutaneous Achilles Tendon Repair

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Research article

Keywords: Percutaneous Achilles tendon repair, Achilles tendon rupture, AOFAS score

Posted Date: June 15th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-590571/v1>

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Abstract

Background

Achilles tendon rupture remains one of the most common tendon injuries in adult population. At present, randomized studies have failed to demonstrate the optimal management of Achilles tendon rupture. Wound complications have been significantly minimized since the emergence of percutaneous repairs when compared to traditional open methods. However, some studies suggested a higher incidence of rerupture rates and iatrogenic sural nerve injuries. The goal of this study was to present the clinical outcomes and ultrasonic evaluation of percutaneous Achilles tendon repair.

Methods

Between August 2015 and May 2018, 36 patients with an acute Achilles tendon rupture, treated in percutaneous repair, were studied retrospectively. American Orthopedic Foot and Ankle Society (AOFAS) score and the 10-point visual analogue scale (VAS) for pain questionnaires were sent to assess the clinical and functional outcomes. Ultrasonic evaluation was recorded using Möller grading system as an objective measurement.

Results

The 25 male and 11 female (mean age 47.03 years) were clinically followed-up for a minimum of 12 months (average 28.97 months). No wound complications or reruptures occurred. Four(11.1%) patients reported sural nerve hypoesthesia and one of them required additional treatment. The mean AOFAS and VAS score was 92.6 and 1.8 respectively at the 12th postoperative month. Ultrasonic evaluation was performed at the average follow-up of 18.3 months and the mean points were 1.8. All treated tendons were healthily recovered and all patients were able to return to previous work or activities.

Conclusion

Percutaneous Achilles tendon repair offers good clinical outcome and no apparent increased risk of reruptures. The risk of iatrogenic sural nerve injury, however, remains the most occurred complication. Ultrasound can be used to visualize and examine the repaired tendon, which demonstrated satisfying healing process.

Introduction

Achilles tendon, being the largest and strongest tendon, is subjected to the highest loads and stress of human body¹ providing strengths to our daily activities and exercises. Achilles tendon rupture (ATR) remains one of the most common tendon injuries in adult population. It is generally agreed that the incidence has been increasing in recent decades^{2,3,4}. The cause of ATR is multi-factorial, including mechanical factors, degenerative changes, or less commonly as a manifestation of systemic disease² or

side effect of drugs such as antibiotics (fluoroquinolones)⁵. The injury occurs most in middle-aged men, and typically occurs during sports activities with sudden excessive loading^{2,6}.

Surgical and conservative managements are both considered in treating ATR. To date, randomized studies have failed to demonstrate the optimal management for ATR^{7,8,9,10,11}. Despite the lack of consensus, surgical treatments have revealed a significant reduction in risks of rerupture yet higher risks of infections and complications such as wound breakdown and iatrogenic nerve injury, while allowing faster return to pre-injury activities^{12,13,14,15,16,17}. Surgical treatments include traditional open, minimally-invasive and percutaneous repair. Various studies comparing minimally-invasive and percutaneous repair with open repair have demonstrated the highest level of Achilles tendon strength and lowest rerupture rates in open surgery¹³.

In recent years, percutaneous methods have emerged aiming at combining the advantages of conservative and open surgical techniques. Wound complication rates are minimised with better cosmetic appearances. It offers optimum functional outcome under reduced costs with better cosmetic results when compared to open repair^{15,18,19,20,21,22,23,24}. However, several authors have suggested a possible higher rerupture rate and higher incidence of sural nerve injury in percutaneous repairs, which necessitates revision surgeries or nerve release^{15,18,21,25}. In this study, we present a series of patients treated with percutaneous surgical repair after ATR and the assessments of their functional and clinical outcomes with ultrasonic evaluations.

