Audit/Musculosk'l medicine in practice

Achilles tendon diagnostic ultrasound examination: A locally designed protocol and audit

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Background: Diagnostic ultrasound is regarded as the gold standard for imaging tendinopathies for diagnosis, focusing rehabilitation, and guided intervention. However, there are no published diagnostic ultrasound protocols for the Achilles tendon which represent best practice. In the Felixstowe Community Hospital Physiotherapy Department a protocol for diagnostic ultrasound examination of the Achilles tendon was implemented in January 2013 and acts as a local guideline.
Objectives: To determine whether a local Achilles tendon image protocol is being adhered to in diagnostic ultrasound examinations of mid-portion Achilles tendinopathy. A pre-determined 75% adherence to the protocol was set as the standard representing best practice in diagnostic ultrasound examination of the Achilles tendon. A target of 100% of diagnostic ultrasound examinations should meet this standard.
Methods: Data collection of acquired and archived diagnostic ultrasound examinations with a subsequent diagnosis of mid-portion Achilles tendinopathy was included. A proforma was developed to collect data to determine whether diagnostic ultrasound examinations met the protocol standard.
Results: The sample included all patients from 1 January to 31 May 2013 ($n = 30$). The study population included 16 females and 14 males with a mean age of 54.2 (SD ± 15.01) years and mostly represented by the age category 36–65 years (76.7%). This audit demonstrated that 73% (22 patients from 30) of diagnostic ultrasound examinations adhered to the standard set. This audit demonstrated inconsistencies in performing components of the diagnostic ultrasound examination procedure including the region of interest power Doppler, contra-lateral grey-scale, contra-lateral power Doppler, split screen images and annotation.
Conclusions: The audit has highlighted the need to enhance Achilles tendon diagnostic ultrasound examinations; a number of recommendations have been made in improving the service for Achilles tendon examinations. It is envisaged that by adoption of these recommendations the musculo-skeletal service for these patients at the Felixstowe Community Hospital Physiotherapy Department will be enhanced before commencement of the second Clinical Audit Cycle is undertaken.

Keywords: Achilles tendon, Audit, Diagnostic ultrasound, Physiotherapy, Protocol

Introduction

Tendinopathy is a common musculo-skeletal injury in the upper and lower limb.[1] In the last decade, diagnostic ultrasound has been at the forefront of research in tendinopathy and has emerged as the gold standard in imaging. In the development of high-frequency probes the main advantages of this non-invasive imaging tool include fine depictions of tendon fibrillar appearance, dynamic and point of care examination, and guided intervention. However, the main disadvantage of diagnostic ultrasound examination is that it is operator dependent. Commonly on diagnostic ultrasound examination, a tendinopathic tissue has a disorganized fibrillar appearance, oedema, tendon thickening, and frequently with neovascularisation present. In tendinopathy, the sonographer has to analyse grey scale and power Doppler tendon appearances and decide on what images are acquired and archived.

In the last decade, the pathogenesis of tendinopathy has remained elusive. Theories have emerged on the pathogenesis of tendinopathy to describe the likely cascade of events from a normal tendon state, to asymptomatic pathological state and subsequently to symptomatic physiological state. A load-induced

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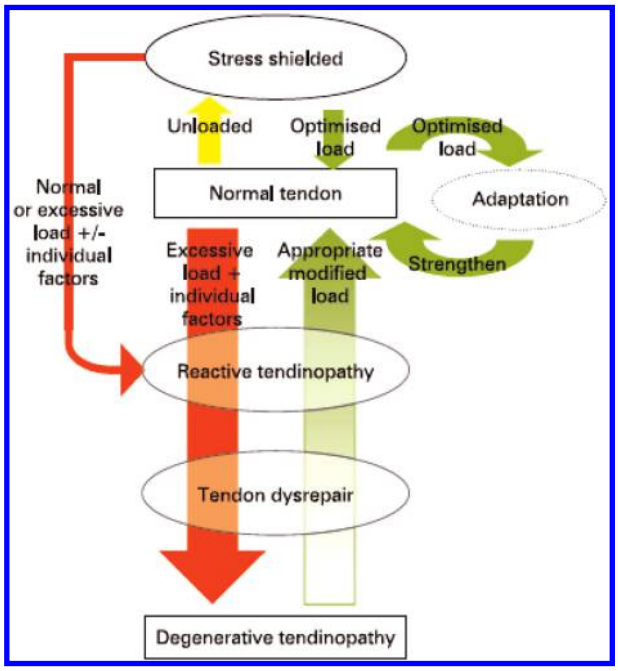

Figure 1 The pathogenesis of tendinopathy load induced continuum as proposed by Cook and Purdam.[2]

continuum theory was proposed by Cook and Purdam[2] and implies load is the definitive factor for tendinopathy (Fig. 1). Tendons have been shown to be anabolic and catabolic depending on loading profiles,[3] and therefore they are load dependent.[4] Cook and Purdam[2] three-stage load-induced continuum embraces the transition from normal tendon state to degenerative tendinopathy and highlights the potential for reversibility early in the continuum. Other recent theories on the pathogenesis of tendinopathy have been proposed recently by Abate *et al.*[1] and Fu *et al.*,[5] but do not correlate the diagnostic ultrasound examination to pathogenesis and treatment.

