ASSESSMENT OF THE VISA-A QUESTIONNAIRE FOR ACHILLES TENDINOPATHY AND ITS CORRELATION WITH IMAGING.

by

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ABSTRACT

Background: Because Achilles tendon disorders, which are common, have a significant morbidity among athletes, further research into efficacious treatments is necessary. Yet there is a lack of objective or quantifiable outcome measurement tools.

Purpose: The purpose of this thesis was to investigate outcome measurement tools used in Achilles tendinopathy research. In particular clinical measures that quantify the severity of the patient's condition and ultrasound and magnetic resonance imaging were examined.

Methods: A 3-month prospective study was done.

Participants: Forty five consecutive patients (27 men, 18 women; mean age 42 years, range 20-66 years) with 57 symptomatic and 33 asymptomatic Achilles tendons (mean duration 21 months, range 0.5 - 120 months) were admitted to the study.

Results: The VISA-A questionnaire had construct validity. The VISA-A scores of the 45 subjects correlated significantly ($p<0.01$) with their scores on two other clinical severity grading systems. There was also a significant difference in scores among the 45 symptomatic subjects (mean 63.75 ± 16.81) compared to the VISA-A scores of 66 asymptomatic University students (mean 95.95 ± 7.41) ($p<0.01$). The test-retest reliability was 0.930, the interrater reliability was 0.903, the intrarater reliability was 0.903 and the short term reliability was 0.805.

Ultrasound had a sensitivity of 0.65 and specificity of 0.67 and an overall accuracy of 0.66. The addition of colour and power doppler interrogation did not enhance the accuracy of US. MRI had a sensitivity of 0.56, a specificity of 0.94 and an overall accuracy of 0.68.

At 3 month follow up 7 of the 45 patients had improved, 37 remained the same and 1 had worsened. Only the baseline VISA-A score correlated with the 3 month results ($p<0.01$) neither US nor MRI was able to differentiate between cases that would improve and those that would worsen.

Conclusion: The VISA-A index of severity for Achilles tendon disorders offers a valid, reliable and quantifiable outcome measurement tool useful clinically and in research. Imaging lacked sensitivity and therefore not suitable as an outcome measure. Neither imaging modality proved more accurate but because of the cost and accessibility US would be preferred when imaging is required.

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INTRODUCTION

Tendon injuries account for a substantial portion of overuse injuries in sports.[4 6] Among recreational athletes the Achilles tendon is one of the most common sites of injury.[7] Overuse Achilles injuries occur particularly among athletes involved in running[2 6 8-10] racquet sports,[11] jumping sports,[9-11] soccer[11 12] and dancing.[12] Among top level runners the incidence of Achilles tendon overuse injury is 7% to 9%.[2] There is significant morbidity associated with an Achilles tendon injury[13 14] because of persistent symptoms,[15] recurrences and in 2%[6] to 16%[16] of athletes abandonment of their sport.[7 17]

Achilles tendinopathy refers to the clinical syndrome of pain in the region of the Achilles tendon with diffuse or nodular swelling in that area.[97] Treatment, typically consists of relative rest, anti-inflammatory medication,[18] physical therapy,[18] modalities, ice, strengthening exercises, orthotics, heel lifts, stretching and even surgery[6 15] for persistent cases. However, few controlled studies have tested the efficacy of these forms of treatment.[6 7 14 17-21]

Double-blind, randomised, placebo controlled trials are required to test treatment efficacy.[22-24] Ideally the severity of the patients condition should be measured because more severe injuries may take longer to improve[14 23] and stratification permits comparison among similar groups. The end point or desired outcome should be defined[25] but there is a lack of a standardised system of assessing this in orthopaedics.[26-28] A standard disease-specific grading system facilitates researchers to

better assess efficacy of treatment and compare different methods of treatment.[28-31] Evidence based treatments may then be used in clinical practice.

The purpose of this thesis was to investigate outcome measures of use in Achilles tendinopathy research. In particular attention was focused on clinical measures that may be used to quantify the severity of the patient's condition and to assess changes in condition. Secondly, the value of imaging as a potential outcome measure was also investigated.

CHAPTER ONE

LITERATURE REVIEW

Because Achilles tendon disorders, which are common, have a significant morbidity among athletes involved in many sports, it has been recognised that further research into efficacious treatments is necessary. Part of the difficulty in assessing differences in treatment results is due to a lack of objective or quantifiable outcome measurement tools.

A literature search was done to identify and analyse potential outcome measures which have been used in Achilles tendon research. Potential outcome measurements include: histopathology; biochemical markers; clinical findings; subjective outcome measures and imaging findings.

1.1. HISTOPATHOLOGY

While histopathological evidence of disease progress is an important gold standard in diagnostics, this is unsuitable for use as an outcome measurement tool in the research and clinical setting. Firstly patients who have improved are not likely to agree to biopsy in order to confirm healing. Secondly, surgery is unacceptable to a patient with a mild Achilles tendinopathy. Thirdly, repeat biopsies may influence tissue such that second and third biopsy results may show evidence of the surgical procedure rather than the nature of the tissue healing. Finally, histopathology has a false positive rate: Kannus and Jozsa found histopathological abnormalities in 160 of 445 cadaver

tendons of healthy individuals with no tendon complaints[32] and Astrom and Rausing found histopathological changes in 20% of asymptomatic control tendons.[33]

1.2. BIOCHEMICAL MARKERS

In general, laboratory or biochemical examinations play a minor role in the diagnosis of tendon disorders.[2] There are no measurable markers of disease activity that would prove useful in a clinical or research setting.

1.3. CLINICAL

In clinical practice a careful history and physical examination forms the basic standard for diagnosing tendon conditions.[2] However in a research setting clinical examination findings are variable[28] and individuals may present with a number of positive clinical findings.[25] Without a standard clinical assessment tool it is difficult to quantify clinical findings and there may be observer bias.[25 37] Patients present mainly because of pain,[2] which is an entirely individual experience and therefore difficult to quantify.[38-40] Nevertheless there has been an attempt to quantify subjective information.

1.4. SUBJECTIVE OUTCOME MEASUREMENTS

While pain is the usual presenting symptom,[38-40] functional status is also an important outcome measure.[41] There is a surprising low correlation between pain and disability[25] and therefore an outcome measurement tool must record pain, function

and activity.[25] In a search for relevant outcome systems, five grading schemes have been identified and listed in Table 1.1. There are however a number of limitations to these grading systems and a need is identified for a more specific and more sensitive measurement tool. A subjective index of severity of Achilles tendinopathy disorders may then be used in research and in the clinical setting.

Table 1.1. List of grading systems for Achilles tendinopathy identified in a literature search.

Author Date	Population intended	Type of Rating system	Comments
Percy and Conochie[42] 1978 (Table 2.4)	Results of surgery of Achilles tendinopathy.	Four point descriptive scale of excellent, good, fair and poor arbitrarily devised.	Arbitrary categories derived. Not validated and reliability not tested.
Curwin and Stanish[43] 1984 (Table 2.5)	Grading of tendinopathy in general.	A 6 point scale, combining the domains of pain and activity in one scale	Arbitrary categories derived, not specific to Achilles tendons. Limited in sensitivity. Not validated and reliability not tested
The American Orthopaedic Foot and Ankle Society. Kitaoka, *et al.*[41 44] 1994	Ankle hindfoot scale for patients undergoing ankle surgery	3 domains of pain, function and alignment, scored over 9 questions on a four point categorical scale totalling 100 possible points.	This is non specific for Achilles tendon disorders, particularly as symptoms such as morning stiffness, pain during and after activity and pain with stairs[6 7 9] are not represented and activity level is not documented.
Thermann *et al.*[45] 1997	Surgically treated ruptured Achilles tendons.	11 questions scored on mostly a 4 point Likert Scale. Items include Range of Motion, Calf circumference, Thompon's test, Strength testing, Pain, sports activity, sensitivity to weather and subjective assessment.	All (excepting pain and sports activity items) not applicable to Achilles tendinopathy. The four point Likert scale has been shown to be insensitive to subtle changes in clinical condition.[27 28] The questionnaire was not validated and reliability not tested.
Leppilahti *et al.* modified from Boyden *et al.*[26] 1998	Surgically treated ruptured Achilles tendons	8 Questions covering the domains of Pain, stiffness, muscle weakness, range of motion and footwear restriction, plus subjective outcome and calf muscle strength all included in 4 point Likert scale, totalling 100 points.	Redundancies in the questions. The four point Likert scale has been shown to be insensitive to subtle changes in clinical condition.[27 28] The questionnaire was not validated and reliability not tested.

1.5. IMAGING

Controversy exists over the value of imaging in assessment of Achilles tendon disorders. In particular a literature search was performed to answer the following questions. (1) What is the best technique to use in imaging tendons? (2) How well do Ultrasound (US) and Magnetic Resonance Imaging (MRI) correlate? (3) Does the severity of a tendon problem correlate with imaging findings? (4) Can imaging severity be regarded as a prognostic indicator in tendon disorders? (5) What is the overall value of imaging in Achilles tendon disorders? A literature review was done using MEDLINE database (from 1966 to the present), which was searched for any articles related to Achilles tendon and imaging. Additional references were reviewed from the bibliographies of the retrieved articles. A total of 26 original papers (Table 1.2) and 8 review articles (Table 1.3) were identified.

1.5.1 What is the best technique to use in imaging tendons?

Before US and MRI, soft-tissue radiography was the most popular imaging examination in Achilles tendon disorders.[2] But tendons are not visible on normal radiographs because of the limited contrast between normal muscle and tendon and injured tissue.[79] Although xeroradiography, bursography, tenography and arthrography were used to increase tissue contrast, the importance of these modalities has diminished.[2 79] Computer Tomography (CT) has also largely been replaced by US and MRI, particularly as Kalebo *et al.*[52] and Weinstabl *et al.*[67] have shown an increased accuracy with US or MRI.

Table 1.2. A list of all original papers dealing with imaging of the Achilles tendon.

First Author/ Date	Study design	Population	Clinical	U/S	MR	Surgery/ Histolology
Blei[46] 1986	Cross Sectional	23 tendons	• GS	•		• 5 tendons
Fornage[47] 1986	Cross sectional	67 patients (24 athletes)	•	•GS		• 1 tendon
Laine[48] 1986	Cross sectional	46 tendons	•	•GS		• 6 tendons
Matieson[49] 1988	Cross sectional + 4 -6 month FU.	30 tendons (athletes)	• GS (10 as / 20 s)	•		• GS 6tendons
Barbolini[50] 1988	Cross sectional	1304 tendons (athletes)	• Not stated	•GS		•
Maffulli[51] 1989	Cross sectional	12 patients (sedentary)	• all ruptures	•		• GS 12tendons
Kalebo[52] 1990	Cross sectional	78 tendons	• (16 a / 62 s)	•GS		• 9 tendons
Kalebo[53] 1992	Cross Sectional	30patients(athletes)/30control	•	•		• GS 37tendons
Kainberger[54] 1990	Cross Sectional	73patients(athletes)/24contol	•	•		• 17 tendons
Lehtinen[55] 1994	Cross Sectional	30 patients (athletes)	•	•		• GS 30tendons
Nehrer[56] 1997	Cross sectional + 2-5 year FU	36 patients(athletes)	• 48 sy /24 as	•		• 5 Rupture
Paavola[57] 1998	Retrospective	79 patients	• 80 tendons	•		• GS 80tendons
Dillehay[58] 1984	Cross Sectional	2 tendons	• GS	•		
Maffulli[59] 1987	Cross Sectional	47 patients (runners)	• GS (39 as / 55s)	•		
Archambault[60] 1998	Retrospective	33 patients	•	•		
Gibbon[61] 1998	Cross sectional	24patients(athletes)/16control	•	• GS		
Marcus[62] 1989	Cross sectional + 3 month FU	7patients(athletes)/30controls	•		•GS	• 1 tendon
Quinn[63] 1987	Cross sectional	30 tendons	• GS (20 as / 10s)		•	
Karjalainen[64] 1997	Cross sectional	20 post op	•		•	
Bottger[65] 1997	Cross sectional	30patients/25controls	• GS 30 sy / 50 as		•	
Soila[66] 1998	Cross sectional	62contralat + 38asy (athletes)	• GS		•	
Weinstabl[67] 1991	Cross sectional	28 patients (sedentary)	•	•	•	• 13 tendons
Neuhold[68] 1992	Cross Sectional	7 healthy controls /28 patients	•	•	•GS	• 12 tendons
Astrom[69] 1996	Cross sectional + 1 year FU.	27 patients (athletes)	•	•	•	• GS 27tendons
Movin[70] 1998	Cross sectional	20 patients	•	•	•	• GS
Karjalainen[71] 1996	Cross sectional	13 post op	•	•	•	

GS: Gold Standard; FU: Follow Up; sy/s: symptomatic; asy/as: Asymptomatic; contralat: contralateral; post op: post operative.

Table 1.3. List of review papers dealing with imaging and Achilles tendons

Author/ Date	Study design	Title	U/S	MR
Josza and Kannus[2] 1997	review	Human Tendons	•	•
Khan and Kannus[72] 2000	letter	Use of Imaging data for predicting outcome	•	•
Khan et al[73] 1998	editorial	Treat the patient, not the x-ray: advances in diagnostic imaging do not replace the need for clinical interpretation.	•	•
Jacobson[74] 1999	review	Muskuloskeletal sonography and MR imaging. A role for both imaging methods.	•	•
Panageas et al.[75] 1990	review	Magnetic Resonance Imaging of Pathological Conditions of the Achilles Tendon.		•
Mink et al.[76] 1991	review	Tendon Injuries of the lower extremity: Magnetic Resonance assessment		•
Kabbani and Mayer[77] 1993	review	Magnetic Resonance Imaging of Tendon Pathology about the Foot and Ankle.		•
O'Reilly and Massouh[78] 1993	review	Pictorial review: the sonographic diagnosis of pathology in the Achilles tendon.	•	

1.5.1.1. Ultrasound:

Table 1.4 summarises technical factors to take into account in imaging tendons by US. The recommendations are for real time ultrasound[47 50] using linear transducers[81] with a frequency of 5 MHz to 15 MHz[85] utilising both longitudinal and transverse views.[81] Care must be taken to place the probe parallel to the fibres in longitudinal scans and strictly perpendicular in transverse scans.[80-82] A thickness of 4.0 - 6.7 mm on transverse images is considered normal[54] and a bursa with thickness less than 2-3 mm is considered normal,[87] but the appearance of the bursa depends on flexion and extension of the ankle.[49] A stand off pad is not necessary.[61] Imaging of the paratendon is unreliable.[69] Grading of imaging findings may be possible either on a 3 point scale, (normal, thickened or hypoechoic),[60] or by area of hypoechogenicity on axial view.[5] Power and colour doppler have not been studied for the Achilles tendon, but in studies of the patellar tendon[89] colour flow may be increased in abnormal areas, which offers objective evidence of abnormalities that are not operator dependant. Similarly positive power doppler may also offer objective evidence of tendon abnormality on US,[88] although these two techniques are as yet experimental.