Materials And Methods

Patients

The present investigation is a retrospective analysis of functional and clinical outcomes on 36 consecutive patients presented to our hospital for ATR. All these patients were treated from August 2015 to May 2018 under percutaneous repair method. The diagnosis of ATR was based on physical findings which include the presence of a palpable gap between tendon, the loss of normal resting tone of the ankle, and the lack of tendon continuity on performing a Thompson test²⁶. In all patients, the diagnosis was either confirmed by ultrasound (US) or magnetic resonance imaging (MRI). We excluded patients who had an incomplete or open rupture, rerupture, rupture at the musculoskeletal junction or calcaneal insertion, previous surgery of Achilles tendon, functional impairments in the contralateral side, as well as systemic or prior local use of corticosteroids to the Achilles tendon. All subjects gave their written informed consents to participate in the study. Institutional Review Board of Taipei Medical University approval was sought and obtained for this case series. (IRB approval #N202004030)

Surgical technique

Percutaneous repair was performed under spinal (5 patients) or general anaesthesia (31 patients) in prone positioning with the operated foot on a gel cushion. All surgical procedures were performed by a

single certified experienced orthopaedic surgeon. Our approach was a slight modification of the percutaneous method described by Carmont and Maffulli²⁷. Instead of the transverse incision made over the defect, more longitudinal stabs were made alongside the tendon. After palpating the gap of ruptured Achilles tendon, proposed incisions were drawn by a marking pen. (Fig. 1a) Four and six symmetrical longitudinal mini-incisions (<5mm) were made medial and lateral to the tendon, respectively, in proximal and distal end. The intervals between each incision were 20-30mm. Depending on the length of tendon, two additional symmetrical stabs might be made proximally and distally. (Fig. 1b) To minimize the risk of sural nerve injury, we kept the incisions as close to the lateral surface of the tendon as possible with careful undermining. FibreWire® sutures 2-0 (REF AR-7221, Arthrax, Florida, USA) were used. In the beginning, needle was passed transversely between the proximal stab incisions through the tendon. Bunnell-fashioned suturing was adopted by passing the FibreWire diagonally through the bulk of tendon to the opposing stab incision and the suture was secured to the distal side. (Fig. 2) The suture was kept in tension during the whole process assisted by plantar flexion and the two surgical knots were buried deep to the distal part of tendon while suturing of the mini-incisions was not necessary. Thompson test was performed immediately after the operation to confirm the reestablishment of tendon continuity.

Postoperative rehabilitation

An anterior below knee plaster-of-Paris slab or hinged ankle-foot orthosis was applied to the patients with the ankle in gravity equinus right after surgery. The patients were discharged and was allowed toe-touch weight-bearing on the first day post surgery. The patients were further allowed to perform progressive to partial weight-bearing activities as tolerated using crutches on the third day postoperatively. The anterior slab or orthosis was shifted posterior allowing ankle dorsiflexion at the forth postoperative week. The slab or orthosis could be completely removed at the end of the sixth postoperative week, allowing full weight bearing. In the meantime, proprioceptive training with stretching and strengthening exercises was conducted according to the demands of patients. In athletes, we allowed the return to professional training at least 4-week time after the removal of slab or orthosis.

Outcome measures

Routine clinical follow-up in outpatient department was performed at 2, 4 weeks, 3, 6, 12 months, and then on an ad hoc basis. Wound healing, complications, ankle range of motion (ROM), weight-bearing, activity status, subjective assessments and imaging data were recorded. Our outcome measures focused on the ankle-hindfoot scale of the American Orthopedic Foot and Ankle Society (AOFAS)²⁸ and the 10-point visual analogue scale (VAS) for pain, at 12 months post surgery to evaluate the patients' opinions to their treatments. Ultrasound (US) scanning was used to inspect the treated Achilles tendon in an objective manner. US was performed by a single experienced radiologist unaware of the treatment, using a real-time scanner (Toshiba Apolio 300), provided by a 12.0 MHz linear array probe. With the subject prone and the injured ankle flexed to 90°, the Achilles tendon was entirely assessed in both longitudinal and axial planes. We adopted the ultrasonography grading points proposed by Möller et al.²⁹ (Fig. 3) The US grading score was assessed at least 12 months post surgery in each patient.

Results

Of 36 patients diagnosed unilateral closed complete ATR treated with percutaneous repair in our study, there were 25(69%) male and 11(31%) female patients with a mean age of 47.03 years (range 25-68 years). The procedures were well tolerated and all 36 patients were clinically followed-up for a minimum of 12 months (average 28.97, range 12-36 months, σ : 7.67) post surgery. No patients were lost to follow-up and none were dropped from our study.