Achilles tendinopathy management with diagnostic ultrasound

Cook and Purdam[2] load-induced continuum theory hypothesises that the treatment should be tailored to the pathology and that one treatment should not applied to all tendinopathies. A treatment algorithm (Alfredson and Cook 2007)[6] is recommended for rehabilitation for mid-portion Achilles tendinopathy and comprising eccentric calf raises and have been demonstrated to have favourable outcomes (van der Plas *et al.* 2012),[7] but not for insertional Achilles tendinopathy (Jonsson *et al.* 2008).[8] Therefore, training profiles need to be specific for the patient because up to 45% do not respond.[9] In the load-induced continuum theory, Cook and Purdam simplified the three tendinopathy stages into a two stages to provide sub-grouping for treatment optimization: in stage 1 (reactive tendinopathy/early tendon dysrepair) where there is a generally thickened tendon, and minor focal hypoechoic sections with no or minimal neovascularisation on diagnostic ultrasound examination, the intervention recommended is relative rest/reduction in load (frequency/intensity/time/type); pacing; biomechanics/podiatry; non-steroidal anti-inflammatory medications; +/− steroid injection. In stage 2 (tendon dysrepair tendinopathy/degeneration) where there is a nodular appearance, large focal regions of heterogenicity and multiple neovascularization, the recommendations are for exercise (eccentric exercise); manual therapy (frictions); extracorporeal shock wave therapy; ultrasound; surgery; prolotherapy; plasma-rich protein; injection (nil substance); aprotinin; sclerosing therapy; and glycerol trinitrate. Therefore, diagnostic ultrasound examination is essential for full evaluation of the integrity of the tendon, tailoring rehabilitation, and guided intervention, despite the optimum management of tendinopathy remaining uncertain.[10]

Competency standards in diagnostic ultrasound

In achieving safety and competency in diagnostic ultrasound formal post-graduate musculo-skeletal focused courses are available accredited by the Consortium of the Accreditation of Sonographic Education.[11] It is mandatory practice to maintain competency by regularly supervision and continuing professional development.[12] Musculo-skeletal diagnostic ultrasound examination guidelines include those from the Society of Radiographers,[13] Royal College of Radiologists,[14,15] and United Kingdom Association of Sonographers,[12] although none include an Achilles tendon protocol. Recommendations from the European Society Musculo-Skeletal Radiology[16] include ankle grey scale images, but do not include an Achilles tendon protocol. The United Kingdom Association of Sonographers states that in diagnostic ultrasound examination *'… compilation of an appropriate number of annotated images that represent the entire ultrasound examination is good practice …'* but does not make specific recommendations.[12]

Nationally, many hospitals operate diagnostic ultrasound protocols based on local guidelines developed in collaboration between radiology departments and the orthopaedic surgeons, but currently, there are no published protocols for diagnostic ultrasound examination of the Achilles tendon. As there is no published standard for the components of diagnostic ultrasound examination for the Achilles tendon, an Achilles tendon image protocol was developed locally. This protocol was designed with respect to clinical experience, available literature and implicit retrospective evidence performed by a service evaluation. The protocol should be adhered to for any patient referred to the department who has an Achilles tendon associated complaint and subsequently has a diagnostic

ultrasound examination as part of their physiotherapy management. The protocol includes the components of the diagnostic ultrasound examination procedure for grey scale and power Doppler images to be acquired and archived for the Achilles tendon. The protocol illustrates the complete examination of the entire tendon and is robust for any pathology of the Achilles tendon.

Regular audit is mandatory practice within radiology departments. However, with the 'Any Qualified Provider' initiative in the United Kingdom National Health Service there are many providers and sonographers offering musculo-skeletal diagnostic ultrasound outside of the radiology department in primary care. Audit is mandatory to maintain clinical governance[12] and commonly include monthly audit comprising 10% of acquired and archived diagnostic ultrasound examinations to ensure patient safety and competency. Commonly a proforma is used to measure performance, but there are none published in the literature. Therefore, a proforma was designed and our Achilles tendon protocol for diagnostic ultrasound examinations was audited in our department.

Achilles tendon diagnostic ultrasound audit

Aims

The audit focused on diagnostic ultrasound images of the Achilles tendon to determine whether the Achilles tendon image protocol was adhered to, and based on the findings, make recommendations for changes and improvements in future practice.

Objectives

The objectives for this audit were as follows:

1. **Set a standard** for imaging the Achilles tendon using diagnostic ultrasound that represents best practice.
2. **Design a proforma** to collect data to determine whether or not the standard was met.
3. **Set the target** of Achilles tendon images that should meet the standard.
4. **Produce recommendations** based on these audit findings and plan the second Clinical Audit Cycle.

Methods

Standard setting

There is no published standard for the components of the diagnostic ultrasound examination procedure in the literature for the Achilles tendon. Therefore, an Achilles tendon image protocol was developed to represent the standard for best practice in diagnostic ultrasound examination of the Achilles tendon (see Appendix 1).

Design of proforma

A proforma was designed to record data from archived diagnostic ultrasound examinations of the Achilles tendon (Fig. 2). The proforma provides a record of what components of the diagnostic ultrasound examination procedure for the Achilles tendon image protocol were adhered to in mid-portion Achilles tendinopathy patients. It includes four criteria focusing on the relevant components of the diagnostic ultrasound examination procedure of grey scale and power Doppler images for the Achilles tendon: these comprise the *type, annotation, settings,* and *logical continuum* of images. The proforma consists of eight questions and include six questions which have mandatory components of the diagnostic ultrasound examination procedure and two have non-mandatory components.

In recording data using this proforma each of the eight questions has to be answered in accordance with the following statements:

Yes means that the requirements of the question have been performed correctly with *no faults* in *all* images.
Yes, incorrectly means that the requirements of the question have been performed incorrectly and includes *some faults,* e.g. incorrect annotation, i.e. long axis incorrectly used instead of short axis.
No means that the requirements of the question have *not been performed*.

The relevant boxes *Yes*; *Yes, incorrectly;* and *No* need to be marked with *1, 2,* or *3*, respectively, e.g. *Yes = 1.* In determining whether the standard is met it was pre-determined that at least any six out of the eight (75%) proforma questions had to be answered *'Yes'*. There was no weighting component for any of the eight proforma questions. Therefore, the standard was set as ≥75% of the questions answered *'Yes',* represents best practice in diagnostic ultrasound examination of the Achilles tendon.

The target set for the Felixstowe Community Hospital Physiotherapy Department was that all (100%) diagnostic ultrasound examinations of the Achilles tendon must meet the standard of the Achilles tendon image protocol. Therefore, all diagnostic ultrasound examinations of the Achilles tendon should achieve ≥75% on the proforma.

