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Learning musculoskeletal ultrasound

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Abstract

Aim: To evaluate if an acceptable diagnostic level of musculoskeletal ultrasonography(US) can be achieved by a US-novice when taught by an expert during a 4 month rotation in an outpatient clinic.

Methods: All patients referred to an out-patient clinic with heel pain during one month (July 2013) were offered participation. No declined and 17 were included. The exam included 4 US images of both feet: a cross sectional scan of the thickest part of the Achilles tendon,a longitudinal scan of the plantar fascia anda cross sectional of the heel fat pad with and without pressure. These 8 images were repeated after a few minutes resulting in 8 pairs of images. After 2 months all the images were reviewed randomly in a blinded manner and measurements were performed.Hereby two different measurements on two different images were performed. The intra-tester reliability was compared by Intra-class Correlation Coefficient (ICC) and typical error (TE).

Results: The US novice trainee achieved an acceptable good ICC (0.64 to 0.90)with agreements (TE 7.1-17.5%), albeit lower than the experienced doctorwith substantial ICC (0.90-0.97) and TE (3.4-6.7%).

Conclusion: A 4 month rotation in an outpatient clinic with daily use of musculoskeletal ultrasound can lead to acceptable ultrasonographic skills in a novice with no prior ultrasonography experience.

Keywords: Musculoskeletal ultrasound, trainee, reliability

Introduction

Musculoskeletal Ultrasound (MSUS) is increasingly being used in rheumatology as a diagnostic tool. When obtaining diagnostic capabilities in the use of MSUS there is a theoretical aspect, which is often covered in courses and by self-study in textbooks. Then there is the practical hands-on component, which is acquired by clinical teaching when observing experts perform exams and by the trainee performing supervised exams them self. It is not known how quickly the latter component can be learned at an acceptable level. Taggart et al described how a whole team of rheumatologists in experienced in ultrasonography in Belfast learned the basics of MSUS over a 5 year period. The primary learning method was MSUS examinations under expert supervision. Nobody in their own department had done MSUS before and they were supervised by a colleague from Italy who also stayed for a 3 month period in Belfast where he was supervising and teaching on a daily basis. They also underwent several courses including EULAR courses. The conclusion was that constant practice under expert guidance is the single most important key to success in MSUS training [1].

In Denmark the education to specialist in "Internal medicine/ Rheumatology" takes 5 years. Six months of this education is in some instances offered to take place in an outpatient clinic, where the main focus is biomechanical problems in the upper and lower extremities including education in MSUS. The purpose of this study was to evaluate if a trainee without previous experience could develop acceptable accuracy and reliability in MSUS after 4 months of a dedicated education program.

Methods

To evaluate if acceptable skills in MSUS could be obtained during this education program, we evaluated after 4 months the skills of a rheumatology resident doctor with no prior ultrasonography experience and compared it to the skills of a specialist in rheumatology with more than 10 years of MSUS experience. The resident doctor went through dedicated MSUS training covering the upper and lower extremity during the rotation period. The US training consisted of a 5 day introduc-

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tion to clinical examination including one half day of basic US principles. For the remainder of the rotation evaluation of patient problems were discussed with the supervisor for 30 min during 3 morning sessions every week. During these sessions US scanning images were evaluated, and US methods changed if deemed necessary. During the first 4 months the trainee obtained 124 US exams of new referred patients with a wide variety of presenting complaints. 12 of these US exams were dedicated exams of the foot. The US system used for all scans was a Esaote scanner Mylab 70, linear transducer, 5-15 Hz.

The trainee was taught MSUS of the hole body but only US examination of the foot, more specific the heel, wasevaluated because it has several different US difficulty levels: a presumable easy measure of the thickness of the Achilles tendon, a presumable more difficult measure of the fascia plantaris, and a dynamic measure of the thickness of the heel fat pad with and without the application of pressure. The study was part of a randomized clinical trial evaluating the treatment of plantar fasciitis including intra- and inter-observer reliability among senior specialists [2].