Under our rehabilitation protocol, all patients were capable of full weight-bearing by the 6th postoperative week. At that time, Thompson test was negative and all were capable of single leg tiptoeing upon physical examination. By 3 months post surgery, less than 5° loss of dorsal and plantar ankle flexion was observed comparable to the contralateral ankle in all patients. (Fig. 4a, b, c) All patients were able to return to previous activities including contact sports at 4 months postoperatively. None of our patients experienced superficial or deep wound infections, skin breakdowns or defects and no clinical evidence of deep vein thrombosis was observed. Furthermore, no Achilles tendon rerupture occurred in either one of our patients during the follow-up period. However, 4(11.1%) patients reported hypoesthesia over the lateral supramalleolar aspect of the leg at the first postoperative outpatient follow-up (2 weeks). The sensation impairment resolved spontaneously within 6 months post surgery in 3 patients. The other patient further described dysesthesia over the area, referring to persistent numbness, tingling and neuropathic pain. Neurolysis was later performed on this patient at the 4th postoperative month to relieve neurological symptoms.

The mean ankle-hindfoot AOFAS and VAS score measured at the 12th postoperative month was 92.6(86-100) and 1.8(0-5, median: 1) respectively. In detail, an AOFAS score greater than or equal to 90 was recorded in most of the patients (86.1%). The vast majority of the patients (75%) also reported minimal pain intensity in VAS score (0-2 points). Notably, a 5-point score was given by the patient undergone neurolysis and a 4-point score was given by the other 3 patients with sensory defects. In the assessment using US and US grading system, the points were recorded at the average follow-up of 18.3 months (range 12-21 months, σ : 2.33). The mean points were 1.8(1-3). Among our inspection and in regard the features described in the grading system, no partial tendon defect was seen. Fusiform or generalized tendon thickening were both noted. The tendon appeared to be either mildly heterogeneous or homogeneous. Either focal or no peritendinous reaction and tendon edema was observed. All patients were presented with normal tendon gliding function. We hereby present the US images from one of our patients to demonstrate the utilization of the Möller grading system²⁹. (Fig. 5a, b, c)

Discussion

The increase in rate of ATR has been considered associated with the emphasis of physical activity during recreational sports in recent years. In line with numerous studies and meta-analyses^{6,14}, our patients were male-predominant. Although the best strategy for managing ATR remains controversial as mentioned, literature suggests a tendency for surgical intervention, as operation is advocated for active patients

especially athletes who seek early return to previous high functional status^{12,13,23}. Current evidence suggests that open compared to percutaneous repair has higher rates of wound complications, mainly infections, and almost double costs^{11,15,22,23,24,30,31,32}. Propelled by these partially unsatisfactory complications, percutaneous repair of ATR has gained favour. In addition, some authors described a possible higher re-rupture rates with percutaneous techniques, from an incidence of 2.1%¹⁵ to even 17%¹⁸, although other studies are ambiguous on this^{7,9,20,22,23}. As in our study, no reruptures were noted after percutaneous repair.

Injuries of the sural nerve remain the most described complication in percutaneous approach^{19,23,25,33}, having an incidence high up to 16.7%¹³. Since the first description of percutaneous technique by Ma and Griffith³⁴ in 1977, many modifications have been proposed thereafter^{18,29,31,35,36,37,38,39} for better vision of pathology and to reduce possible complications. Some were focused to prevent sural nerve damage, for example exposing the nerve³⁵, making posterior¹⁸ or paramedial incisions³⁷, and placing the knots at the medial aspect of the Achilles tendon³⁶. No current studies could guarantee complete prevention of sural nerve lesions under percutaneous method, except the method by Amlang et al.³⁷ with the aid of Dresden instrument, resulting no signs of sural nerve injuries under such technique^{33,37}. In accordance with most literature, we found 4 amongst 36 patients (11.1%) in our study experiencing sensory disturbances after surgery. Although there were authors believing the injury was not restricted to operative techniques⁷, we regard their conditions iatrogenic based on the location of discomforts and the denial of related complaints prior to surgical intervention. The anatomic variations and courses of the sural nerve are considerable^{40,41}, we tried to minimize the damage by making the incisions small and longitudinal paralleling the nerve with careful undermining. We also kept the incisions as close to the lateral tendon edge as possible relying on the anatomical identification by Kammar et al.⁴¹, which gave us the mean distances between the sural nerve and the Achilles tendon in respective heights, as well as the findings that the distance could be lower in older patients and men tended to have the nerve more lateral to the Achilles tendon insertion. Nevertheless, we concluded certain difficulties to fully protect the sural nerve, due to unidentifiable variants and possible nerve displacement by local soft tissue swelling in Achilles tendinopathy and paratendinopathy. Yet, nerve injuries were mostly temporary and there was a good chance of spontaneous resolution of symptoms.