Table 1.4. Technical factors in performing US on tendons.

Author/ Date	Technical advance
Fornage 1987[80]	The obliquity of the superficial tendon results in a false hypoechogenicity due to reflection and refraction of the US beams. Therefore the probe should be placed strictly parallel to the tendon fibres in longitudinal scans and strictly perpendicular in transverse scans.
Mathieson *et al.* 1987[49]	Described the variability of the retrocalcaneal bursa with flexion and extension of the ankle.
Barbolini *et al.* 1988[50] and Fornage 1986[47]	Real time ultrasound rather than B-mode static US.
Fornage 1988[81]	Linear transducers with beams perpendicular to the superficial tendon preferable. Frequency of the probe from 5 MHz to 10 MHz allows an overview of the entire tendon at the lower frequencies and then optimal spatial resolution at the higher frequencies. Both longitudinal and transverse views required. Use of a stand off pad improves contact between the surface of the probe and the anatomic structures allowing visualisation of the subcutaneous tissue.
Crass *et al.* 1988[82]	Confirmed the angle dependence of the echogenicity of tendon (anisotrophy) in a controlled ex vivo setting.
Kainberger *et al.* 1990[54]	Described the normal thickness of the tendon as 4.0 - 6.7 mm in healthy adults with athletes tendons thicker than 6mm.
Kallinen and Suominen 1994[83]	Showed width of tendon larger in elderly athletes than elderly sedentary controls. There were no differences in echogenicity among athletes and sedentary individuals. Suggested width of tendon during transverse imaging better dimension to use for detecting inter tendon differences.
Koivunen-Niemela *et al.* 1995[84]	There is a large variation in shape of the tendon causing up to 25% variation in the measured thickness values. The tendon thickness correlates with body height.
Bertolotto *et al.* 1995[85]	Suggested higher frequencies of 10 - 15 MHz, which differentiated anatomically distinct tendon portions arising from the soleus and gastrocnemius muscles.
Astrom *et al.* 1996[69]	Imaging of paratendon unreliable.
Movin *et al.* 1997[86]	US guided percutaneous biopsy feasable.
Gibbon and Cooper 1998[61]	No stand off pad used.
Archambault *et al.* 1998[60]	Graded US findings as 1= normal; 2= enlarged tendon; 3= tendon with hypoechoic lesions regardless of size.
Fessel *et al.* 1998[87]	Review of US technique. Confirmed measurement in axial plane. Defined abnormal retrocalcaneal bursa as thicker than 2-3mm at insertion.
COLOUR AND POWER DOPPLER	
Newman *et al.* 1994[88]	Assessed value of power doppler among a variety of musculoskeletal complaints including shoulder, elbow "tendonitis, bursitis." Hyperaemia seen in areas identified as abnormal on grey scale.
Weinberg *et al.* 1998[89]	Increased colour flow in areas already identified as abnormal on grey scale.

1.5.1.2. Magnetic Resonance Imaging:

On MRI (Table 1.5) normal tendons appear black on all sequences due to dense collagen.[90] On T1 -weighted and T2-weighted MRI tissue contrast is enhanced and fluid and pathological processes appears grey (low signal intensity) on T1- weighted images and white (high signal intensity) on T2 -weighted images.[91] Other pulse sequences have been developed including partial flip angle, gradient reversal, fat suppression, chemical shift and three-dimensional volumetric imaging.[91] Contrast between abnormal increase in water content may be optimised by gradient acquisition; short tau inversion recovery or long repetition time/echo time (TR/TE) sequences.[76] Spin-Echo T1-weighted and T2-weighted images in various planes as well as either fat-suppressed or fast inversion recovery sequence have also been used to look for fluid and oedema.[92] In the patellar tendon and therefore possibly in the Achilles tendon, T2-weighted sequences (particularly the T2*-weighted GRE sequences) may have greater sensitivity than the T1-weighted protocols.[5] Similarly contrast enhanced imaging may increase sensitivity of detecting abnormalities in the Achilles tendon.[70] A head coil may be used to assess bilateral tendons[63 76] then a 3mm slice thickness without an interslice gap is usually used, with a 256-matrix for T1 weighted images and 128 matrix for T2 weighted images.[76]

Imaging of paratendon is unreliable[66 69] and the dimensions of the retrocalcaneal bursa are variable. Although generally a dimension of more than 1 mm in the anteroposterior plane, 11 mm in the transverse plane and 7 mm in the craniocaudal plane may be considered abnormal.[65] The appearance of normal tendon is also variable, with 45% of asymptomatic tendons showing heterogenous signal intensity with distal stripes or punctate foci.[66] Small intermediate intensity intratendinous

regions have also been detected in 4% of asymptomatic cases on FLASH.[66] For Achilles tendons the magic angle phenomenon is not as crucial as for a curved tendon such as the rotator cuff, however, artefactual hyperintensity on short-TE and GRE images due to T2 augmentation, must be considered.[92 93]

1.5.2 How well do Ultrasound and MRI correlate?

Five studies (Table 1.6) were identified that assessed US and MRI among the same group of patients. Weinstabl *et al.*[67] and Neuhold *et al.*[68] were able to confirm the appearance of total rupture on imaging, but this was also identified clinically and confirmed at surgery for 8 patients in both studies. For the remaining 20 patients with unclear clinical diagnosis, imaging was presumed to be the gold standard, and all patients had positive findings on imaging. While in both of these two studies the absolute diagnosis (for example tendinosis, partial rupture or peritendinosis) did not correlate exactly among the two imaging modalities. Surgery was only performed in 20% of these patients and did not offer additional information to assist identifying unique imaging features of specific diagnoses. This is not surprising considering that partial ruptures and tendinosis show the same degenerative histological features, and therefore it would be expected that the imaging findings would be the same in both these conditions.[33]

Table 1.5. Techniques in Magnetic Resonance Imaging of Achilles tendons.

Author / Date	Technical advances
Beltran *et al.* 1987[90]	Normal tendons appear black on all sequences due to dense collagen. T1-weighted sequences yield high contrast between the dark tendon and the bright signal from the surrounding fat.
Quinn *et al.* 1987[63]	Utilised 1.5T superconductive MR unit. Use of head coil. T1 weighted spin density and T2-weighted spin echo images obtained.
Kerr *et al.* 1990[91]	Suggested obtaining both T1 -weighted and T2-weighted images as tissue contrast is enhanced. Fluid is of low signal intensity (grey) on T1- weighted images and high signal intensity (white) on T2 -weighted images. Pathologic processes ought to demonstrate a pattern of signal intensity similar to that of fluid. Other pulse sequences have been developed. Introduced other sequences including partial flip angle, gradient reversal, fat suppression, chemical shift and three dimensional volumetric imaging.
Mink *et al.* 1991[76]	Contrast between abnormal increase in water content may be optimised by Gradient acquisition; short tau inversion recovery or long (Repetition time/echo time) TR/TE. sequences. Use of head coil to assess bilateral tendons. 3mm slice thickness without an interslice gap usually used, with a 256-matrix for T1 weighted images and 128 matrix for T2 weighted images.
Erickson *et al.* 1993[93]	Described magic angle phenomenon in tendons that become artefactually hyperintense on short-TE and GRE images due to T2 augmentation.
Brandser *et al.* 1995[92]	Review of MRI appearance of normal and injured tendons. Reinforced importance of magic angle. Suggested using Spin-Echo T1-weighted and T2-weighted images in various planes as well as either fat-suppressed or fast inversion recovery sequence to look for fluid and edema.
Astrom *et al.* 1996[69]	T1-weighted and T2-weighted images (SE TE/TR 30/587 and 85?2000, respectively) with 4 mm slices in sagittal plane and T1-weighted iamges (SE TE/TR 30/693) with 5 mm slices at 10 mm intervals in the axial plane. Imaging of paratendon unreliable.
Bottger *et al.* 1997[65]	Defined the dimensions of a normal and abnormal retrocalcaneal bursa. Asymptomatic ankles have detectable bursa, but of a dimension of no more than 1 mm in the anteroposterior plane, 11 mm in the transverse plane and 7 mm in the craniocaudal plane.
Khan *et al.* 1998[5]	Assessed patellar tendons. First to suggest that the T2-weighted sequences (particularly the T2*-weighted GRE sequences) have greater sensitivity than the T1-weighted protocols. However the T1-weighted signal can image most cases of patellar tendinopathy.
Movin *et al.* 1998[70]	Contrast enhanced imaging may increase sensitivity of detecting abnormalities.
Soila *et al.* 1999[66]	Described the normal appearance of the tendon, utilising images at 1.5T with axial high resolution T1-weighted gradient echo (fast low-angle shot (FLASH)) and short inversion recovery (STIR) sequences. Showed heterogenous signal intensity with distal stripes or punctate foci. Small intermediate intensity intratendinous regions detected in 4% of asymptomatic cases on FLASH. Paratenon visualised in all cases on both sequences.

Table 1.6. Table of studies correlating clinical findings, US, MRI and surgical findings.

Author / Date	Subjects / Clinical	Results			Comments
			Symptomatic tendons (n)	Asymptomatic tendons (n)	
Weinstabl *et al.*[67]	28 patients achillodynia (20 diagnosis uncertain)	US positive US negative	10 (10)	NS	Actual diagnoses did not correlate perfectly on US or MRI. But all symptomatic patients had positive imaging findings.
1991	(8 total rupture)	MR positive MR negative	28 (28)	NS	MR presumed as gold standard. Surgery only performed on 8 with total rupture (diagnosed clinically)
		Surgical: Total Ruptures (Clinical) other (partial rupture and tendinosis)	8 (8) 4 (4)		and 4 partial ruputres, true correlation unknown.
Neuhold *et al.*[68]	7 control (healthy) 28 patients achillodynia	US positive US negative	28 (28)	 7 (7)	No false positives among control No false negatives among symptomatic group, but actual diagnoses did not correlate perfectly
1992	(8 total rupture)	MR positive MR negative	28 (28)	 7 (7)	MR presumed as gold standard. Surgery only performed on 8 with total rupture (diagnosed clinically)
		Surgical: Total Ruptures (Clinical) other (partial rupture and tendinosis)	8 (8) 4 (5)		and 4 partial ruputres, true correlation unknown.
Astrom *et al.*[69]	27 patients (21 athletes)	US positive US negative	21 (26) 5 (26)	1 (13) 12 (13)	Partial ruptures were thicker clinically, on US and MR.
1996	chronic painful tendinopathy 1 year follow up.	MR positive MR negative Surgical: Total Ruptures (Clinical) other (partial rupture and tendinosis)	26 (27) 1 (27) 0 (0) 27 (27)	2 (14) 12 (14)	Imaging of paratenon unreliable. Imaging not predictive of result at FU. Tendinosis in all 27 operated tendons.
Movin *et al.*[70]	20 patients achillodynia	US positive US negative	20 (20) 0 (20)	NS	Hypoechoic areas markedly abnormal biopsy , normoechoic regions also abnormal.
1998	CME-MR biopsy	MR positive MR negative	19 (20) 1 (20)	2 (20) 18 (20)	Tendon disorder more generalised than imaged by US. CME-MR lesions larger than on US.
		Surgical: Total Ruptures (Clinical) other (partial rupture and tendinosis)	0 (0) 14 (15)		US and MR correlated with 14/15 surgical findings.
Karjalainen *et al.*[71]	13 patients post operative	US positive US negative	13 (13) (thicker) 0 (13)	0 (9) 9 (9)	In none of the patients had the cross sectional area returned to normal. Only 2 patients with poor
1996	(Total rupture repaired) 11 / 13 good recovery.	MR positive MR negative	13 (13) (thicker) 0 (13)	0 (9) 9 (9)	outcome - inadequate n to comment on prognostic significance of imaging findings.
		Surgical: Total Ruptures (Clinical) other (partial rupture and tendinosis)	N/A		US showed increased and decreased echogenicity. MRI showed intratendinous changes in some operated tendons.

n: total number of tendons CME-MR: Contrast enhanced MRI. NS: Not stated. N/A: Not applicable

One is unable to draw any conclusions from these studies regarding which imaging technique is more effective.

On the other hand, in a 1996 study by Astrom *et al.*[69] of 27 tendons, all verified as having tendinosis by surgery, it was found that presurgical US had a sensitivity 80.1%, and specificity 92%. MRI on the other hand had a sensitivity of 96% and specificity of 86%. Overall accuracy of US was 95% and of MRI was 93%. One would therefore conclude that neither imaging modality is superior.

Movin *et al.*[94] suggested that Gadolinium enhancement improved the imaging of intratendinous signal abnormality on T1-weighted images. They also showed that when compared to US the volume of intratendinous change on contrast enhanced MRI was larger than the corresponding hypoechoic area on US, although the shape and tendon enlargement was the same.[70]

Karjalainen *et al.*[71] assessed a group of post operative patients and showed thickening of the tendon on both US and MRI in all cases where a rupture was repaired surgically, despite good clinical results. This cross sectional study offers little additional information on the comparison between US and MRI, although it offers evidence that imaging changes remain positive in post surgery tendons, despite improvement clinically.