Study population

The audit location was the Felixstowe Community Hospital Physiotherapy Department. The inclusion criteria included male and female patients above 18 years of age that were referred to the department by general practitioners and/or physiotherapists. The study population included all patients who as part of their physiotherapy management, subsequently had a diagnosis of mid-portion Achilles tendinopathy based on archived diagnostic ultrasound examination reports from 1 January to 31 May 2013.

The exclusion criteria included patients with a diagnosis of Achilles tendinopathy being assessed and treated (surgical or non-surgical) in secondary care

Achilles tendon image proforma

NHS No:_____

DOB:_____ Age:_____

Gender:_____

CRITERION 1 – Type of images	Yes	Yes, incorrectly	No
REGION OF INTEREST			
Q1: Has GS been performed consistently and accurately in LAX and/or SAX images; +/- with reference measurements to adjacent anatomy?			
Q2: Has PD been consistently and accurately performed in SAX, +/-LAX images?			
CONTRA-LATERAL SIDE			
Q3: Has GS been performed consistently and accurately in LAX and/or SAX images; +/- with reference measurements to adjacent anatomy?			
Q4: Has PD been consistently and accurately performed in SAX, +/-LAX images?			
SPLIT SCREEN			
Q5: Has GS and/or PD split screen been performed to region of interest side with contra-lateral side (i.e. LAX/LAX and/or LAX/SAX); +/- region of interest LAX with SAX?			

CRITERION 2 – Annotation	Yes	Yes, incorrectly	No
Q6: Has the GS and PD images consistently and accurately include annotation of region of interest, relevant anatomical landmarks, relevant orientation and +/- body mark?			

CRITERION 3 – Settings	Yes	Yes, incorrectly	No
Q7: Has the GS and PD images consistently and accurately include the relevant settings?			

CRITERION 4 – Logical continuum of images	Yes	Yes, incorrectly	No
Q8: Has the GS and PD images consistently include a logical continuum of images that consistently and accurately displays region of interest, which allows the sonographer to arrive at a confident and safe diagnosis using diagnostic ultrasound?			

Legend:
GS = grey scale; PD = power Doppler; LAX = Long axis; SAX = Short axis
Questions: 1 = Yes; 2 = Yes, incorrectly; 3 = No

Figure 2 The Achilles tendon image proforma Achilles tendon image proforma.

and/or by consultant-led care. Patients who were unable communicate in the English language were also excluded.

Data collection

The data collection included patient and diagnostic ultrasound image data from the Felixstowe Community Hospital Physiotherapy Department Logic e BT11 diagnostic ultrasound machine which had passed all quality assurance tests. The physiotherapy team including a musculo-skeletal sonographer with an MSc musculo-skeletal diagnostic ultrasound (Consortium of the Accreditation of Sonographic Education approved) utilizes the machine daily.

The data collection followed a logical step process.
Step 1: In compiling raw data a search was performed on the diagnostic ultrasound machine on patient files for *Ankle* setting, therefore identifying all ankle pathology. All diagnostic ultrasound reports with a subsequent diagnosis of mid-portion Achilles tendinopathy were selected that matched the inclusion and exclusion criteria. The NHS numbers were collected and coded to a number representing the patient file and were transferred to an NHS secure Excel Spreadsheet for long-term storage.
Step 2: Confidential patient data including gender, age, and grey scale and power Doppler image data were recorded onto the proforma for each patient file. Repeat of Step 2 was performed by the same auditor to ensure accuracy of data collection.
Step 3: All proforma data were summarized onto an Excel spreadsheet for data analysis.

Data analysis

Data analysis was performed on an NHS secure computer using Excel spreadsheet.

Ethical considerations

This audit obtained ethical authorization from the Felixstowe Community Hospital Physiotherapy Department Clinical Director and from the supervising institution. All security measures were applied and there were no incidents of patient confidential data loss in this audit.

Results

The study population consisted of 30 patient files which met the inclusion and exclusion criteria. There were 16 females and 14 males with a mean age of 54.2 (SD ± 15.01) years. The respective age categories that represent young (18–35 years), middle (36–65 years), and older (>66 years) aged patients were 13.3%, 76.7%, and 10%, respectively. Seventy-three (22 from 30 patients) of files met the set standard for best practice in diagnostic imaging (Fig. 3). Thus, the target of 100% was not met.

The components of the diagnostic ultrasound examination procedure including *region of interest grey scale*, *settings,* and *logical continuum* of images demonstrated 100% adherence to the standard. However, the components of the diagnostic ultrasound examination procedure including *region of interest power Doppler*, *contra-lateral grey-scale* and *contra-lateral power Doppler*, *split screen* and *annotation* demonstrated a range of 30–87% adherence to the standard (Fig. 4).

Discussion

This audit demonstrated that nearly three-quarters of patients at Felixstowe Community Hospital Physiotherapy Department who had a diagnostic ultrasound examination and a subsequent diagnosis of mid-tendon Achilles tendinopathy met the standard.

The demographic data of this audit demonstrated comparative findings to Magnussen *et al.*[17] in that middle aged persons have a higher frequency of mid-portion Achilles tendinopathy. However, the audit demonstrated an even gender split, whereas Magnussen *et al.* demonstrated a higher incidence in men.[17]

The justification for the inclusion of *region of interest grey scale* and *contra-lateral grey scale* and *region of interest power Doppler* images as mandatory components of the diagnostic ultrasound examination procedure is based on the pathogenesis of tendinopathy. Grey scale tendon abnormalities including hypoechoic regions, tendon thickening, and a disorganized fibrillar pattern may be present in both the symptomatic patient[18] and the asymptomatic patient.[19] In addition, there is emerging literature indicating bilateral Achilles tendinopathy in unilateral symptomatic patients.[20–22] Therefore, contra-lateral side images are acquired