There is no general accepted evaluation score for ATR treatments. In our study, we used ankle-hindfoot AOFAS and VAS score as subjective evaluation. AOFAS score is one of the mostly used assessment tools in foot surgery⁴² and was also seen in various studies acting as an outcome measure of ATR percutaneous repair^{22,31,43,44,45}. Some authors have established subgroups of scores to define 'excellent', 'good', 'fair' and 'poor' outcomes⁴⁶. For instance, scores between 90 and 100 points are indicative of an 'excellent' result. Therefore, we regarded most of our patients to have excellent results. We found our mean AOFAS score comparable to the referenced studies although their combined results marked a slightly higher average score at 95.5(44-100), in which we believed it was contributory mainly to a much longer follow-up time (average 28.78 months, range 12-82) at the time of assessment. We chose the

follow-up point at 12 months postoperatively for the patients to complete the survey as previous studies have shown functional scores following ATR repair may plateau beyond 1-year time point^{43,47}. Similarly, VAS score for pain was evaluated at 12 months postoperatively. Our result was less than satisfactory compared to previous studies^{44,45} which gave a mean VAS score of 0.6 at an average follow-up period of 31.2 months. The difference observed was partly on account of the deviation caused by the higher VAS scores given by patients suffering from complications. However by crosschecking with the AOFAS questionnaire, we found only the patient requiring neurolysis gave a 30-points in the 'pain' category, otherwise full 40-points were recorded in the same category from all the remaining 35 patients. Another cause for higher value might be associated with the observational phenomenon in our region that patients appear to give an at-least-one-point in VAS even in years after injuries, no matter on how the treatment or improvements have been.

Although the AOFAS scoring contains questions evaluated by physicians, we considered the survey to be mostly subjective. The follow-up of ATR also needs to be realized objectively. US was chosen over other diagnostic imaging studies in our study as it acted as a reproducible, non-invasive, and cost-effective tool. Möller grading system²⁹ was used to quantify our US findings. In our study, US was performed on each patient at a minimum of 12-month outpatient follow-up. As patients were asked to visit on an ad hoc basis, the average follow-up time for the US scores to be recorded was 18.3(12-21) months. We regarded the results representative as the changes in US findings after 12 months post injury were reported insignificant²⁹. The US features of the Achilles tendon in all our patients after one year post surgery agreed with the tendon appearances described²⁹. Furthermore, the mean positive points of 1.8(1-3) from our results were superior than that given by Möller et al. (mean 4.3, range 2-8)²⁹, which can be attributed to the development of better surgical techniques and advancement of rehabilitation protocols over years. Patients after surgical repair specifically percutaneous repair in our current study did demonstrate a smaller positive findings, in other words better results. On the other hand, none of our patients was presented with US abnormalities⁴⁸ and the healing processes of all the examined tendons were healthy.

The concept of rehabilitation for ATR has changed notably as early dynamic functional rehabilitation, when compared with traditional postoperative immobilization, led to more excellent rated subjective responses and no difference in rerupture rate^{49,50}. Our promotion of immediate weight bearing after surgical repair was also well acknowledged^{43,51,52}. Early active ankle mobilisation results in reduces range of motion loss, increases blood supply, and reduces the degree of muscle atrophy⁵³, all our patients were able to attain swifter near-to-normal range of motion restoration. Time of returning to sports was also pleasing, a shorter period was observed comparing to the general treated population²³.