1.5.3. Does the severity of a tendon problem correlate with imaging findings?

1.5.3.1. Ultrasound:

No studies were identified, that classified tendon disorders by clinical severity prior to imaging. However, Kainberger *et al.*[54] classified their 73 symptomatic patients with Achilles tendon disorders into duration of symptoms, with three classes: (1) symptoms less than 2 months; (2) symptoms lasting 2 months to one year and (3) symptoms lasting longer than one year. Unfortunately it was not clear how many patients were in each group. Nevertheless, they found that US was normal in 20 of the 73 patients of whom 14 cases had symptoms for less than 2 months (Table 1.7). Maffulli *et al.*[59] and Mathieson *et al.*[49] similarly suggested that their false negative US findings (20.5% and 40% respectively) were found in patients with acute or milder symptoms (Table 1.7.)

This is in contrast to the studies by Paavola *et al.*,[57] Kalebo *et al.*[53] and Astrom *et al.*[69] who found that in patients severe enough to undergo surgery, there were some false negative US findings. Paavola *et al.*[57] for example found among 80 symptomatic tendons 3 that were normal on US yet abnormal at surgery and Kalebo *et al.*[53] found, in their series of 37 tendons undergoing surgery for a clinically suspected partial rupture, that 5 patients had negative US, yet surgery revealed oedema, peritendinitis or post operative changes. Astrom *et al.*[69] who operated on one false negative US patient still found pathology on histology although the grading of the histology was less severe than the patients with abnormal imaging (Table 1.7).

Biopsy evidence also reveals abnormal histology in normoechoic areas of a tendon. Movin *et al.*[70] were able to obtain a histological grade of severity for all 20 of their subjects with Achilles tendon pain. Clinically all patients had a painful, swollen tendon and all had US directed biopsy of any hypoechoic lesions as well as biopsy of the adjacent normoechoic areas. It was found that all hypoechoic areas were markedly abnormal on biopsy, and even normoechoic areas were moderately abnormal on histopathology, implying that the correlation between what is seen at imaging is not necessarily what is expected at pathology.

1.5.3.2 MRI:

Astrom *et al.*[69] and Movin *et al.*[70] acknowledged that all of their cases were severe enough to have warranted surgery. Astrom *et al.* found that tendons that were thicker and had increased signal intensity on MRI had higher (worse) histopathological scores than those with normal imaging. Movin *et al.* too found one case of false negative imaging, however, in neither of these studies was the clinical outcome reported and the clinical significance of the false negative MRI is unclear. Nevertheless it would suggest that in MRI a negative result in a symptomatic patient does not necessarily mean a milder condition (Table 1.8).

Table 1.7. Studies reporting false negative US results.

Author / Date	Imaging Modality	Rate of false negatives	Comment on severity
Acute or mild cases only			
Maffulli *et al.*[59] /1987	US	8/55 (20%)	Possible acute cases
Mathieson *et al.*[49] /1988	US	8/20 (40%)	Resolved in 4-6 months.
Kainberger *et al.*[54] /1990	US	20/73 (27%)	14 acute cases with no swelling.
Severe surgical cases			
Lehtinen *et al.*[55] /1994	US	2/34 (3%)	One normal on surgery as well.
Astrom *et al.*[69] / 1996	US	5/26 (19%)	Severe enough to warrant surgery.
Paavola *et al.*[57] /1998	US	3/79 (4%)	2 surgery positive; one negative.
Severity undefined.			
Kalebo *et al.*[52]/1990	US	2/62 (2%)	Not Stated
Weinstabl *et al.*[67] /1991	US	1/10 (10%)	Not Stated
Nehrer *et al.*[56] /1997	US	20/48 (42%)	US graded not clinical findings.
Archambault *et al.*[60] /1998	US	11/33 (33%)	US graded not clinical findings.

Table 1.8: Studies reporting false negative MRI results.

Author / Date	Imaging Modality	Rate of false negatives	Comment on severity
Astrom *et al.*[69] 1996	MRI 27 patients	1/27 (4%)	Severe enough to warrant surgery.
Movin *et al.*[70] 1998	Contrast enhanced MRI 20 patients	1/20 (5%)	Severe enough to warrant surgery.

1.5.3.3. Conclusion:

It would seem therefore among symptomatic patients, that there is a poor correlation between findings at US and MRI and severity of tendon disorder. This is reinforced by the number of false positive imaging findings in asymptomatic tendons (Table 1.9). However no one single study has assessed the correlation of imaging findings among a spectrum of cases of different clinical severity and this issue therefore remains controversial.

1.5.4. Can imaging severity be regarded as a prognostic indicator in Achilles tendon disorders?

Despite twenty-six original papers and eight review papers dealing with the value of Ultrasound or Magnetic resonance imaging in assessing Achilles tendinopathy, the usefulness of imaging as a predictive determinant remains controversial. Khan and Kannus remind us that only prospective controlled studies provide evidence of causality while cross sectional studies offer only descriptive information.[72] Four studies (Table 1.10) have been identified that prospectively assessed outcome of patients with Achilles tendon disorders and attempted to correlate outcome to imaging findings. A fifth study was identified that did this in a retrospective fashion.

Table 1.9. Studies reporting false positive US and MRI results.

Name / Date	Imaging	False positives	Comment
US			
Kalebo *et al.*[52] /1990	US 16 contralateral asymptomatic tendons	7/16 (43.8%)	US presumed Gold Standard. Insufficient data - outcome not reported. Unknown significance.
Gibbon *et al.*[61] /1999	US 38 tendons of healthy volunteers	occasional small hypoechoic foci.	US presumed Gold Standard. Insufficient data - outcome not reported. Unknown significance.
Astrom *et al.*[69] / 1996	US 13 asymptomatic contralateral tendons	1/13 (7.7%)	Thickening and hypoechoic lesion. Insufficient data - outcome not reported. Unknown significance.
Kainberger[54] /1990	US 24 healthy asymptomatic volunteers; contralateral asymptomatic tendon	4/24 (16.7%) Thickening in 4 asymptomatic volunteers. 9/? "abnormalities of tendon structure" in contralateral tendons (7/9 previous history)	Insufficient data - outcome not reported. Unknown significance.
Nehrer *et al.*[56] /1997	US 24 asymptomatic contralateral tendons	5/24 (20.9%)	None of these had ruptured on follow up, however, insufficient data as to outcome.
Sell *et al.*[95] /1996	US 34 asymptomatic cadaver tendons. Mean age 55 years.	19/24 (79.1%) echo change and increased diameter.	Sonography prone to artefact; No correlation to strength or rupture. Histology: necroses, scars and fissures in all regions of the tendons.
Name / Date	Imaging	False positives	Comment
MRI			
Astrom *et al.*[69] / 1996	MRI 14 asymptomatic contralateral tendons	2/14 (14.3%)	2 high signal intratendinous lesions on T1. Insufficient data - outcome not reported. Unknown significance.
Movin *et al.*[70] /1998	Contrast enhanced MRI Contralateral asymptomatic side of 20 patients.	2/? high signal abnormality near the insertion.	Insufficient data - number of unilateral cases not reported. outcome not reported. Unknown significance.
Soila *et al.* [66] / 1999	MRI T1-weighted FLASH and STIR. 19 healthy volunteers (38 tendons) 62 asymptomatic contralateral tendons	Signal intensity noted: 45/100 mildly inhomogeneous intratendinous. 38/100 thin, intermediate 30/100 patchy intratendinous intermediate- high 4/100 small areas of intratendinous ground glass intermediate	Only a single sequence done, most other studies report MRI as positive if on more than one sequence. Description of normal variants.

Table 1.10: Imaging findings correlated to clinical outcome.

Author / Date Follow up (FU)	Imaging Subjects Clinical at baseline	Findings at baseline US	Clinical at FU	Imaging at FU	Comment
Mathieson *et al.*[49] / 1988 4 - 6 months	US 20 symptomatic	8 normal 3 fluid around tendon 3 bursa 3 indistinct border 6 thickened or hypoechoic	8 resolved 3 resolved 2 resolved 3 resolved 5 surgery	8 normal 3 normal 2 normal 2 normal. 6 thickened	Thickening or hypoechoic changes on US would suggest a poorer prognosis.
Nehrer *et al.*[56] /1997 2 - 5 years	US 36 patients (48 symptomatic 24 asymptomatic tendons)	20 true negative 20 false negative 5 false positives 28 true positives 17 grade 1 (6-8mm) 6 grade 2 (8-10mm) 5 grade 3 (10 - 12mm)	No ruptures No ruptures 14 good, 6 fair No ruptures 1 rupture; 6 good, 11 fair 2 ruptures; 2 good, 4 fair 4 ruptures 1 good, 4 fair	 0 better; 13% worse 18% improved 14% worse 0 better; 80% worse.	Normal or low grade US had better clinical outcome, and less likely to have US worsen. Incidence of rupture high compared to the reported prevalence of 0.01%. [96] Possibly influenced by the 3 patients who had infiltrations preruture. Outcome possibly confounded by treatments, which were not stated.
Archambault *et al.* [60] / 1998 retros-pective 1 year	US 33 patients	11 grade 1 (normal) 11 grade 2 (enlarged tendon) 11 grade 3 (hypoechoic changes)	8 recovered 3 symptomatic 5 recovered 6 symptomatic 5 recovered 6 symptomatic	Not done	Outcome among the 3 grades the same, although rate of recovery different among grades, with a higher likelihood of recovery if grade 1.
Astrom *et al.*[69] / 1996 1 year	US 26 patients chronic severe tendinopathy All underwent surgery	5 normal US 1 hypoechoic 20 thickened and hypoechoic	Not correlated to imaging: 20 excellent 2 good 2 fair 3 poor	Not done	Tendency towards better clinical response in 6 cases that were not thickened. Excellent outcome in those with abnormal imaging.
	MRI 27 patients chronic severe tendinopathy. All underwent surgery.	1 normal 4 low signal & thickened 22 high signal & thickened	Not correlated to imaging: 20 excellent 2 good 2 fair 3 poor	Not done	Outcome of those with normal or thickened MRI the same as those with high signal intensity.
Marcus *et al.*[62] /1989 3 months	MRI 7 patients (4 total rupture; 2 possible total rupture; 1 chronic tendinopathy)	 3 total rupture; 1 partial tear. 1 normal continuity; 1 total rupture. 1 tendinopathy.	 4 good results (1 surgery) 2 good results poor result.	Not done	MRI presumed gold standard. 6 good results with only one total rupture undergoing surgery. Results at follow up biased as non randomised, open study. Prognostic value of MRI unclear.

1.5.4.1. Ultrasound:

The findings of Mathieson *et al.*,[49] Nehrer *et al.*[56] and Archambault *et al.*[60] would have us believe that imaging may be predictive of outcome. They all found that patients with normal imaging tended to have a better prognosis and that those with thickening or hypoechoic lesions tended to have a poorer prognosis. Astrom *et al.*[69] similarly found a tendency towards a better clinical response in those tendons that were not thickened on imaging. They do however caution that excellent results are still compatible with abnormal imaging. They also note that the patients were easily diagnosed clinically and acknowledged that all their patients were severe cases that required surgery.

1.5.4.2 MRI:

Astrom *et al.*[69] found that among their 27 surgically treated patients the outcome at 1 year follow up was the same for those with normal or thickened tendon as for those with intratendinous high signal intensity. Marcus *et al.*[62] similarly had mostly good results in the seven patients who all had positive MRI findings, suggesting that abnormal MRI is compatible with good clinical results.

Therefore, although earlier studies would suggest a prognostic benefit of imaging, the issue remains controversial.

1.5.5. What is the overall value of imaging in Achilles tendon disorders?

1.5.5.1. Ultrasound:

Seven studies were found that offered sufficient data that the sensitivity and specificity of US could be calculated (Table 1.11). The overall accuracy of US ranged from 0.65[56] to 0.95.[53]

Of these studies only four (Table 1.12)[49 54 56 69] were felt of sufficient quality (radiologists blinded to the clinical findings and adequate control group used), that an attempt at a meta-analysis could be done. The sensitivity is calculated as 0.66 and specificity as 0.85 for an overall accuracy of 0.72. The positive predictive value of US is calculated as 0.92 and negative predictive value as 0.50.

1.5.5.2 MRI:

Only two studies had sufficient information from which sensitivity and specificity could be calculated (Table 1.11). The overall accuracy of MRI is 0.92[69] to 0.93.[70]

If a meta-analysis is done combining these two studies, a sensitivity of 0.95 and specificity of 0.88 is calculated, for an overall accuracy of 0.92. The positive predictive value of MRI is calculated as 0.93 and negative predictive value as 0.88.

Table 1.11. Sensitivity and Specificity of US and MRI

Author/ Date	Subjects (tendons)	Gold standard	Sensitivity	Specificity	Overall accuracy	Comment
US						
Maffulli *et al.* 1987[59]	55 symptomatic tendons 39 contralateral asymptomatic tendons	Clinical	0.85	1.0	0.91	Radiologist not blinded to clinical findings: May have influenced interpretation of asymptomatic cases.
Mathieson *et al.* 1988[49]	20 symptomatic tendons 10 healthy controls	Clinical, and 4-6 month FU.	0.6	1.0	0.73	Radiologist blinded. Control group adequate & sufficient data reported.
Kalebo *et al.* 1990[52]	78 tendons (62 symptomatic; 16 asymptomatic.)	9 surgery 69 US	1.0	0.56	0.91	US presumed gold standard and false positives misinterpreted. Not stated whether radiologists blinded or not
Kainberger *et al.* 1990[54]	73 symptomatic patients 24 asymptomatic controls	17 surgery 80 US presumed correct	0.72	0.83	0.75	Radiologists blinded. Control group adequate & sufficient data reported.
Kalebo *et al.* 1992[53]	30 patients (37 tendons) 30 asymptomatic controls	37 surgery	0.94	1.0	0.95	Not stated whether radiologists blinded or not. Control group adequate & sufficient data reported.
Astrom *et al.* 1996[69]	35 symptomatic tendons 13 asymptomatic tendons	26 surgery 26 clinical	0.69	0.92	0.75	Radiologists blinded. Control group adequate & sufficient data reported.
Nehrer *et al.*[56] /1997	36 patients, 48 symptomatic tendons, 24 asymptomatic contralateral	Clinical	0.58	0.72	0.65	Not stated whether blinded or not. Control group adequate & sufficient data reported.
MRI						
Astrom *et al.* 1996[69]	36 symptomatic tendons 14 asymptomatic tendons	27 surgery 27 clinical	0.94	0.86	0.92	Radiologists blinded. Control group adequate & sufficient data reported.
Movin *et al.* 1998[70]	20 patients	Surgical	0.95	0.9	0.93	Radiologists blinded. Control group adequate & sufficient data reported.