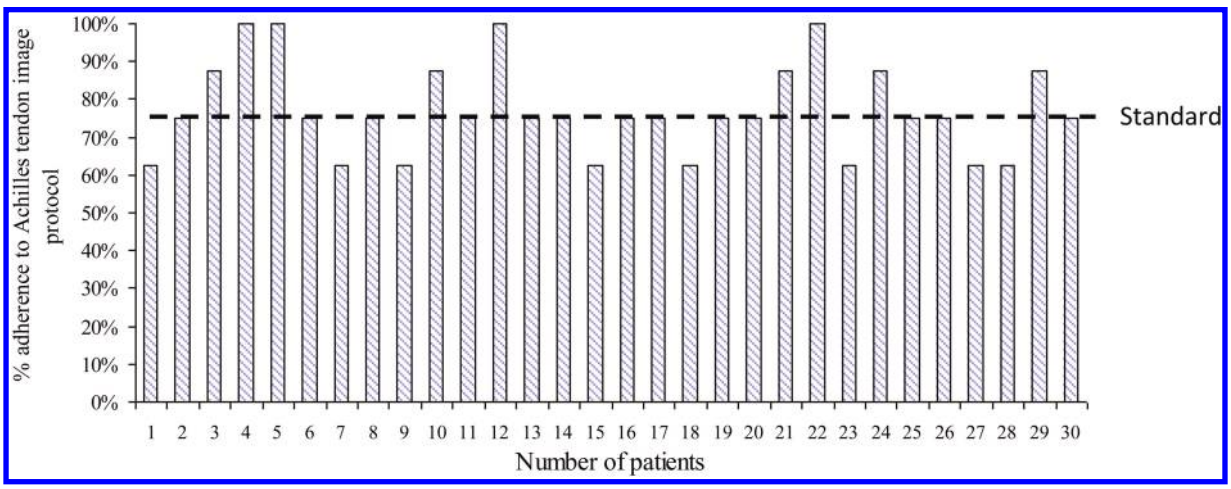

Figure 3 The diagnostic ultrasound examinations that adhered to the Achilles tendon image protocol in patients with mid-portion Achilles tendinopathy.

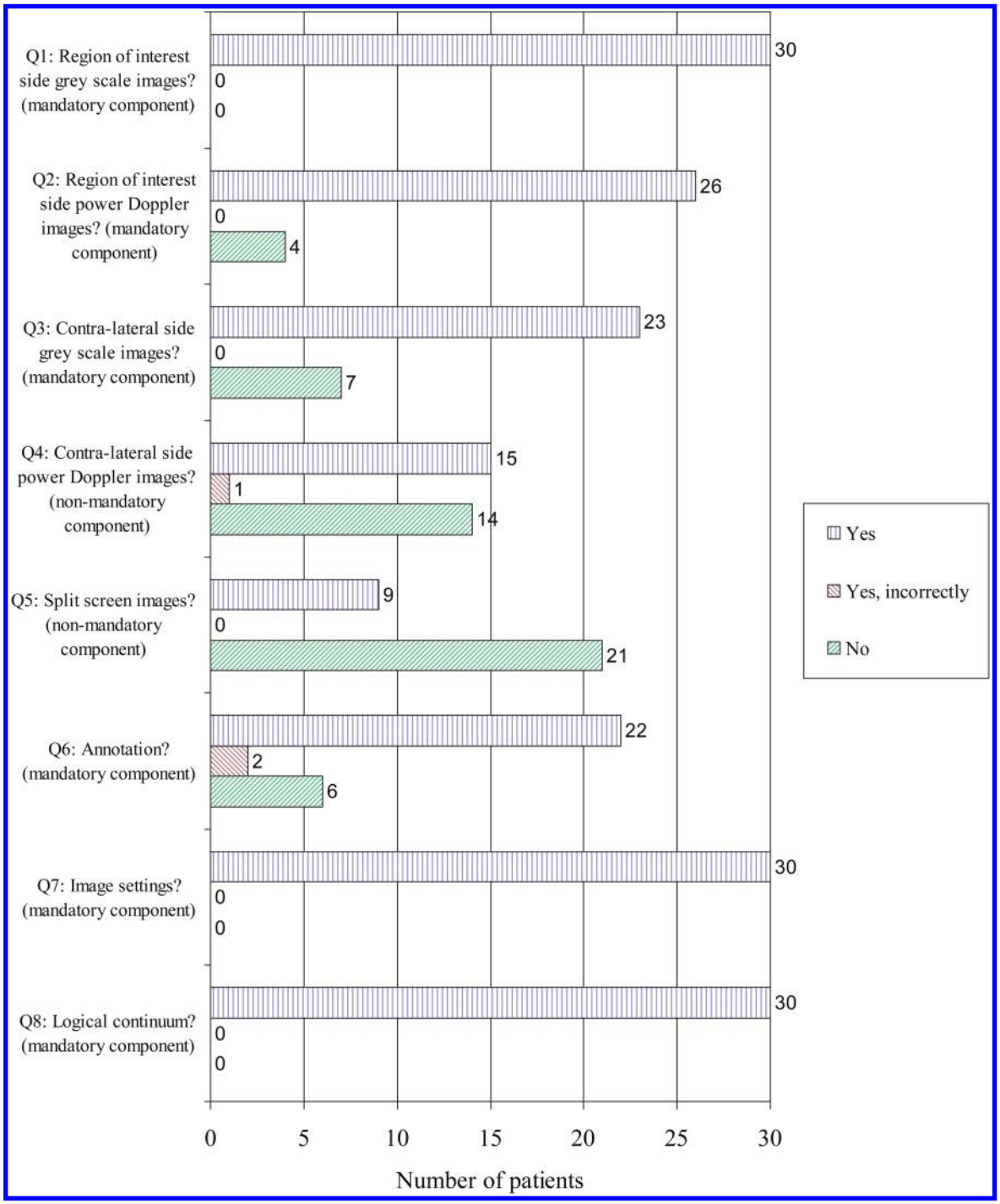

Figure 4 The components of the diagnostic ultrasound examination procedure that adhered to the Achilles tendon image protocol in patients with mid-portion Achilles tendinopathy.

and archived to compare to region of interest and is supported by the literature. However, in this audit, *contra-lateral grey scale* images were not acquired and archived consistently. A recommendation for best practice is for *region of interest grey scale* images displaying tendon abnormalities should be directly compared with *contra-lateral grey scale* images and justifies the inclusion as mandatory components of the diagnostic ultrasound examination procedure.