There are several limitations in this series. First, this is a retrospective case series with the absence of control group and a relatively small sample size. We were unable to report direct comparisons of clinical outcomes and ultrasonic evaluation due to the restriction by patient choice for treatment. Second, the follow-up period was relatively short compared to other existing case series. Nevertheless, we have

elaborated a more-than-12-month evaluation was adequate for patients to reach a clinical and functional plateau and for the treated tendon to be well-healed. Third, it remains unclear to what extent the rehabilitation program could possibly affect our measurement on clinical outcomes. Furthermore, the rehabilitation of each patient was unsupervised, which may lead to individual differences in functional performance. Notwithstanding the stated limitations, strength of this study is the combination of subjective and objective quantitative measurement, namely the validated AOFAS with VAS score and ultrasonic evaluation respectively, which is different from previous studies.

Conclusion

Percutaneous Achilles tendon repair following Achilles tendon rupture offers significantly lower rate of wound complications with better cosmetic appearances, and no apparent increased risk of reruptures. The approach leads to functional and clinical outcomes as good as open repair. There is however a small increase in risk of iatrogenic sural nerve injury. Ultrasound, acting as a convenient and inexpensive tool, can be used to visualize and examine the repaired tendon. Postoperative evaluation demonstrates satisfying healing process which supports our clinical parameters. Accelerated rehabilitation protocol permits with immediate weight bearing is safe and allows earlier return to pre-injury activities. We recommend percutaneous surgical repair for treating Achilles tendon rupture.

Declarations

Ethics approval and consent to participate:

Consent forms were obtained and the study was agreed by all participants. Joint Institutional Review Board of Taipei Medical University (TMU-JIRB) approval was sought and obtained. (IRB approval #N202004030) All methods were performed in accordance with the relevant guidelines and regulations.

Consent for publication:

Joint Institutional Review Board of Taipei Medical University (TMU-JIRB) approval was sought and obtained for this publication with review of consent form. (IRB approval #N202004030) Availability of data and materials:

All data generated or analysed during this study are included in this published article.

Competing interests:

The authors declare that they have no competing interests.

Funding:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' contribution:

Ben-Mao Liu wrote the main manuscript text.

Hung-Chou Chen performed the ultrasound and presented the results.

Chen-Kun Liaw and Chia-Hsien Chen analyzed and interpreted the patient data.

Pei-Wei Weng, Chih-Hwa Chen, Yang-Hwei Tsuang participated in the design and conception of this article.

All authors reviewed the manuscript.

Acknowledgements:

Not applicable.