Table 1.12: Meta-analysis of US and MRI results from adequate studies.

Author / Date	Imaging	Symptomatic	Asymptomatic	Total
US				
Kainberger *et al.* 1990 [54]	US positive	53	4	57
	US negative	20	20	40
	TOTAL	73	24	97
Mathieson *et al.* 1988[49]	US positive	12	0	12
	US negative	8	10	18
	TOTAL	20	10	30
Astrom *et al.* 1996[69]	US positive	24	1	25
	US negative	11	12	23
	TOTAL	35	13	48
Nehrer *et al.*[56] /1997	US positive	28	5	33
	US negative	20	19	39
	TOTAL	48	24	72
MRI				
Astrom *et al.* 1996[69]	MR positive	34	2	36
	MR negative	2	12	14
	TOTAL	36	14	50
Movin *et al.* 1998[70]	MR positive	19	2	20
	MR negative	1	18	20
	TOTAL	20	20	40

1.6. SUMMARY AND RATIONALE FOR STUDY

Despite being a common problem, Achilles tendon disorders are difficult to manage and many patients have prolonged symptoms and a high morbidity.[14 79] Conservative management is applied anecdotally and may fail in chronic cases. Surgical techniques have not been tested through stringent randomised controlled trials.[14] Further randomised controlled trials are needed to assess efficacy of treatment options in Achilles tendinopathy. The current lack of an acceptable, objective gold standard makes pre-treatment and post-treatment measurements arbitrary. In addition subjective outcome measurement tools are also inadequate. There is therefore a need for a quantitative index that assesses severity of Achilles tendinopathy that may be used as an outcome measurement tool in research.

Secondly, while it is clear that US or MRI are the imaging modalities of choice in Achilles tendon disorders, controversy remains over which is of more value, and whether imaging correlates to clinical severity or whether imaging offers prognostic information. There are no prospective, controlled studies of imaging in Achilles disorders and the cross sectional studies offer circumstantial evidence only.[72]

There is therefore clearly a need for further research in this area, utilising a prospective study design[72] and testing patients of varying severity[69 79] including non operative cases.[69]

CHAPTER TWO

THE VALIDITY AND RELIABILITY OF A CLINICAL AND RESEARCH MEASURE OF SEVERITY OF ACHILLES TENDON DISORDERS - THE VISA-A QUESTIONNAIRE

2.1 INTRODUCTION

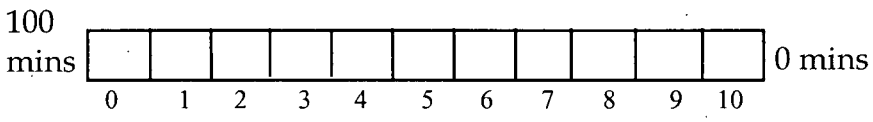
The literature review identified inadequate outcome measurement tools for assessing Achilles tendinopathy. Particularly with reference to grading subjective and clinical information (Section 1.4). A need for a simple questionnaire specific to Achilles tendinopathy was identified. The Victorian Institute of Sport (VIS) Tendon Study group (Appendix A) undertook to develop a questionnaire specific to Achilles tendinopathy, the VISA-A Questionnaire (Table 2.1).

The VISA-A questionnaire consists of eight questions, covering the three domains of pain (question 1- 3), function (question 4-6) and activity (question 7 & 8.) Questions one to seven were scored out of 10 each and question 8 is scored out of 30. Scores are summed to give a total out of 100. An asymptomatic person would score 100, someone who is symptomatic less than that.

Table 2.1. VISA-A Achilles tendon questionnaire.

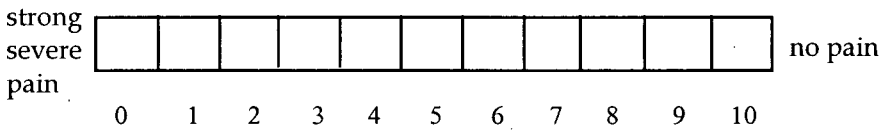
IN THIS QUESTIONNAIRE, THE TERM PAIN REFERS SPECIFICALLY TO PAIN IN THE ACHILLES TENDON REGION

1. For how many minutes do you have stiffness in the Achilles region on first getting up?



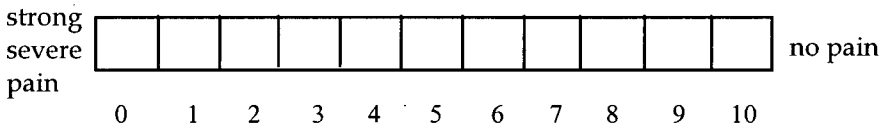
POINTS ❒

2. Once you are warmed up for the day, do you have pain when stretching the Achilles tendon fully over the edge of a step? (keeping knee straight)



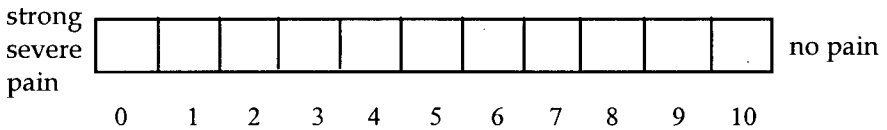
POINTS ❒

3. After walking on flat ground for 30 minutes, do you have pain within the next 2 hours? (If unable to walk on flat ground for 30 minutes because of pain, score 0 for this question).



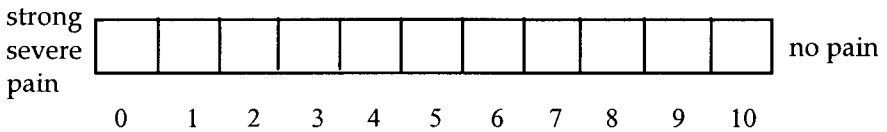
POINTS ❒

4. Do you have pain walking downstairs with a normal gait cycle?



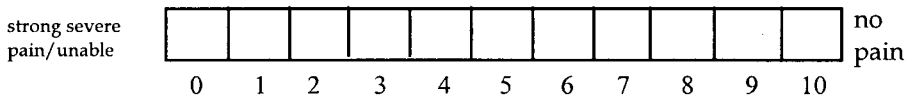
POINTS ❒

5. Do you have pain during or immediately after doing 10 (single leg) heel raises from a flat surface?



POINTS ❒

6. How many single leg hops can you do without pain?



POINTS ❒

7. Are you currently undertaking sport or other physical activity?

0 ❒ Not at all
4 ❒ Modified training ± modified competition
7 ❒ Full training ± competition but not at same level as when symptoms began
10 ❒ Competing at the same or higher level as when symptoms began

POINTS ❒

8. Please complete **EITHER A, B or C** in this question.

- If you have **no pain while undertaking sport** please complete **Q8a only**.
- If you have **pain while undertaking sport but it does not stop you from completing the activity**, please complete **Q8b only**.
- If you have **pain which stops you from completing sporting activities**, please complete **Q8c only**.

A. If you have **no pain** while undertaking sport, for how long can you train/practise?

NIL	1-10 mins	11-20 mins	21-30mins	>30 mins	POINTS
❐	❐	❐	❐	❐	❐
0	7	14	21	30	

OR

B. If you have some pain while undertaking sport, but it does not stop you from completing your training/practice for how long can you train/practise?

NIL	1-10 mins	11-20 mins	21-30mins	>30 mins	POINTS
❐	❐	❐	❐	❐	❐
0	4	10	14	20	

OR

C. If you have **pain that stops you** from completing your training/practice, for how long can you train/practise?

NIL	1-10 mins	11-20 mins	21-30mins	>30 mins	POINTS
❐	❐	❐	❐	❐	❐
0	2	5	7	10	

TOTAL SCORE (/100) ❐%

2.2 MATERIALS AND METHODS

2.2.1. Population Identification

The questionnaire was not intended to be a diagnostic tool, rather an index of severity once the diagnosis of Achilles tendinopathy is made. This allows an individuals progress to be monitored. Achilles tendinopathy may be identified clinically as a combination of Achilles tendon pain, tenderness (diffuse or localised) and impaired performance.[97] For the purposes of this study we used patients with a spectrum of clinical problems.

2.2.1.1. Ethics Aproval

Ethics approval was obtained from the University of British Columbia Ethics Committee, and from the Vancouver Hospital and Health Sciences Research Advisory Committee. Informed written consent was obtained for all participants prior to their participation in this study. All results were kept confidential.

2.2.1.2 Subject Recruitment.

Sports medicine physicians, physiotherapists, podiatrists, massage therapists and fitness consultants in the Greater Vancouver Region referred the patients. The inclusion criteria into the study were adult patients older than 18 who were able to give informed consent. Patients were included if they had a diagnosis of Achilles tendinosis, paratendinitis or partial rupture with or without a retrocalcaneal or Achilles bursitis. Patients were excluded if they were pregnant or nursing. People

with full ruptures of the Achilles tendon were also excluded. Patients who were unable to attend a clinical interview for whatever reason were excluded.

Of the sixty-two patients who inquired about the study, seventeen were excluded. This was because of work commitments (7), location (2), holiday travel (3). Three people had an incorrect diagnosis (plantar fasciitis (2) and ankle sprain (1)) and two people developed unrelated conditions and preferred not to continue the study.

Forty five consecutive patients (27 men, 18 women; mean age 42 years, range 20-66 years) referred because of symptomatic Achilles tendinopathy (mean duration 21 months, range 0.5 - 120 months) were admitted to the study. Twelve patients had bilateral symptoms and thirty-three patients had unilateral symptoms for a total of 57 symptomatic and 33 asymptomatic tendons. Five of the latter had previous symptoms, while twenty eight were never symptomatic. None of the patients were sedentary, eighteen patients (40%) exercised 1 -3 hours per week, fourteen patients (31%) exercised between 4 - 6 hours per week and thirteen patients (29%) exercised more than 7 hours per week. This was a significantly lower training volume than prior to becoming symptomatic (Table 2.2).

Table 2.2. Activity of patients before and after onset of symptoms.

Hours of activity per week	Number of subjects exercising at each level prior to symptoms.*	Number of subjects exercising at this level after onset of symptoms.
0	0	0
> 0 - 3	8	18
> 3 - 7	19	14
> 7	18	13

* $x^2=22$; $p<0.01$

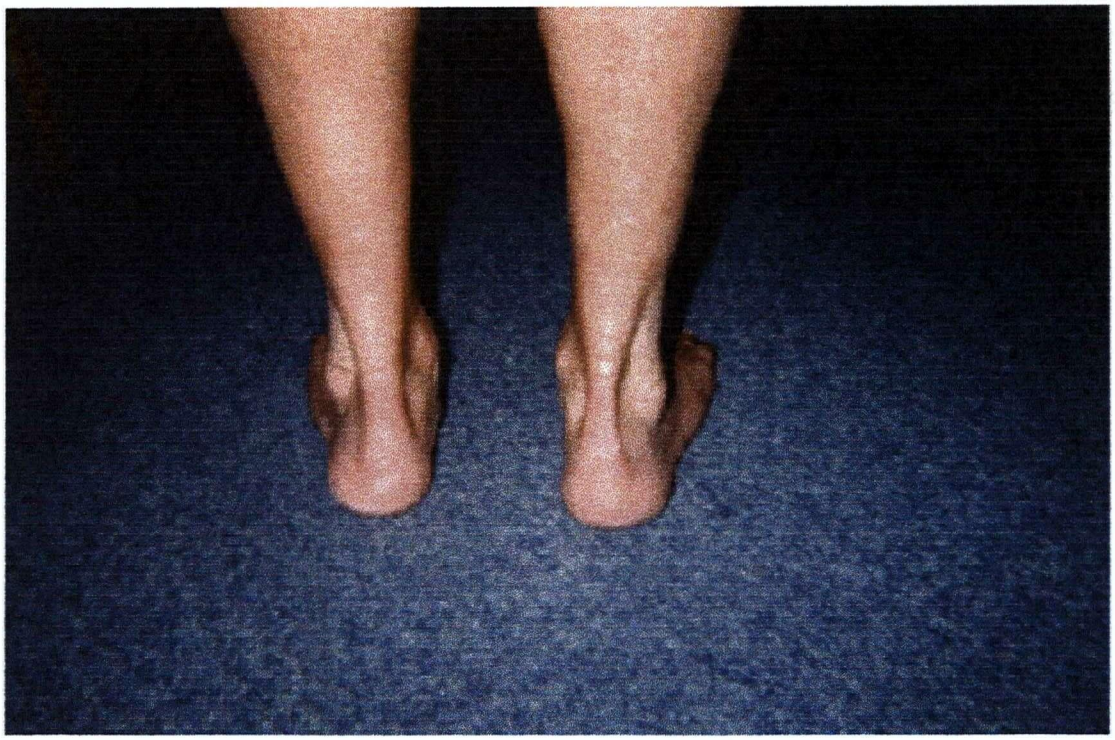
Ten patients had stopped their running sports because of their Achilles tendinopathy. The usual complaint was pain with activity and morning stiffness. Tenderness was found at the mid tendon in 41 tendons, at the insertion in 12 tendons and diffusely throughout the tendon in 2 patients (4 tendons). The same 4 were thought to have a bursitis as well and an additional 3 other patients were thought to have a bursitis in addition to the tendinopathy. Four tendons, (3 patients) had prior surgery for a Haglund deformity but remained symptomatic, and one patient had received cortisone injections into both tendons and also remained symptomatic.