Neovascularization has been demonstrated to be present in both the symptomatic[23] and asymptomatic[24] patients with grey scale tendon abnormalities. In applying the Cook and Purdam[2] load-induced continuum theory early-stage grey scale tendon thickening with normal organized fibrillar appearance, with hypoechoic regions between intact fibrils with no neovascularization, potentially progresses to end-stage thickened tendon, disorganized fibrillar appearance with few intact fibrils and neovascularization. In this audit, *region of interest power Doppler* images were not acquired and archived consistently. A recommendation for best practice is to ensure the *region of interest power Doppler* images, a mandatory component, is included in the diagnostic ultrasound examination

procedure to allow an accurate diagnosis, tailored rehabilitation, and possible guided intervention.

In the load-induced continuum theory tendinopathy grey scale abnormalities are evident in the early-stage, whereas power Doppler evidence of neovasularization appears in mid to end-stage tendinopathy. Therefore, neovascularization is only present with grey scale tendinopathic abnormalities.[23,24] Therefore, in the clinical reasoning of the *logical continuum* of images the literature implies that in the presence of no grey scale tendinopathic abnormalities, neovascularization is not present. Hence, if the *region of interest grey scale* has no tendinopathic changes, then *region of interest power Doppler* is not indicated. However, for best practice it is recommended to perform *region of interest power Doppler* despite no grey scale tendinopathic abnormalities, therefore is a mandatory component. However, if *contra-lateral grey scale* images have normal appearances then *contra-lateral power Doppler* images is not indicated and therefore is a non-mandatory component of the diagnostic ultrasound examination procedure.

The justification for a *split screen* component of the diagnostic ultrasound examination procedure is based on the guidelines and clinical experience because depiction of the tendon pathology in two planes[12] or contra-lateral side comparison represents best practice, but is a non-mandatory component.

The justification for correct use of *annotation* component of the diagnostic ultrasound examination procedure is based on Acquisition, Archiving and use of Ultrasound Data Guidelines[12] to illustrate image orientation which represents best practice and is mandatory component.

The justification for the *settings* component of the diagnostic ultrasound examination procedure is that images are acquired and archived at the discretion of the sonographer based on their knowledge, skill, and the quality of the diagnostic machine. Tendinopathy has been identified as having hypoechoic regions on short axis of >1 mm;[19] however, incorrect machine settings may reduce the axial and lateral resolution of the image quality, hence an incorrect diagnosis. The literature has demonstrated studies with methodological faults in their design, for example, Yang *et al.*[25] presented inadequate study designs for power Doppler settings which may potentially account for why neovascularization is demonstrated in symptomatic[23] and asymptomatic patients.[24] Therefore, Yang *et al.*[25] state that studies have inadequate machine settings and study methodology, but until the literature reaches a consensus as to appropriate standards for imaging tendons, study designs will potentially have these limitations and the pathogenesis will continue to be a theory.

The Achilles tendon image protocol has applied the literature on the pathogenesis of tendinopathy to the components of the diagnostic ultrasound examination procedure ensuring a logical step-by-step process in acquisition and archiving of images (Fig. 5).

Design of the Achilles tendon image protocol

The design of the Achilles tendon image protocol is based on the classification system by Boesen *et al.*,[26]

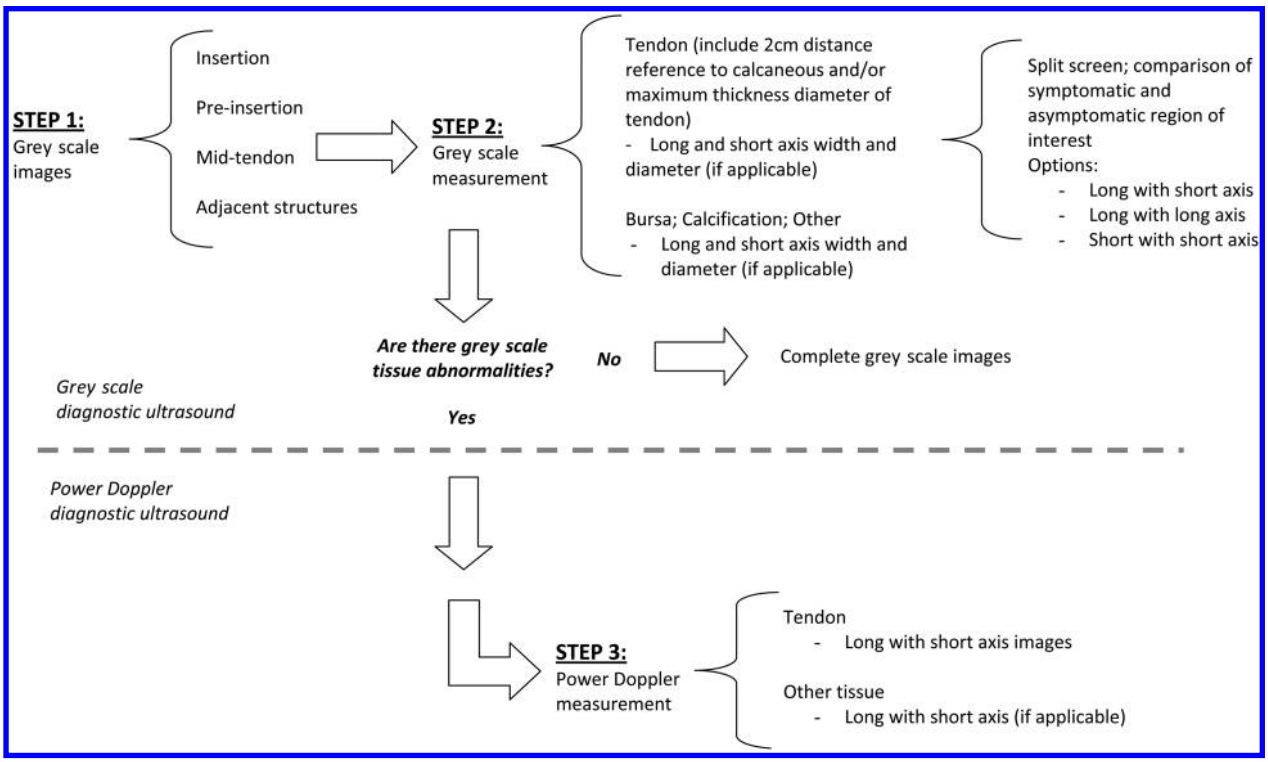

Figure 5 The Achilles tendon image protocol logical continuum for diagnostic ultrasound examination.