The US examinations of the foot performed by the trainee were compared to those of a senior specialist rheumatologist who had performed US exams daily for the past 10 years. Including approximately 5000 US exams of the foot. All patients referred to an out-patient clinic with heel pain during one month (July 2013) were offered to be included. Inclusion criteria were heel pain in one or both feet and age of 18-67 years. Exclusion criteria were surgery or tendon ruptures in the region. No patients declined to participate and a total of 17 patients (34 feet) were included. After informed consent, all patients had two MSUS exam of both feet done by the trainee. The exam included 4 images: a cross sectional the thickest part of the Achilles tendon, a longitudinal scan of the thickest part of the plantar fascia and a cross sectional scan of the thickest part of the heel fat pad with and without pressure. This resulted in 8 pairs of images (16 images per patient). Two to 5 weeks after the trainee had included the patients and performed the US imaging the experienced senior rheumatologist performed all the US imaging on the same structures on the same patients during a two-day session. After 2 months all the images were retrieved randomly in a blinded manner and both the trainee and the experienced doctor performed measurements independently on their own pictures using the "caliber" measurement in the US machine. The intra-tester reliability were compared by Intra-class Correlation Coefficient (ICC) and typical error (TE) by comparing the two measurements of the two different obtained US pictures of the same structure in the same patient. That made the study a intra-tater reliability test more than a full validity test. The ICC and TE were calculated for each doctor and compared. It was not possible to calculate the inter-tester reliability, due to the time gap (1 month) between the two testers measurements. ICC increases with increased heterogeneity, but during this short time gap we did not expect any big changes in the heterogeneity.

Statistics

Statistical analysis was performed using SPSS version 22,0. Estimates of reliability were calculated using the intraclass correlation coefficient (ICC) two way mixed (model 3) consistency type, single measure to indicate the level of agreement between successive assessments. ICC scores were categorized according to Shrout (ref] as: (0.00-0.10): "virtually none correlation"; (0.11-0.40): "slight correlation"; (0.41-0.60): "fair correlation"; (0.61-0.80): "moderate correlation"; (0.81-1.00): "substantial correlation" [3]. Measurement precision was assessed by Typical Error (TE) as the standard deviation (SD) of the difference between all sequential measurements divided by square root of 2. TE was also calculated in percent (TE %) of the mean measured thickness of each measured structure.

Results

Location for table I

In **Table 1** the intra-tester ICC and TE are presented for the different structures for both the trainee and the experienced doctor.

Table 1. Presents the ICC with 95% confidence intervals (CI) and typical error (TE) for all the structures for both the experienced doctor and the trainee.

ICC (95% CI)	Experienced doctor	Trainee
Fasciaplantaris	0.96 (0.91-0.98)	0.90 (0.81-0.95)
Achillestendon	0.90 (0.81-0.95)	0.64 (0.39-0.80)
Heel fat pad no pressure	0.90 (0.81-0.95)	0.74 (0.54-0.86)
Heel fat pad with pressure	0.97 (0.94-0.98)	0.89 (0.79-0.95)
Typical Error (TE) mm (%)	Experienced dotor	trainee
Fasciaplantaris	0.25mm (6.7%)	0.31mm (7.1%)
Achillestendon	0.16mm (3.4%)	0.51mm (10.6%)
Heel fat pad no pressure	0.66mm (4.7%)	1.34mm (9.2%)
Heel fat pad with pressure	0.36mm (3.7%)	2.03mm (17.5%)

TE are presented in mm and in percent (%) of the average thickness of each structure.

The main diagnosis was plantar fasciitis. The trainee assessed 20 feet as having this diagnosis based on the US criteria of more than 4.0 mm thickness of the fascia. After 2-5 weeks the experienced doctor was in agreement with 14 of these diagnoses. In the remaining 6 feet the trainee found an average thickness of 4.5 mm (range 4.1-5.0), whereas the experienced doctor graded these as normal (thickness below 4.0 mm). **Figure 1** shows all the measurements for both the experienced doctor and the trainee. The first and third column are the first measurement and the second and fourth column the second measurement.