2.2.1.3. Clinical examination

The clinical diagnosis was made by the referring clinician and confirmed by a sports medicine fellowship trained physician. Patients were examined first standing barefoot and alignment or swelling about the Achilles tendon area was noted (Figure 2.1). Functional tests were done by asking the patients to: 1) walk; 2) do single leg heel raises for each side and 3) hop 10 times on each leg. Patients were then examined seated and ankle range of motion and power testing of the ankle muscles was assessed with patients' knees flexed at 90 degrees. Patients were then examined lying prone. Both Achilles tendons were examined for swelling and palpated for nodules, thickening and tenderness. The insertional area and Achilles and retrocalcaneal bursae were palpated for tenderness or thickening. The calf muscle was palpated for tenderness, gaps or nodules.

Measurement of transverse diameter of the Achilles tendon was done using a "Value Power" plastic calliper. Measurements were made in millimetres. The tendon was measured first at 1 cm above the calcaneal superior border, which was identified by

Figure 2.1. Clinical examination of patient showing thickening of left Achilles tendon.



palpating the edge of the calcaneus. Next the tendon was measured at its most visible thickest width and the distance of this thickest width from the calcaneal superior border was measured in centimetres.

2.2.2. Item Generation

The VIS Tendon study group first developed a successful index of severity score for Patellar tendinopathy.[98] Following this a questionnaire was developed for use in Achilles tendinopathy. A literature review was done to find items that would be appropriate for inclusion. In addition colleagues were consulted to find unpublished items used in clinical practice. The second step involved interviewing colleagues with expertise in the area of Achilles tendinopathy. Finally patients were informally interviewed regarding symptoms they felt important.

2.2.3. Item Reduction

A focus group consisting of the principal questionnaire developer, a primary care sports medicine physician and two physiotherapists reviewed the items generated. Three domains of pain,[38-40] functional status[41] and activity[25] with equivalent of three questions each were felt appropriate (Table 2.1).

2.2.4. Item Scaling

A visual analog scale (VAS) has been found to be more accurate and sensitive than categorical verbal scales.[37 40 99-102] The first 6 questions utilise a VAS to allow a

continuous method of expression by which the patient may describe the magnitude of a subjective experience of symptoms.

The final two questions asked about activity. Harrison *et al.*[25] suggested that activity might best be assessed on a categorical rating system based on incremental range of values. The final two questions therefore used a categorical rating scale rather than a VAS.

2.2.5. Pretesting

Prior to being shown the VISA-A questionnaire, a group of fifteen "experts" in the field of tendon injuries were asked to identify questions they felt were important in assessing the severity of Achilles tendon disorders. The group was comprised of 8 physiotherapists, 4 primary care physicians, one orthopaedic surgeon and one rehabilitation specialist from the Allan McGavin Sports Medicine Centre in Vancouver. Their questions are listed in Table 2.3.

The same 15 participants were then shown the VISA- A score and asked to evaluate the questionnaire. They were specifically asked if there were any questions they would add, and if there were any questions they would remove or change.

Fourteen of the participants had no questions to add, none wanted any removed and none wanted any changed.

Table 2.3. Questions identified by "Experts" as important in assessing Severity of Achilles tendinopathy.

Question	Number of Times asked	Comment
Diagnostic: e.g. Rule out back pain, hip pain, location of pain, previous treatments.	30	Not pertinent for severity; Covered in diagnostic interview.
Ambigous: e.g. Are there any aggravating or relieving factors, Are you limited in activities.	11	Unable to quantify answers to open ended questions. Useful in initial diagnostic interview.
Timing of pain:	24	
Morning pain	6	Question one
Stiffness & Pain with stretching	6	Question one and two
Pain after activity	7	Question three
Pain during activity	4	Question three
Activities of daily Living	29	
Pain at rest	8	Question one
Pain walking	9	Question three
Pain up and down stairs	5	Question four
Sports Activities	25	Question seven and eight
jogging	9	Question seven and eight
heel raises	3	Question five
jumping	8	Question six
Quantified sports disability	5	Question seven and eight
How long can you play?	3	Question eight
How far can you run?	1	Question eight
Have you missed practices?	1	Question eight

2.2.6. Weighting

This questionnaire essentially tests the three significant domains by three questions each (question 8 is effectively 2 questions relating to pain with activity and duration of activity). By removing redundancies and eliminating items of less importance weighting of the remaining items may be the same (each question is scored out of 10) without affecting the value of the questionnaire.[28]

2.2.7. Validity

From the literature review it has been shown that the gold standard histopathology is unacceptable to a patient with mild symptoms (Section 1.1). Similarly there are no laboratory or biochemical markers[2] of disease severity (Section 1.2) and the value of radiology (Section 1.5) remains controversial. Therefore this study utilised a clinical gold standard.[2 34-36]

This study therefore had to rely on construct validity. Firstly the VISA -A was administered to 45 patients with Achilles tendinopathy. Concurrently the patients were also graded according to two other grading systems that of Percy and Conochie[42] (Table 2.4) and that of Curwin and Stanish[43](Table 2.5). The scores from the three grading systems were correlated using the Pearson's product moment coefficient and Spearman's Rank correlation coefficient.

Secondly, a class of 66 healthy University students, who were not involved in this study in any other way were asked to complete the VISA-A questionnaire. Thirty women and thirty-one men (aged 20 - 32 years, mean 23 years ± 2.86) answered the questions.

Table 2.4. Percy and Conochie's grading scheme for results of surgery of Achilles tendinopathy and a modification for non surgical patients.

Percy and Conochie's grading scheme[42]		Modification for non surgical patients (Nehrer *et al*)[56]
Excellent	A patient who had full function with no residual disability whatsoever.	Amelioration of symptoms, and return to full sporting activity
Good	A patient with slightly questionable weakness, an adherent scar, and minor sensory deficit, but no real limitation of activities and full return to function as in the prerupture period.	Amelioration of symptoms, minor limitations in sporting activity
Fair	A definate weakness and some limitation of activities and a slight limp.	Limited sporting activities.
Poor	A patient in which there was a re-rupture or complete failure with severe weakness and a marked limp.	Abandonment of their sport.

Table 2.5. Tendinopathy grading system of Curwin and Stanish.

Grading system of Curwin and Stanish [43]		
Grade	Description of Pain	Disability
1	No pain	No effect on activity
2	Pain only with extreme exertion; pain resolves when activity ceases.	No effect on activity
3	Pain with extreme exertion and 1-2 hours afterwards.	Little effect on activity, may limit more intense physical activities.
4	Pain during and after vigorous activity.	Performance level decreased; Unable to perform some necessay tasks.
5	Pain during activity forcing termination.	Causes immediate withdrawal from activity.
6	Pain with daily activities.	Unable to participate in any sports; daily activities may also be restricted.

2.2.8. Reliability

Reliability is a concept that repeated administration of a questionnaire will produce the same results.[28]

The same cohort of 45 subjects with Achilles tendon disorders was used to assess the reliability of the VISA-A questionnaire. The VISA-A questionnaire was administered three times to each patient. In order to examine the test-retest reliability of the questionnaire two questionnaires were administered an hour apart, either on the first or second patient visit (this was randomly assigned). A third questionnaire was administered one week after the first to assess short term reliability. For 16 of the subjects on one occasion the VISA-A questionnaire was administered by either a different sports medicine physician or a medical student.

2.3. RESULTS

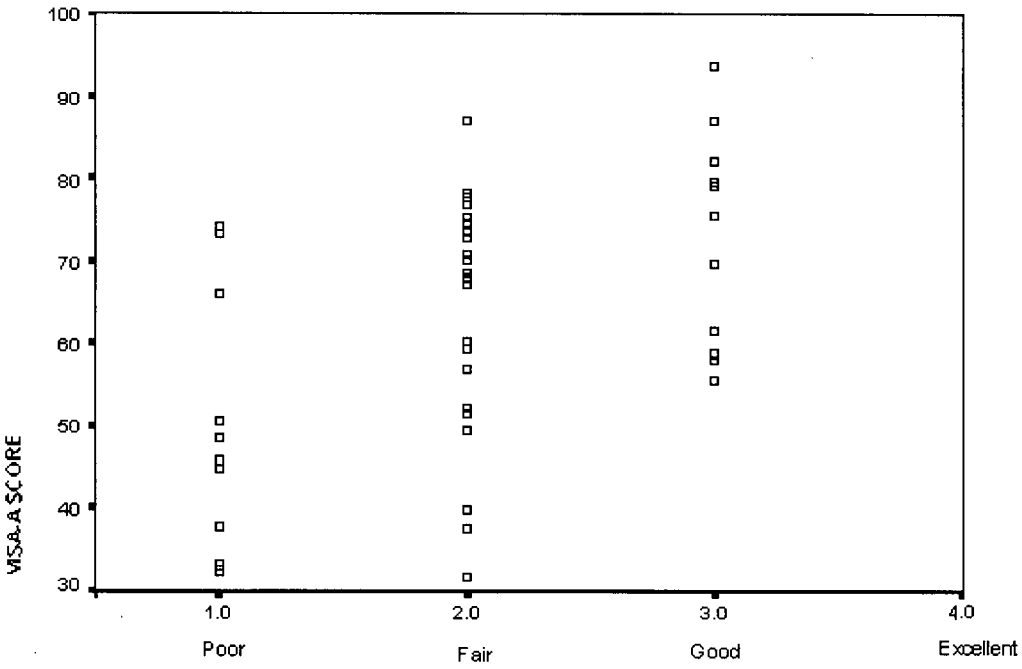
2.3.1 Validity

The construct validation is shown in Figures 2.2 and 2.3. While the VISA-A score was significantly correlated to the both grades of severity ($p<0.001$) there was a wide variability in the scores. As shown in Figure 2.4 the VISA-A scores approximate a normal curve (albeit skewed to the right, reflecting the inclusion of mild non surgical cases).

In the second part of construct validity testing, patients who are known to have the condition were compared with those known not to have the condition. Forty-five of the 66 healthy University students had a VISA-A score of 100 (68%). Of the twenty-one with VISA-A scores less than 100 - nine students had scores between 90 and 99 (three of whom had a history of injury to the lower limbs), ten had scores between 80 and 89 (two who had lower body injuries and two with achilles tendon pain), and two scored less than 80 (one with Achilles tendon pain, and the other with calf pain). No students who scored 100 on the questionnaire had a history of Achilles tendon pain either in the past or currently. Achilles tendon pain was a significant predictor of VISA-A score ($p=0.004$) whereas other injuries was not ($p=0.114$). Age did not correlate with VISA score ($p>0.05$). Neither sex ($p=0.371$) nor sporting activity ($p=0.21$) were predictors of VISA-A score.

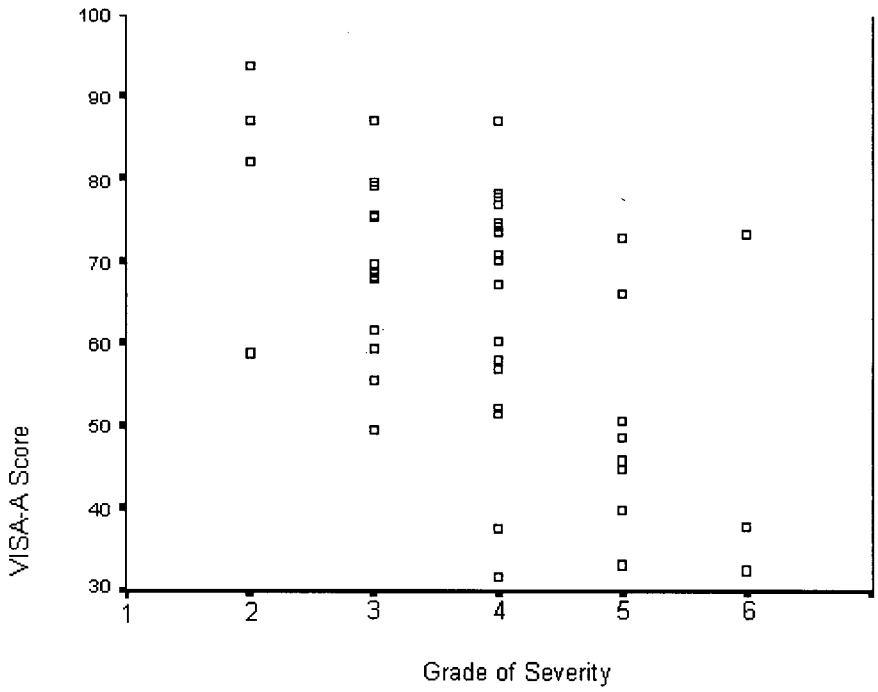
When comparing the VISA-A scores of the 63 students without any history of Achilles pain (Mean Score 96 ± 7.4), to the VISA-A score of the 45 subjects in the study group (Mean Score 63.8 ± 16.8) there was a significant difference between the scores ($p<0.001$; independent two tailed t-test) (Figure 2.5).

Figure 2.2. Scatter Plot of VISA-A score compared to modified Percy and Conochie's grade of severity.



Percy and Conochie: Am J Sports Med,1978; 6(3)132-6.

Figure 2.3. Scatter Plot of VISA-A score compared to Curwin and Stanish's grade of severity.



Curwin and Stanish: Tendonitis: Its Etiology and Treatment; 1984

Figure 2.4. Frequency histogram of VISA-A scores among non surgical patients (normal curve superimposed).