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Figures

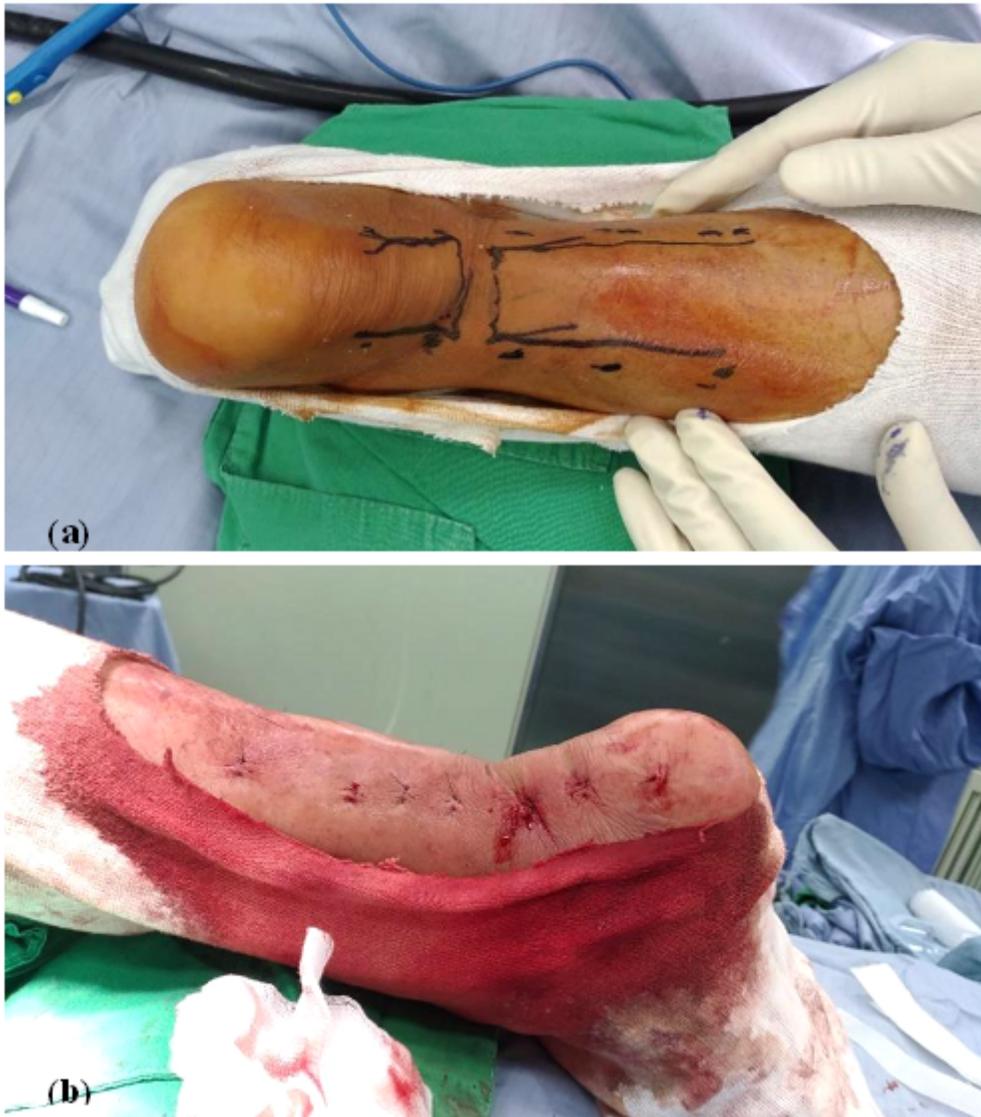


Figure 1

Four and six symmetrical longitudinal stab mini-incisions were made lateral and medial to the tendon, respectively, proximal and distal to the tendon gap.(a) Two additional symmetrical stabs might be made proximally and distally for a longer tendon.(b)

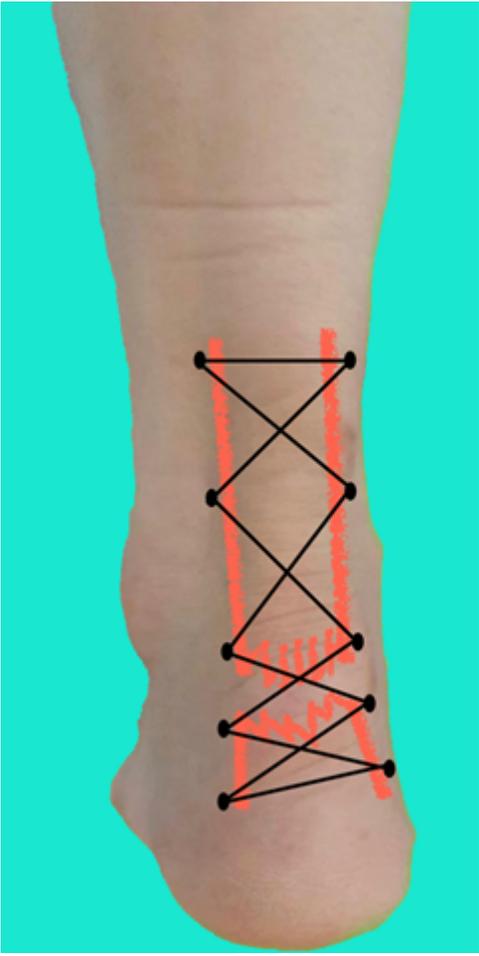


Figure 2

Bunnell-fashioned suturing by 2-0 FibreWire.

Findings	Points
Partial tendon defect	
None	0
Smaller than 5mm	1
Larger than 5mm	2
Tendon thickening	
None	0
Fusiform	1
Generalised	2
Tendon homogeneity	
Homogeneous	0
Mildly heterogeneous	1
Heterogeneous	2
Peritendinous reaction	
None	0
Focal	1
Generalised	2
Tendon edema	
None	0
Focal	1
Generalised	2
Tendon glide function	
Normal	0
Decreased	1

Figure 3

Möller grading system.



Figure 4

Ankle in gravity equinus.(a) Dorsal(b) and plantar flexion(c) 3 months post percutaneous repair.