Discussion

We found that 4 months of training in an outpatient rheumatology clinic after performing 124 MSUS as part of a clinical diagnos-

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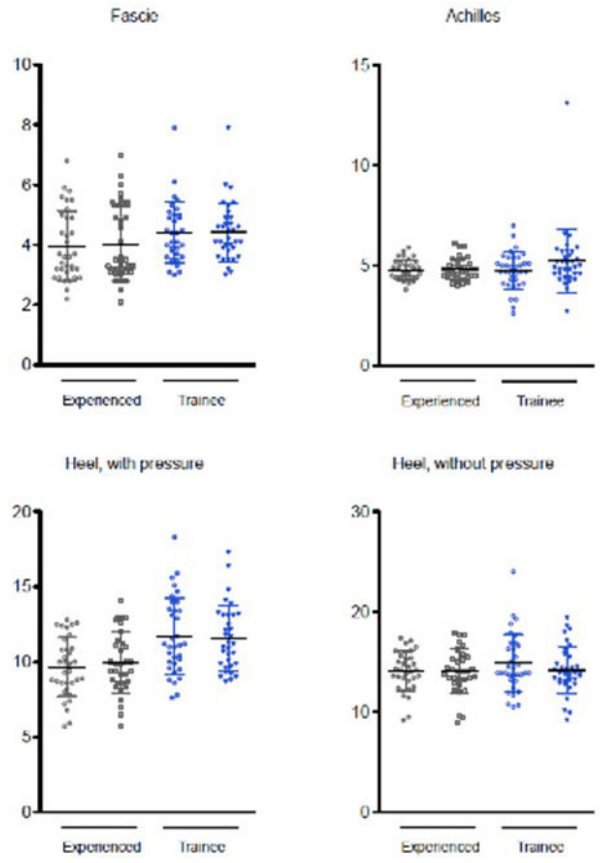

Figure 1. Shows all the measurements.
The Achilles tendon measurements are very homogeneous compared to the more heterogeneous measurements of the plantar fascia and the heel fat pad. The trainee measures constantly a little higher on average. The outlier in the Achilles tendon figure explains partly the intra observer difference for the trainee in that setting.

tic education program led to acceptable MSUS accuracy and reliable measurements for diagnostic purposes when compared to a senior specialist. Albeit the experienced specialist was more accurate and precise in diagnostic performance.

Miguel et al showed a moderate to good reliability coefficient when comparing trainee rheumatologists' interpretation of US images when compared to 3 experienced ultrasonographers [4]. They achieved this after a session lasting only 30 min covering the theory behind elementary ultrasound and a 60 min reading session of ultrasonographic images. There was no significant correlation between previous experience in musculoskeletal ultrasound and the results obtained when looking at the sensitivity, specificity, and percentage of correctly classified lesions. But they were only looking at images – not obtaining the images themselves. Acquiring US skills is not only about interpreting images, but indeed also to obtain images. EULAR states that learning ultrasound include theoretical and practical performance with a maximum of 6 participants and a minimum of 50% of total time devoted to practical sessions [1]. In our education program both theoretical and practical MSUS was performed. All new patients referred to our clinic with symptoms from the upper and/or lower extremity were scanned with US in a standardized way. The MSUS method were rehearsed and corrected if the obtained images did not meet the expectation of the specialist. Approximately 20% of the MSUS performed by the trainee were performed directly supervised.