that includes imaging of the Achilles tendon in three sections: insertion, pre-insertion, and mid-tendon and allows classification of the site of the tendon pathology. The advantages compared with Chan *et al.*'s[27] classification is precision in identifying the tendon sections, for example, Boesen *et al.* measured 2 cm in long axis proximally from the calcaneous border to define the pre-insertion section and may anatomically signify the site of pathology with respect to vascularity of the tendon with studies indicating a hypovascular section in the mid-portion of the Achilles tendon [28,29] and with some studies indicating association with maximum neovascularization.[25,30,31] Short axis images demonstrate Achilles tendon fascicle bundles as proposed by Szaro *et al.*[32] and can be correlated to long axis images depicting the fibrillar echotexture of the tendon. In mid-portion Achilles tendinopathy, the pathology should be imaged in two planes.[33,34] The protocol recommends grey scale long and short axis measurement to quantify the precise site for the maximum thickness of the Achilles tendon as supported by Syha *et al.*[35]

Justification for setting the standard

The Achilles tendon image protocol represents best practice in diagnostic ultrasound examination of the Achilles tendon. In determining whether the standard was met it was pre-determined that at least six out of eight (75%) components of the diagnostic ultrasound examination procedure had to be performed. The justification for setting the standard at this level is associated directly to the proforma questions; six had mandatory components and two were non-mandatory. However, there were no weightings for the components of the diagnostic ultrasound examination procedure, which is a potential limitation of the study.

Limitations of the audit and recommendations

The Achilles tendon image protocol was produced based on the available literature, clinical experience and a service evaluation. However, the protocol has no other evidence to support its use. In addition, the protocol is designed for the Achilles tendon diagnostic ultrasound examination, but this audit only focused on the diagnosis of mid-portion Achilles tendinopathy. The data collection included patients who had a diagnostic ultrasound examination with a subsequent mid-portion Achilles tendinopathy diagnosis only. Therefore, would the protocol be relevant and applicable to other pathology of the Achilles tendon? A recommendation is that further pilot audits are performed in all types of Achilles tendon pathology to validate this protocol.

A limitation of the Achilles tendon image protocol and proforma is that its designed specifically for the Achilles tendon only and in a diagnostic ultrasound department where multiple soft tissue and joint pathologies are referred it may have limited applicability for its use due to resources. Although the protocol is specific to the Achilles tendon, the proforma should be applicable to other common tendinopathies. In the research or sporting arena where diagnostic ultrasound is regularly used for assessment and treatment outcomes for the Achilles tendon, it would be relevant and applicable.

The data collection from diagnostic ultrasound examinations may be subject to bias because whether components of the diagnostic ultrasound examination procedure has been performed relies on interpretation of an image, which may be subjective and reliant on the auditor's background and clinical experience. In this audit, the auditor was a physiotherapist/musculo-skeletal sonographer who performed a percentage of the diagnostic ultrasound examinations. A recommendation for the second Clinical Audit Cycle is to have an external source with significant musculo-skeletal diagnostic ultrasound qualifications and experience to perform the audit, hence remove any bias. In addition, the audit findings identified that some components of the diagnostic ultrasound examination procedure were not adhered to, i.e. *region of interest power Doppler*, *contra-lateral grey scale*, *contra-lateral power Doppler*, *split screen,* and *annotation.* However, the audit also demonstrated that the *logical continuum* of images were 100% adhered to and allows for the physiotherapist/musculo-skeletal sonographer to arrive at a safe and confident diagnosis. However, if some components and/or images are not acquired and archived, how can we arrive at a safe and confident diagnosis? This implies that despite not adhering to some of the components of the diagnostic ultrasound examination procedure, the auditor can still interpret the acquired and archived images as comprising enough information to allow the physiotherapist/musculo-skeletal sonographer to arrive at a confident and safe diagnosis.

The logical continuum of images implies that a minimum quantity of images needs to be acquired and archived. However, this audit did not collect data on the quantity of the images. In addition, diagnostic ultrasound is used to rule out pathology. A recommendation for the next audit is to include the quantity of acquired and archived images to ensure the absolute minimum is obtained necessary for adherence to the protocol. The physiotherapist/musculo-skeletal sonographer needs to display the pathology and provide unequivocal evidence to support the diagnosis in the report. If pathology coexists in two sections of the Achilles tendon a higher number of images would be necessary.

Diagnostic ultrasound is operator dependent; however, this audit focused on the department's

performance as a whole. Therefore, some of the clinicians may be meeting the standard and target consistently, but with the design of this audit this would not be identified. A recommendation would to include data to indicate which clinician performed the examination. Therefore, the findings would directly impact on the departmental educational training and to each clinician.

A controversial area of this audit is how the standard and target were set because of the absence in the literature of defined standards of the mandatory and non-mandatory components in diagnostic ultrasound examination of the Achilles tendon in representing best practice. However, based on clinical observation of findings these appear to be valid and further pilot studies are recommended to sustain further improvement.