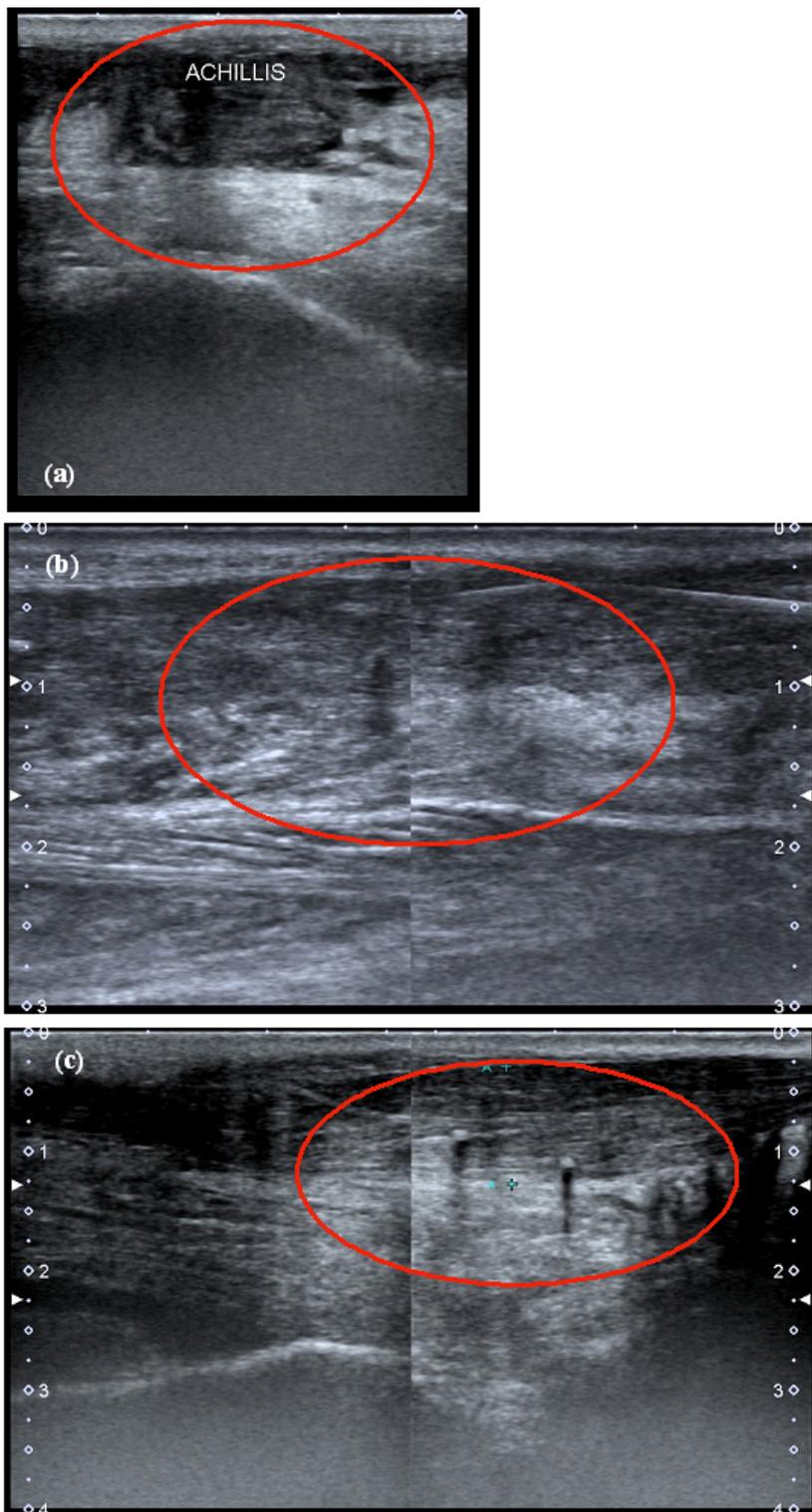


Figure 5

Preoperative ruptured Achilles tendon.(a) 6 postoperative months showing generalised tendon thickening (2 points), mild tendon heterogeneity (1 point) and focal tendon edema (1 point), 4 points in total.(b) 12 postoperative months showing fusiform tendon thickening (1 point) and no other positive findings, 1 point in total.(c)