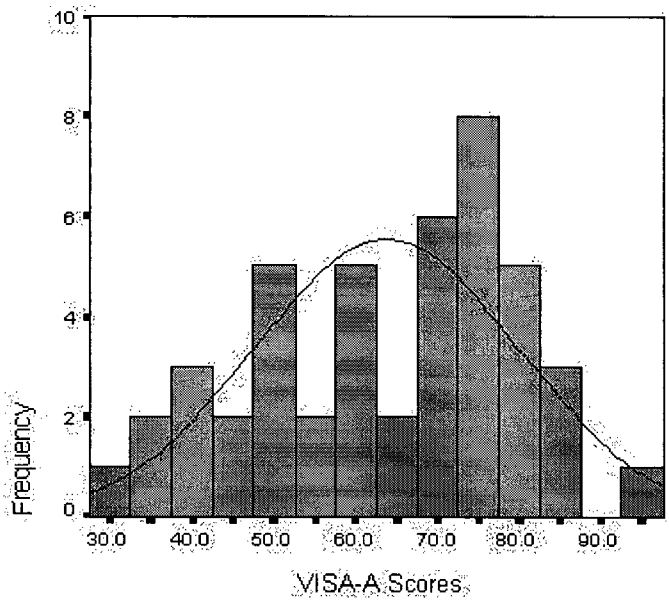
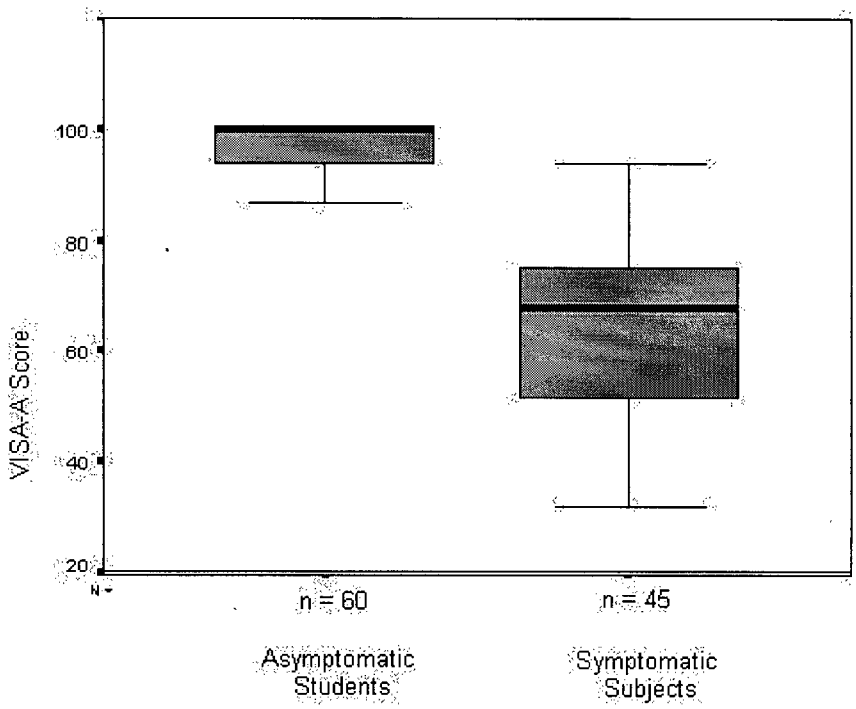


Figure 2.5. Box Plot showing VISA-A scores among asymptomatic students and symptomatic subjects.



2.3.2. Reliability

The results are summarised in Table 2.6. There was no difference in scores whether the test-retest questionnaires were done at the first visit or at the second visit (p=0.576).

Table 2.6. Summary of Reliability of VISA-A score

Reliability	Description	Pearson's Correlation Co-efficient
Test-retest reliability	This measures whether an instrument is capable of measuring a variable with consistency. Here one sample of individuals is subjected to the identical test on two separate occasions under the same circumstances as the first test.	0.93
Intrarater reliability	This refers to the stability of data recorded by one individual across two or more trials.	0.90
Interrater reliability	This concerns the variation between two or more raters who measure the same group of subjects.	0.90
Short term reliability	Tests whether the measurement remains the same over a short period of time.	0.81

2.4 DISCUSSION

This study shows that the VISA-A questionnaire is an effective and sensitive measurement tool of severity of Achilles tendinopathy, across a wide spectrum of patients. The VISA-A questionnaire, being specific to the Achilles tendon, is preferable when compared to other non-specific scoring systems such as that developed for hind foot problems by the American Orthopedic Society,[41 44] that

devised by Thermann *et al.*[26] and that devised by Boyden *et al.*[45] (Table 1.1). The VISA-A questionnaire is also more sensitive than that of Percy and Conochie and that of Curwin and Stanish, since the latter two use a categorical rating scale,[42 43] which has been shown to be insensitive to subtle changes in clinical condition.[27 28] While there is a wide variability in the scores as measured on the categorical rating scales, this may be due to a lack of sensitivity in the categorical grading schemes.[37 40 99-102]

No training is required to administer the VISA-A questionnaire. The scores were the same whether administered by an untrained student or by a sports medicine trained physician. The advantage therefore of the VISA-A questionnaire is in a simple assessment of subjective data. Until an objective marker of disease severity is discovered, subjective data remains the most important outcome variable. The value of a valid and reliable subjective outcome measurement tool is in repeated measures before and after an intervention. The use of a numerical questionnaire allows statistical comparisons, useful in the research setting both for conservative and surgical therapies. Studies may be done in various centres and results compared.

The VISA-A questionnaire is not a diagnostic tool, other diagnoses may bias the final VISA-A score. For example a patient with an acute ankle sprain may be unable to perform some of the functional tests.

Nevertheless the VISA-A score offers clinicians an indicator of severity of their patients' condition, which allows them a simple tool to monitor progress and response to therapy.

2.5 CONCLUSION

The VISA-A index of severity for Achilles tendon disorders is a valid and reliable measurement tool. It would be useful both in the clinical setting and in research settings as it has been shown to be accurate across a wide spectrum of patients. It is also reliable to administer by practitioners who are not specialist trained. The VISA-A index offers a suitable outcome measurement tool for treatment studies, for tendinopathy research and for monitoring individual patients with Achilles tendon disorders.

CHAPTER THREE

ARE OPTIMISED ULTRASOUND AND MAGNETIC RESONANCE IMAGING OF VALUE IN ACHILLES TENDON DISORDERS?

3.1 INTRODUCTION

The evidence presented in the literature survey (Section 1.5) is inconclusive as to the benefit of imaging in Achilles tendon disorders. There is a need for a prospective controlled study into the predictive value of US and MRI.[72]

In the present study, a group of patients suffering from Achilles tendon disorders varying in severity from mild to severe, and acute to chronic were assessed clinically and by state of the art US and MRI. The purpose was to compare the two modalities with regard to their use in mild cases, to assess whether the clinical severity of the condition correlated with the severity of the imaging findings and to discover whether either method was predictive of outcome.

3.2 PATIENTS AND METHODS

3.2.1. Clinical

3.2.1.1. Patients.

The forty-five consecutive patients recruited for the assessment of the VISA-A questionnaire (Section 2.2.1) also provided informed written consent to participate in the imaging part of the study. Ethics approval was similarly obtained.

The demographics of the forty five subjects was: Age range: 20 and 66 years (mean 42.35 ± S.D.11.35); Onset of symptoms: Range 0.5 and 120 months (Mean 21.5 ± S.D. 29.34). Bilateral symptoms were present in 12 patients (24 tendons), giving a total of 57 symptomatic tendons and 33 asymptomatic tendons. The symptoms were usually pain with activity and morning stiffness, and signs were mid tendon tenderness (41 tendons), insertional tenderness (12 tendons) or diffuse tenderness (4 tendons.)

3.2.1.2. Clinical Severity

The severity of the clinical condition was ranked according to the VISA-A questionnaire discussed in Chapter two.

3.2.1.3. Follow Up

Patients were contacted by telephone 3 months after the initial examination and imaging studies. They were questioned on symptoms, treatment they may have undergone, and the clinical severity of their condition was assessed using the VISA-A

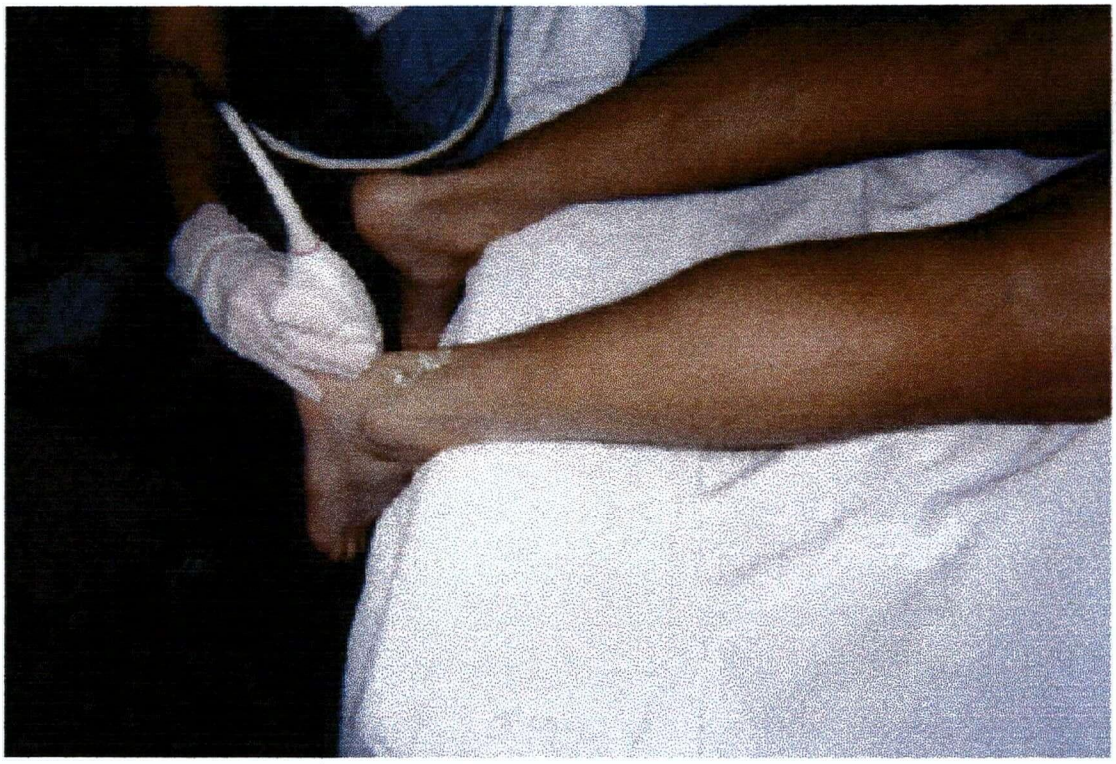
index and the grading system of Percy and Conochie.[42] Patients with ongoing complaints or questions were invited to attend a clinical examination.

3.2.2. Imaging

3.2.2.1. Ultrasound

Real time US was performed by one of two ultrasound technicians using a high-resolution 12-5L array scanner. (Advanced Technology laboratories 5000, Bothell, WA). Their findings were confirmed by one of two radiologists who were blinded to

Figure 3.1. US was performed with the patient prone.



the clinical findings or other imaging findings. US was done the day of or within one week of the clinical examination. Patients were positioned prone with their feet hanging over the end of the scanning table in a relaxed posture (Figure 3.1). An acoustic stand-off pad or a synthetic gel spacer was not necessary. Sonograms were obtained in the sagittal plane of the entire length of both tendons, as well as transverse sections. Particular care was taken to ensure the scan plane was parallel to the tendon fibres to avoid acoustic fibre anisotropy.[50 80 82 103] Thickness was measured by the anteroposterior (AP) diameter in a transverse scan at a neutral position of the talocrural joint.[54 56 83 87] A thickened tendon was defined as one that was greater than 6 mm.[84] A sonographic abnormality was defined as either one or more hypoechoic and / or hyperechoic areas evident in both the longitudinal and the transverse scans, or a fusiform swelling of the tendon with or without hypoechoic areas.

Both colour and power Doppler interrogation was utilised in all patients.

3.2.2.2. Grading of US severity

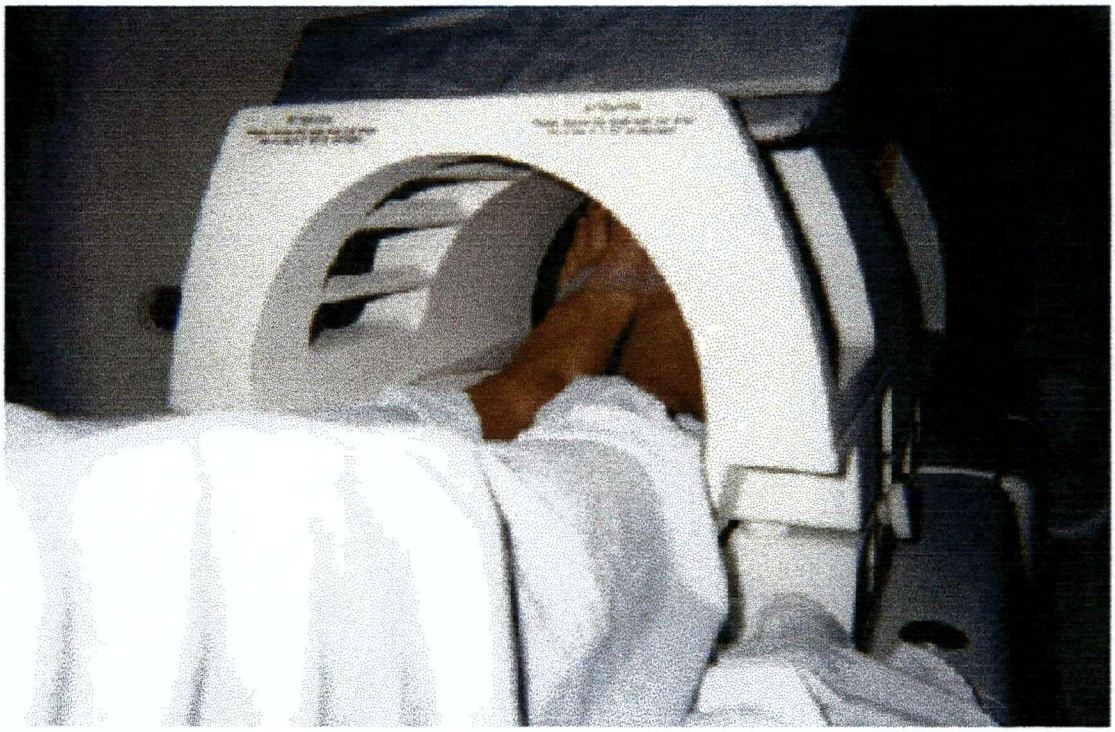
Measurements of any hypoechoic areas were made using electronic callipers in both the axial (transverse) and sagittal (longitudinal) planes.[83] Length was measured on the sagittal image, whereas width (mediolateral dimension) and height (anteroposterior dimension) were measured on the axial image. The approximate volume of each hypoechoic lesion was calculated using the product of length, width and height.[70] The tendons were also graded according to a grading scheme developed by Archambault *et al.*[60] Grade 1 was assigned if the tendon appeared normal; Grade 2 was assigned if the tendon showed evidence of thickening, with a homogeneous echotexture; Grade 3

was assigned if there were any hypoechoic areas, or calcifications, within the tendon with or without thickening.[60]

3.2.2.3 Magnetic Resonance Imaging

MRI was performed on the first 25 consecutive patients who enrolled in the study using a 1.5 Tesla echo speed scanner (General Electric Milwaukee, WI). MRI was done within two weeks of the US and clinical examination. With the patient supine multiple sagittal and axial sequences were obtained using a quadrature head coil (Figure 3.2). The following sequences were used: For T1-weighted sagittal spin echo imaging and axial spin echo T1 imaging, repetition time was 500 msec, echo time was 14 msec, section thickness was 3mm with no interslice gap, field of view was 12 cm, matrix was 256 X 256, signals acquired were 2 and imaging time was 4 minutes 24 seconds. For sagittal fast short tau inversion recovery (FSTIR): effective echo time was 32 msec, repetition time was 4,000 msec, inversion time was 150 msec, field of view was 16 cm X 16 cm, section thickness was 3mm with no gap, matrix was 256 X 192, number of excitations was 3 and imaging time was 5 minutes 36 seconds. For two-dimensional $T2^*$-weighted sagittal gradient-recalled echo (GRE) imaging: repetition time was 800 msec, echo time was 30 msec, flip angle was 70°, field of view was 12 cm, section thickness was 3mm with no gap, matrix was 256 X 256, signals acquired were 1.5 and imaging time was 5 minutes 10 seconds. MRI was read by two radiologists and concurrence was obtained for all 50 tendons.