The first Clinical Audit Cycle has produced a number of recommendations to improve the standard of the diagnostic ultrasound examination, which will further enhance the Felixstowe Community Hospital Physiotherapy Department musculo-skeletal service. The implementation of these recommendations is necessary before the commencement of the second Clinical Audit Cycle.[36]

Acknowledgement

I would like to thank all the specialists at Bournemouth University for their guidance, expertise, and support. In particular, I would like to thank diagnostic ultrasound director Dr Budgie Hussain for his enthusiasm, professionalism, and desire in providing a high class teaching environment to non-radiology clinicians in the musculo-skeletal diagnostic ultrasound examination. Also, I would like to extend my thanks to Professor Jenni Bolton for her support and guidance in this audit.

Appendix 1: Achilles tendon image protocol

The Achilles tendon image protocol is a local guideline for Felixstowe Community Hospital Physiotherapy Department for diagnostic ultrasound examination of the Achilles tendon. The protocol represents best practice for the mandatory acquisition and archiving of images for disorders of the Achilles tendon or adjacent structures.

The Achilles tendon image protocol has a logical continuum of images. The images for the Achilles tendon requires full depiction of the origin and insertion of the Achilles tendon, therefore, divided into insertional, pre-insertion, and mid-tendon regions.

The recommended relevant setting for grey scale diagnostic ultrasound images:

- Linear probe
- High frequency >12 MHz
- Focus position relevant to region of interest
- Depth relevant to region of interest
- Optimization of image quality and gain
- Mechanical and Thermal Index as low as reasonably achievable (ALARA) principle during examination (BMUS 2009).[37]

Tendon specific

- Image perpendicular to tendon reduced anisotropy +/− heel/toe probe.

Optimizing power Doppler machine settings are as follows (Table A1).

A diagnostic ultrasound grey scale long and short axis images of the Achilles tendon insertion is mandatory (Fig. A1). Relevant measurement of depth of Achilles tendon is recommended from proximal calcaneous border. Relevant settings and annotation included.

A diagnostic ultrasound grey scale long and short axis images of the Achilles tendon pre-insertion are mandatory (Fig. A2). It is recommended the following grey scale measurements are applied: distance from proximal calcaneous border to maximum thickness of the Achilles tendon. Relevant settings and annotation included.

A diagnostic ultrasound grey scale long and short axis images of the Achilles tendon mid-tendon are mandatory (Fig. A3). It is recommended the

Table A1 Recommendations for optimizing power Doppler settings for tendinopathy[25]

Parameter	Settings
PRF	Lowest possible where 'flash' artifacts are eliminated
CG	On the threshold to noise
Doppler frequency	Higher possible to maximize spatial resolution and have good blood flow

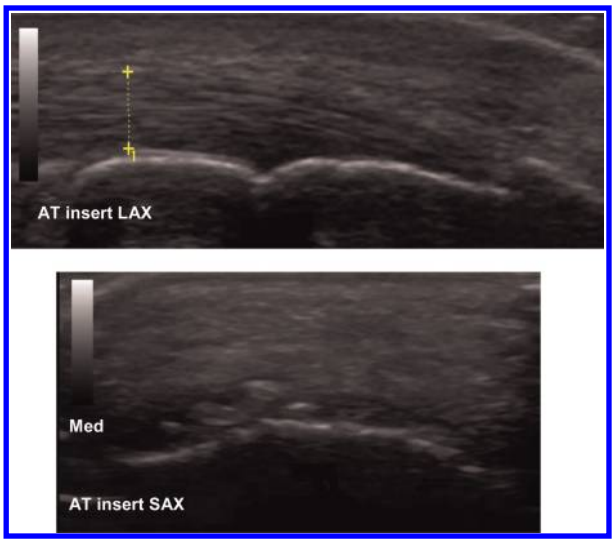

Figure A1 Insertional: grey scale long and short axis images of Achilles tendon insertion section.

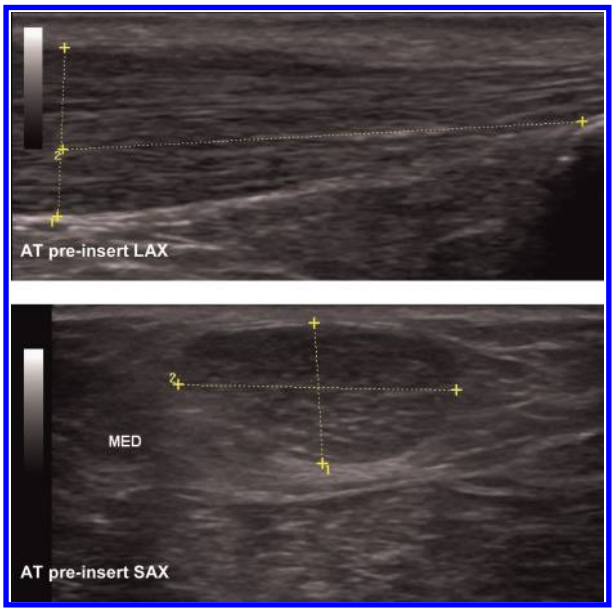

Figure A2 Pre-insertional: grey scale long and short axis image of Achilles tendon pre-insertion section.

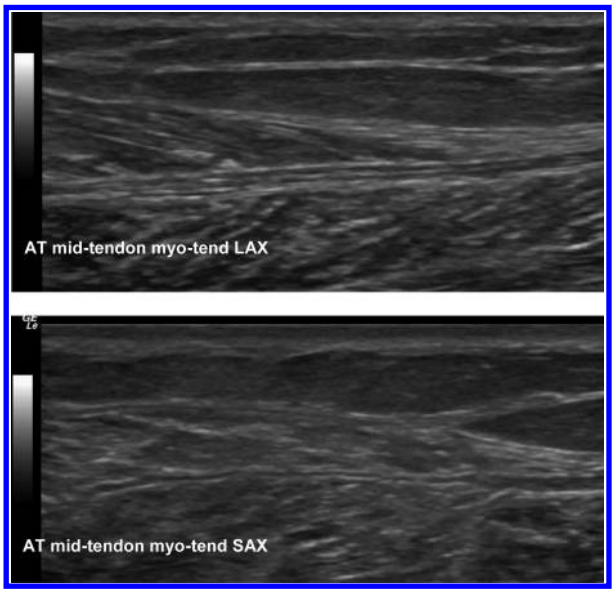

Figure A4 Myo-tendon junction: grey scale long and short axis image of Achilles tendon mid-tendon section.

maximum thickness of the Achilles tendon is measured. Relevant settings and annotation included.