Filippucci et al tried to see if rheumatologists with strong motivation to learn ultrasound could do so at an E-learning basis. They did a 3-day course at resident doctor level and the following 6 months they performed a mean of 250 min web training and were offered the opportunity to submit images to a tutor for review and comments [5]. After 6 months they had to pass a clinical assessment and a multiplechoice exam in ultrasound competency. 3 out of 60 did not pass the multiplechoice part of the assessment, and only 14 out of 60 passed the clinical part the assessmentin accordance with the method described by Taggart et al [1]. This showed one more time that direct supervision by an expert is an essential element in learning ultrasonography. In our study, we only evaluated the skills in certain measurements in the foot. Patients were referred with heel pain, and the trainee found 20 out of 34 feet with MSUS signs of plantar fasciitis defined alone as a thickness above 4.0 mm. The specialist agreed on 14, and the remaining 6 were found to be normal. This discrepancy might partially be explained due to the improvement of symptoms in the time span between the performance of the two measurements and partially be explained by measurement error. The thickness of the plantar fascia in the remaining 6 feet had an average thickness of 4.5 mm (range 4.1-5.0) according to the trainee's measurement, meaning they were only slightly affected, and therefore could easily have improved within the 2-5 weeks timespan between the measurements conducted by the trainee and the specialist. However the trainee TE found for plantar fascia measurement was 0.31 mm, which also could explain some of the error.

Poltawski et al showed that an inexperienced clinician could conduct a specific assessment using ultrasound (tennis elbow) with 6 endpoints after a short focused course with 12 hours of training in general and musculoskeletal ultrasound and 20 hours of actual hands-on experience, 6 of them supervised by an experienced radiologist [6]. Test-retest (intra-rater) reliability were best for calcification (ICC 0,86) and worse for tendon thickening (ICC0,70). They did not calculate TE. In our study, we only measured thicknesses and the trainee accomplished ICC 0.64-0.90, which was good or very good, but still markedly poorer than the specialist who scored 0.90-097. Surprisingly the trainee's Achilles tendon measurements showed poorer results. This can be explained partly by the Achilles tendon measurements being very homogeneous resulting in lower ICC, compared to the more heterogenous measurements of the heel fat pad and plantar fasciae in our study. However

this does not affect the agreement measurements (TE), where the trainee had acceptable TE 7.1-17.5%, but still poorer than the specialist: 3.4-6.7%. These agreement measurements are important to the clinician since a change larger than the TE with 67% probability represents a real difference.

Fillipucci has shown that a novice could learn to perform 66 standard scans in 8 main anatomical areas with acceptable quality in 24 nonconsecutive hours [7] and obtained a quality score >6 (from 0-10). The novice spent a mean of 6 minutes per image that encompasses descriptions on hypoeccogenicity, hypereccogenity, increased flow and thickness. This is in contrast to our study where we only focused on thickness measurement, but as we performed 8 scans within 10 min, we think these studies are comparable and reflect the time spent on MSUS in daily clinical practice.

Others have also found that beginners can improve relative quickly in MSUS but they often carried their investigations out in patients with rheumatoid arthritis in order to find synovitis and erosions [8,9].

Many other studies have used healthy volunteers which often make it easier to obtain good images because of the more marked boundaries compared to that of a sick tendon [2]. Others have only been shown pictures of images without obtaining them themselves and some have spent 6 minutes per obtained image [4,7]. We tried to make our study more clinically relevant by obtaining the images on patients referred to the clinic with heel pain, and performing the MSUS within the normal time constraints of daily clinical practice. The images were saved and the measurements were performed again in a blinded manner after onemonth in random order.

Despite that, the trainee reached an acceptable good to very good reliability (ICC) and acceptable high agreement (low TE). This was a intra-rater test rather than a full validity because the senior specialist did not review the images obtained by the trainee. Test We used the foot as an example, but the trainee also had the same education and performed the same number of scans in other regions of the lower and upper extremity and we presume that the trainee developed the same level of skills concerning other measures in other parts of the extremities.

Conclusion

A simple theoretical and practical learning program over 4 months in a rheumatology outpatient clinic can lead to acceptable MSUS skills in a novice with no prior ultrasonography experience.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

Authors' contributions	SJ	FEJ
Research concept and design	✓	✓
Collection and/or assembly of data	✓	✓
Data analysis and interpretation	✓	✓
Writing the article	✓	✓
Critical revision of the article	✓	✓
Final approval of article	✓	✓
Statistical analysis	--	✓

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