Figure 3.2. Bilateral tendon MRI was performed using a quadrature head coil.



3.2.2.4. Grading of MR severity

The size of any intratendinous pathology was measured and the approximate volume of the lesion calculated as a product of the length (craniocaudal dimension on longitudinal plane), width (mediolateral dimension on axial plane) and height (anteroposterior dimension on axial plane).[70] For comparison purposes the MRI was also graded in a similar manner to the US grading as - 1: normal, 2: thickened or 3: intratendinous signal intensity change.

3.2.3. Data Analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences software (SPSS) for windows (version 7.0). Patient characteristics were analysed using descriptive data. Grades of severity clinically, by US and MRI were compared using Pearson's correlation co-efficient and Spearman's rank correlation for non parametric data. Relationship between clinical findings and imaging findings was analysed using a Chi-squared analysis with 2 X 2 contingency tables. Follow up data was analysed using a Chi-squared analysis with 3 X 3 contingency tables.

3.3 RESULTS

3.3.1 Imaging

3.3.1.1. Ultrasound

Ultrasound (Figure 3.3) correctly identified 37 of the 57 (65%) symptomatic tendons as being abnormal and 22 of the 33 (67%) asymptomatic tendons as being normal (Table 3.1).

Table 3.1. US results.

US results	Clinical findings		
n=90 tendons	Symptomatic	Asymptomatic	Total
US Positive	37	11	48
US Negative	20	22	42
TOTAL	57	33	90

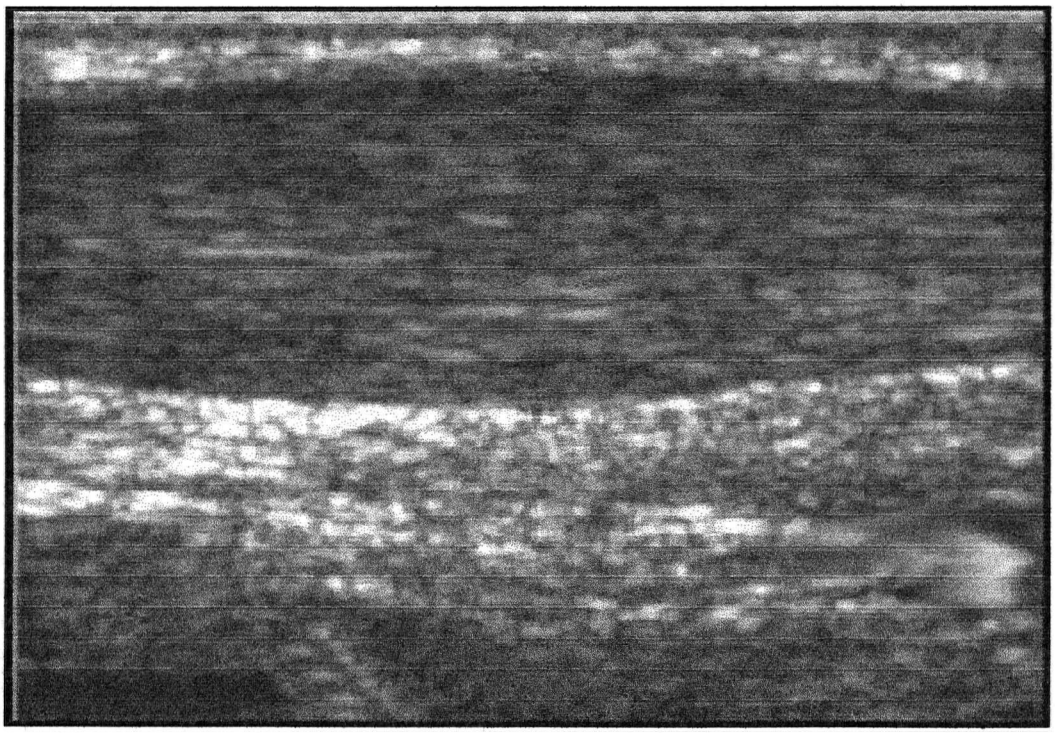
The absolute clinical diagnosis (e.g. tendinosis, partial rupture, peritendinitis) did not correlate well to the imaging diagnosis (Table 3.2).

Table 3.2. Chart listing clinical diagnosis and US correlation.

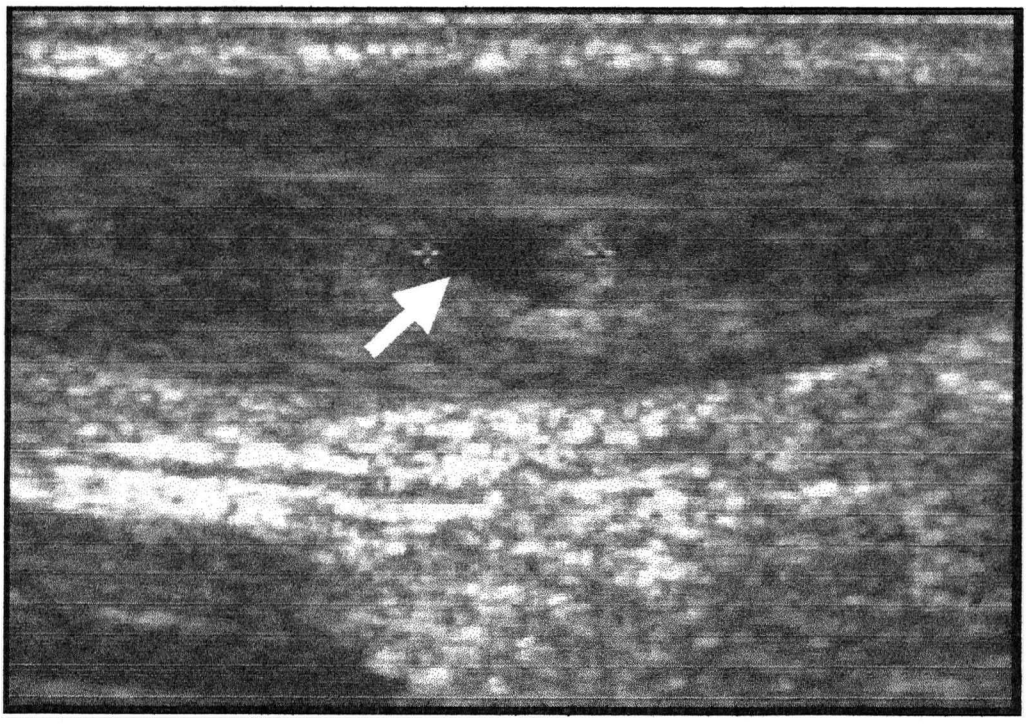
CLINICAL DIAGNOSIS*		US	
SYMPTOMATIC	No. of tendons.	Agree n	Disagree n
Tendinosis+ partial rupture	45	32	13
Insertional tendinopathy	16	2	14
Bursitis	5	3	2
Peritendinitis	0	-	-
TOTAL	66	37	29
ASYMPTOMATIC			
Never	26	19	7
Prior	7	3	4
TOTAL	33	22 (67%)	11 (33%)

* More than one diagnosis is possible.

Figure 3.3. Hypoechoic lesion as seen on US (sagittal view).



Appearance of a thickened tendon on sagittal view.



Appearance of a hypoechoic lesion on sagittal view. (White Arrow)

Thus US had a sensitivity of 0.65 and specificity of 0.67 and an overall accuracy of 0.66. The positive predictive value was 0.77 and negative predictive value 0.52. The addition of colour and power doppler interrogation did not enhance the accuracy of US (Table 3.3).

Table 3.3. Relationship between clinical findings and colour and power doppler flow on US.

	Clinical Findings		
Colour Doppler (US)	Symptomatic	Asymptomatic	Total
positive	32	7	39
negative	25	26	51
Total	57	33	90
Power Doppler (US)	Symptomatic	Asymptomatic	Total
positive	5	1	6
negative	52	32	84
Total	57	33	90

Of those 39 tendons with increased colour flow, 21 were thickened or nodular clinically ($x^2 = 17.9$; $p<0.01$)(Table 3.4). There was also a correlation between positive colour flow and age (Spearman's rho = 0.56; $p<0.01$) but not between onset of symptoms ($x^2 = 0.111$; $p = 0.74$)(Table 3.5), or sports participation ($x^2 = 1.05$; $p = 0.59$).

Table 3.4. Relationship between positive colour flow on US and clinical thickening of the tendon.

		Colour		
		no	yes	TOTAL
clinical thickening	no	44	18	62
	yes	7	21	28
	TOTAL	51	39	90

Table 3.5. Relationship between onset of symptoms and colour doppler flow on US.

		Colour		
		no	yes	TOTAL
onset of symptoms	acute	4	5	9
	chronic	12	24	36
	TOTAL	16	29	45

3.3.1.2. Ultrasound Severity

Although arbitrarily defined, the calculated volume of hypoechoic lesions correlated significantly with the index of severity suggested by Archambault *et al.*[60] (Spearman's rho = 0.87; $p<0.01$) and both correlated significantly with the VISA-A score (Spearman's rho = -0.33; $p<0.01$ and -0.34; $p<0.01$ respectively).

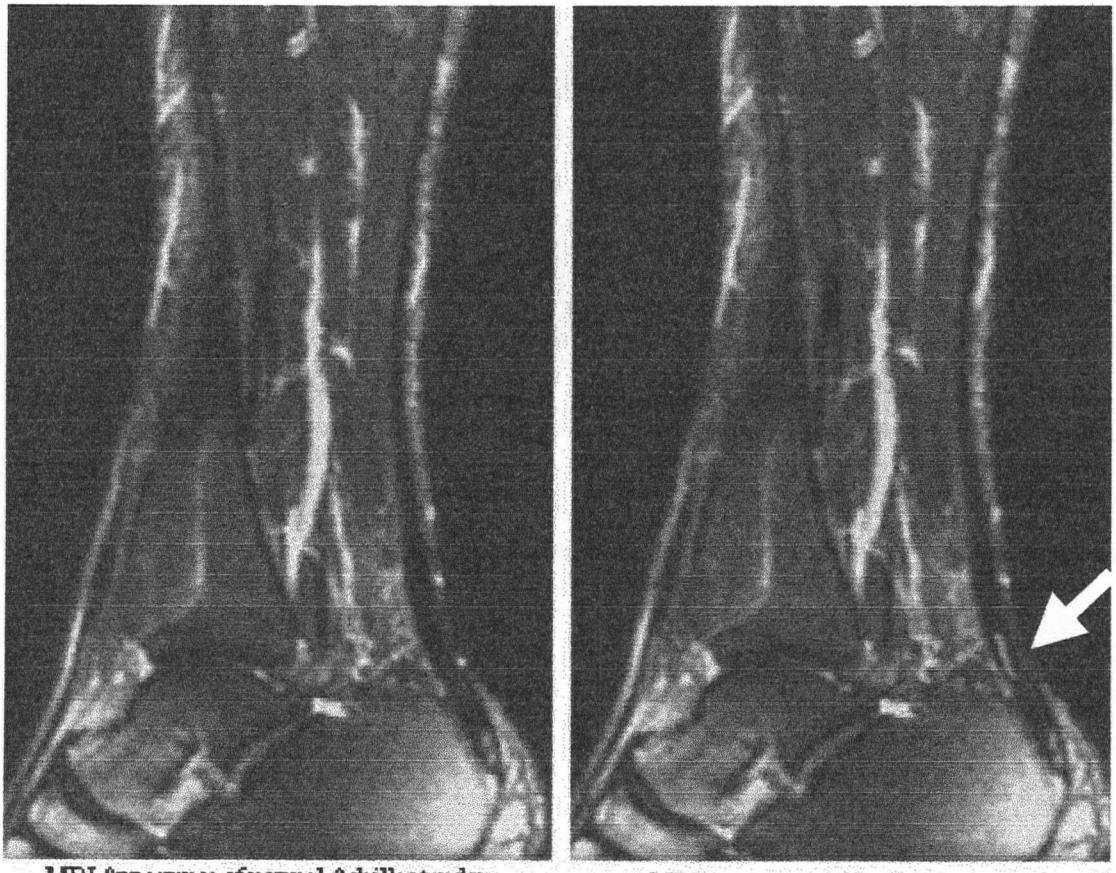
3.3.1.3 MRI

MRI (Figure 3.4) correctly identified 19 (56%) of the 34 symptomatic tendons as being abnormal but 15 symptomatic tendons were falsely identified as being normal (Table 3.6).