A diagnostic ultrasound grey scale long and short axis images of the Achilles tendon myo-tendon junction are mandatory (Fig. A4). Grey scale measurements maximum thickness of the Achilles tendon is applied if relevant (not demonstrated). Relevant settings and annotation included.

A diagnostic ultrasound split screen grey scale image of the Achilles tendon is recommended for the best practice to display the region of interest in various planes (Fig. A5). Grey scale measurements are applied if relevant and applied for comparison. Relevant settings and annotation included. In addition, split screen may include region of interest Achilles tendon with contra-lateral side for comparison to demonstrate pathology (Fig. A6).

A diagnostic ultrasound power Doppler image of the Achilles tendon in the short axis is mandatory

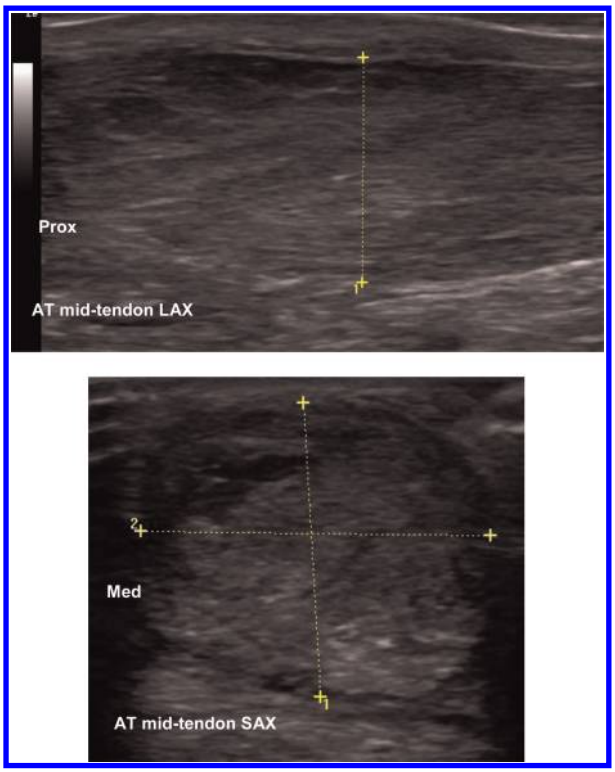

Figure A3 Mid-tendon: grey scale long and short axis image of Achilles tendon mid-tendon section.

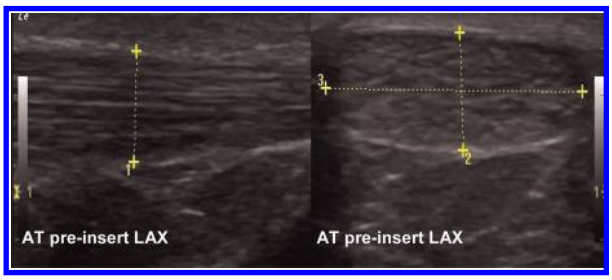

Figure A5 Pre-insertion: grey scale images using split screen to demonstrate thickened pre-insertion Achilles tendon in long axis and short axis with relevant measurements.

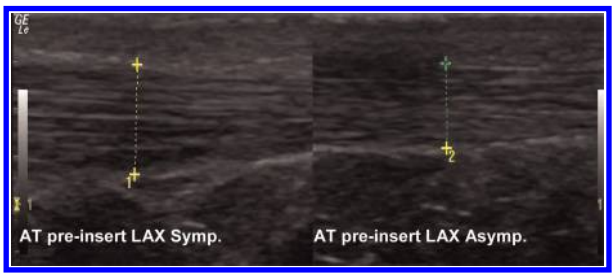

Figure A6 Pre-insertion: grey scale images using split screen to demonstrate thickened pre-insertion Achilles tendon in long axis and contra-lateral side with relevant measurements.

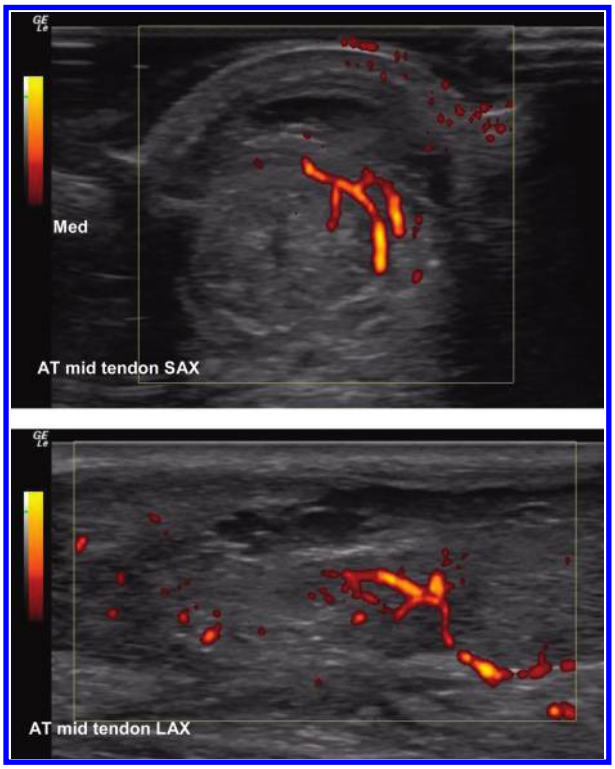

Figure A7 Pre-insertion: power Doppler short and long axis image of the Achilles tendon.

(Fig. A7). Power Doppler in long axis is non-mandatory. Relevant settings and annotation included.

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