Table 3.6. MRI results

MRI results	Clinical findings		
n=50 tendons	Symptomatic n=34	Asymptomatic n=16	Total
MRI Positive	19	1	20
MRI Negative	15	15	30
TOTAL	34	16	50

Figure 3.4. Intratendinous high signal intensity seen on T1-weighted MRI.



MRI Appearance of normal Achilles tendon T1-weighted Images

MRI Appearance of Intratendinous high signal intensity change (White Arrow)

Sixteen tendons were asymptomatic, and MRI was normal in 15 (94%) of them. In the sixteenth case MRI showed increased signal intensity within the tendon that had "never" been symptomatic. Thus MRI has a sensitivity of 0.56, a specificity of 0.94, a positive predictive value of 0.95, a negative predictive value of 0.50 and an overall accuracy of 0.68.

There was no significant difference in MRI results between those presenting acutely or chronically ($x^2 = 0.15$; $P = 0.69$). However the false negative cases were significantly milder than the true positive cases (paired t-test; $p<0.01$) (Table 3.7), and were less likely to be thickened (Table 3.8)(Figure 3.5).

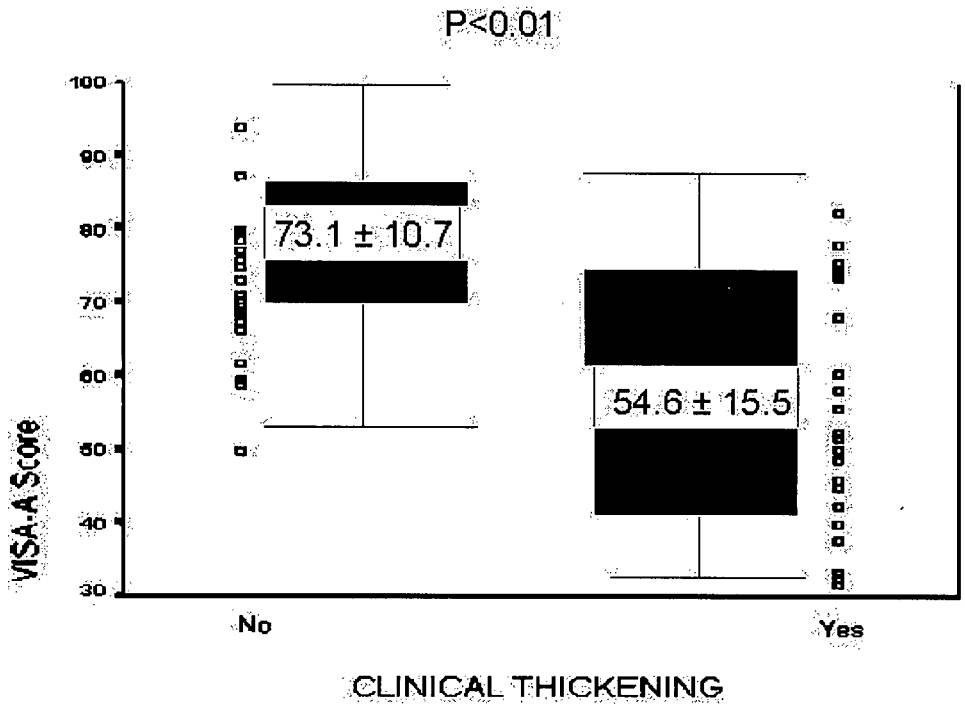
Table 3.7. Relationship between MRI results and clinical severity.

MRI results	Clinical findings		VISA-A Scores*
* t-test; $p< 0.01$	Symptomatic n=34	Asymptomatic n=16	mean ± SD
MRI Positive	19	1	60.2 ± 19.5
MRI Negative	15	15	86.9 ± 16.1

Table 3.8. Relationship between clinically thickened tendons and positive MRI.

MRI results	Symptomatic n=34	
$x^2 = 12.2$; $P<0.001$	Thickened	Not Thickened
Positive	14	5
Negative	2	13

Figure 3.5. Combined box plot and scatter plot showing relationship between clinical severity and thickening of the tendon in patients with positive MRI results.



3.3.1.4. MRI Severity

Although arbitrary, the volume of intratendinous high signal intensity lesions correlates significantly with a simple grading scheme suggested by Archambault *et al.*[60](Spearman's rho = 0.736; $p<0.01$). This volume also correlated significantly to the clinical severity (Spearman's rho = -0.424; $p<0.01$), and the volume of hypoechoic lesions on US (Spearman's rho = 0.673; $p<0.05$).

3.3.1.5. Follow up

In order to show a significant change in a subject's condition, a change of 25 or more points on the VISA-A score is required. From the test retest reliability data (Section 2.3.3, Table 2.6) the standard error of measurement may be calculated as 2.4 points (95% CI 58.9 to 68.6). Therefore a significant difference not due to measurement error can be calculated as 0.25 (25%) (2.4 / (68.6-58.9)). At 3 month follow up 7 of the 45 patients had improved by more than 25 points on the VISA-A scale, 37 remained the same and 1 had worsened. In assessing whether the severity indexes (clinical, US and MRI) are predictive of outcome at 3 months, we assessed whether the improvement at 3 months was related to severity scores at baseline. While the baseline clinical VISA-A score did correlate with the 3 month VISA-A score (Pearson's r = 0.615; $p<0.01$) neither US nor MRI grade of severity correlated to outcome at 3 months ($x^2 = 1.98$; $p = 0.73$ and $x^2 = 2.56$; $p = 0.63$ respectively) (Table 3.9).

Table 3.9. Relationship between imaging severity at baseline and clinical outcome at 3 month follow up.

		Follow up			
$x^2 = 4.98$; p = 0.28		Improved	Same	worsened	Total
US	normal	2	9	1	12
	thickening	2	2	0	3
	hypoechoic	3	26	0	30
	Total	7	37	1	45
$x^x = 2.74$; p = 0.6	normal	1	9	1	11
MRI	thickening	1	2	0	3
	intensity change	1	10	0	11
	Total	3	21	1	25

There was no relationship between outcome and onset of symptoms ($x^2 = 2.8$; p = 0.24) nor between outcome and thickening of the tendon ($x^2 = 2.6$; p = 0.26).

3.3.1.6.Correlation between US and MRI

Among the 34 symptomatic tendons both US and MRI were correct in 18 tendons and falsely negative in 10 tendons (Table 3.10).

Table 3.10 Correlation between US and MRI.

		Clinical findings		
n=50 tendons	Ultrasound	Symptomatic n=34	Asymptomatic n=16	Total
MRI Positive	Positive	18	0	20
	Negative	1	1	
MRI Negative	Positive	5	3	30
	Negative	10	12	
TOTAL		34	16	50

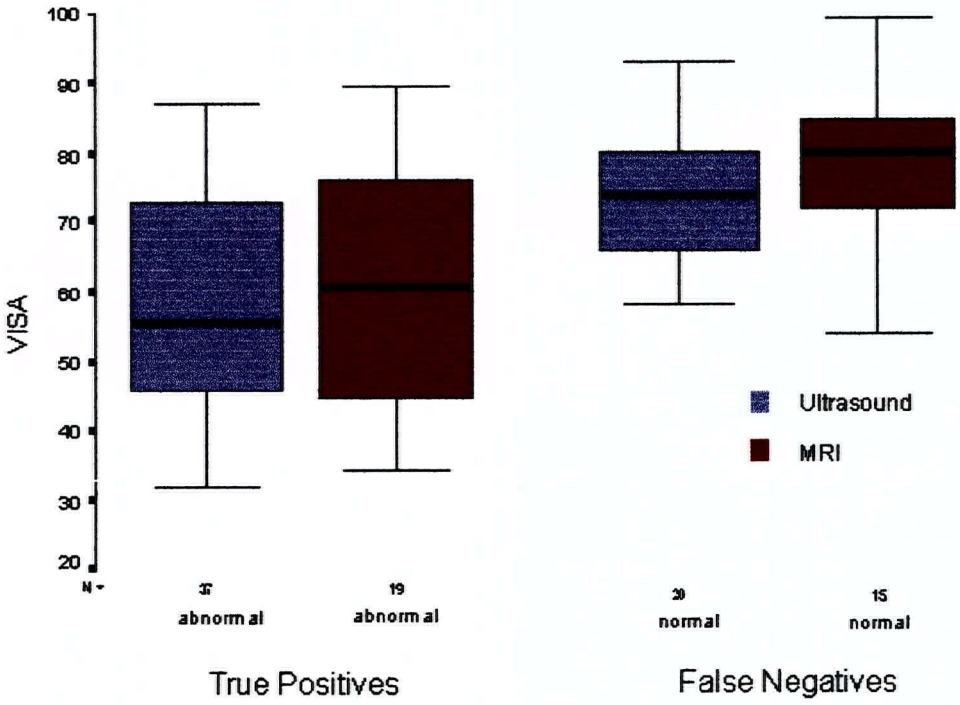
On 2 way ANOVA, the VISA-A scores of the patients falsely identified as having normal imaging were significantly higher (milder condition) than those with positive imaging ($p<0.05$) (Figure 3.6; Table 3.11).

Table 3.11. Correlation between US and MRI and VISA-A score in 34 symptomatic subjects.

	US RESULTS	n	VISA-A Score mean ± SD
MRI Positive	positive	18	57.6 ± 18
	negative	1	67.3
MRI Negative	positive	5	66.4 ± 13.6
	negative	10	77.4 ± 11.7

Among the 16 asymptomatic tendons, only one tendon was falsely positive on MRI but not US and 3 tendons were falsely positive on US but not MRI. The remaining 12 tendons were correctly identified as normal on both imaging modalities.

Figure 3.6. Correlation between US, MRI and VISA-A Score.



3.4. DISCUSSION

Because histopathology was unacceptable to the patients, and there are no biochemical markers of disease severity, this study utilised a clinical gold standard. While this is the first study to stress this in Achilles tendon research, others have utilised a clinical gold standard in patellar tendon research. Lian et al.[35] and Shalaby and Almekinders[36] showed convincing evidence that clinical findings are indeed a preferable standard than imaging in research in the patellar tendon.[37]

We were unable to show a difference in accuracy between either imaging modalitiy. These findings, among a cohort of nonoperative cases, complement those of Astrom *et al.*[69] who found little difference between US and MRI among a group of more severe cases. This lack of sensitivity would suggest that US and MRI are inadequate as an outcome measurement.

The value of US was not enhanced by the addition of colour and power doppler interrogation. Colour and power doppler sonography have been used successfully in depicting high volume flow as in large vessels, and only recently has been used in identifying change of perfusion in low velocity areas such as the musculoskeletal soft tissues.[88 104] Because grey scale and colour sonography is operator dependant, it was hoped the addition of power doppler assessment would add objective evidence of pathology.[89] But like Weinberg *et al.*[89] we found all tendons with positive colour flow also had positive findings on grey scale. We also found colour doppler to be significantly more sensitive and more visible than power doppler, in contrast to the suggestion of Breidahl *et al.*[104] who thought that power doppler may be more suitable.

Colour doppler unlike power doppler is dependant on angle. Until the histology is identified, of tendon with positive colour and power doppler sonography, the mechanism for increases in flow are speculative. Further research is needed in this regard.

This study used the volume of intratendinous abnormalities seen on US and MRI to quantify imaging abnormality. Although this has also been used by Movin *et al.*[70] the reproducibility and validity of this measurement has not been assessed. Khan *et al.*[105] in their series assessing patellar tendon imaging findings suggested that cross sectional area in the axial plane was a more reproducible measurement. Whether this is the case in the Achilles tendon remains a subject for further research.

Despite these limitations imaging grade of severity correlated well to clinical severity. However, no additional information was obtained that was not evident clinically.

Imaging was unable to differentiate between cases that would improve and those that would worsen. Despite normal imaging one patient was worse at follow up. This is in contrast to the studies of Mathieson *et al.*,[49] Nehrer *et al.*[56] and Archambault *et al.*[60] but more in keeping with the findings of Astrom *et al.*[69] and Marcus *et al.*[62] Clinical index of severity at presentation was the only predictor of outcome at 3 month follow up.

3.5. CONCLUSION

Clinicians should exercise discretion in ordering imaging tests and in interpreting their findings. Because of the cost, accessibility and convenience of US this should be the imaging modality of choice. Imaging may be best suited to answer specific diagnostic questions, such as the location of hypoechoic regions in a diffusely thickened tendon; the presence of additional lesions such as xanthoma[2] and as an adjunct to an US directed biopsy. Where imaging is ordered one would stress the need for communication between the clinician and radiologist.[73]

CONCLUSION AND RECOMMENDATIONS

This study has introduced a new valid and reliable tool for measuring the severity of Achilles tendon disorders the VISA-A questionnaire that will be useful in research and in clinical practice. The VISA-A questionnaire offers a quantifiable measure of subjective clinical findings that allow for comparisons over time. In clinical trials of therapy researchers will find the index useful as an outcome measurement tool. Clinicians too will find the index useful assess patient response to therapy and changes in clinical condition over time.

This thesis has also shown that imaging findings do not add to the clinical assessment of a patient and should be reserved for specific cases. Where imaging is required US was shown to be as accurate as MRI, and therefore would be the preferred imaging method. Color and Power Doppler sonography did not add value to grey scale sonography and need not be performed. Where imaging may be of use is in the diagnosis of unusual conditions such as tendon xanthoma; identifying the site of hypoechoic lesions presurgically and as an adjunct to an US directed biopsy. Communication between the clinician and radiologist will facilitate appropriate interpretation of the imaging findings.

This thesis assessed patients over a short term follow up period. Further prospective studies to assess the long term prognostic value of the VISA-A score are needed. In addition there is a need for prospective studies to characterise the natural history of changes seen in imaging studies within symptomatic and asymptomatic Achilles tendons.

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APPENDIX A

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