

CASE REPORT-DIAGNOSTIC CORNER
**THE USE OF DIAGNOSTIC MUSCULOSKELETAL
ULTRASOUND TO DOCUMENT SOFT TISSUE
TREATMENT MOBILIZATION OF A QUADRICEPS
FEMORIS MUSCLE TEAR: A CASE REPORT**

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INTRODUCTION

Musculoskeletal ultrasound (MSK US) is emerging as a beneficial diagnostic tool for sports medicine and rehabilitation practitioners in identifying structural changes within tissues and joints. MSK US can also be used as an outcome measurement tool to determine whether subjective reports accurately represent structural changes within the injured tissue or joint. During rehabilitation, MSK US can be used to monitor treatment effectiveness as well as provide visual feedback during treatment to aid muscle contraction and relaxation.¹

Diagnostic MSK US must be distinguished from therapeutic ultrasound commonly used in physical therapy as a modality. Diagnostic MSK US is used to evaluate soft tissues (muscle, ligament, etc.), detect fluid collection, and can also be used to visualize other structures such as cartilage and bony surfaces.¹ Ultrasound wave frequencies, however, cannot penetrate into bone. Imaging of intra-osseous disease is generally not believed to be possible. The “real time” capability of ultrasound allows for dynamic evaluation of joint and tendons, which can be a valuable assessment tool. Ultrasound can be effectively used for guidance and localization during joint aspirations, injections, and biopsies. Finally, diagnostic MSK US is relatively inexpensive and can be convenient to use as compared to magnetic resonance imaging (MRI). Advantages of ultrasound also include its non-invasiveness, portability, and lack of ionizing radiation.¹

Instrumented soft-tissue mobilization is often recognized as a beneficial adjunct to both stretching and exercise when treating a variety of musculoskeletal conditions. Some practitioners choose to augment the applications of soft tissue mobilization through the use of specific applicators such as those promoted by the Graston Technique® and ASTYM®. These soft tissue techniques as shown later in this commentary (Figures 2-5) have been supported in the literature to demonstrate efficacy based upon subjective reports and functional outcomes for a variety of conditions ranging from trigger thumb² and carpal tunnel syndrome³ to plantar heel pain.⁴ Limited research data exists related to utilizing musculoskeletal ultrasound to both diagnose and document treatment of muscle tears. The authors of this case report investigated the use ultrasound to evaluate and document the efficacy

of soft tissue treatment including the augmented applications of the deep pressure techniques in treating a quadriceps femoris tear.

CASE REPORT

A 24-year-old male competitive cyclist presented to the sports medicine clinic with complaint of right anterior thigh pain. He reported injuring a muscle of this thigh while playing a recreational soccer game twelve months prior to initial evaluation. The injury occurred when he was sprinting to pursue a pass and felt a popping sensation and immediate pain upon decelerating. Edema and ecchymosis were visible along the anterior mid-thigh within 24 hours following the injury onset. The patient reported a palpable “indentation” which became more apparent when the initial tissue swelling subsided. He elected not to pursue formalized treatment for the initial injury and noted that it gradually improved. He stated he resumed his cycling training schedule of 200-plus miles per week without pain or limitations at 4 weeks following initial injury despite the soft tissue defect that remained, which was confirmed by visual appearance and palpation. He did, however, confirm that the pain was more noticeable while playing soccer at 12 weeks following initial injury, especially when making any type of cutting or pivoting maneuver several weeks following the injury.

He first presented to the sports medicine clinic seven days following a re-injury to the thigh that occurred 12 months and one day after the initial injury. This re-injury event occurred while also playing soccer. He stated that as he was kicking the ball, a sudden feeling of a “pulling” sensation occurred, which resulted in pain and mild swelling. During examination, the patient described a visible and palpable defect in the proximal anterior thigh. Furthermore, he recalls there was an increase in size of the defect at 12 months following initial injury when re-injury occurred. Visual inspection and evaluation through palpation confirmed the defect. Musculoskeletal ultrasound imaging was utilized to confirm the existence of a defect in the proximal third of the rectus femoris (Figure 1). The palpable defect had presumably filled with fibrotic tissue as suggested by the hyperechoic area that was seen within the musculature as visualized on MSK US. Decreased flexibility along the right lateral thigh was detected that corresponded with painful, latent trigger points in the tensor fasciae latae, iliotibial band and biceps femoris.

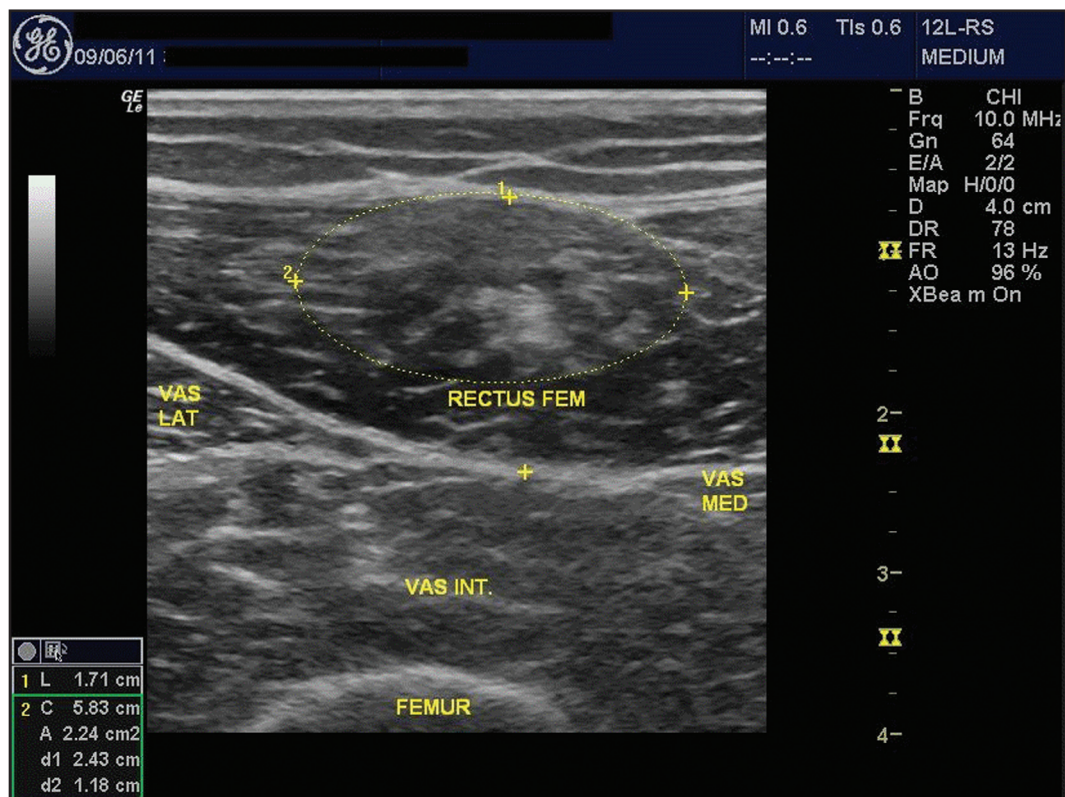


Figure 1. Pre-treatment diagnostic musculoskeletal image of proximal rectus femoris tear as shown by hyperechoic area within rectus femoris muscle belly and decreased continuity of muscle fibers.

Special testing confirmed a positive Ober's test in the involved extremity. Ranges of motion in the knee and hip were measured as being within normal limits and symmetrical. Prone knee flexion measurements were symmetrical in range, but the involved extremity demonstrated a stiffer end-feel. He reported greater difficulty in achieving full prone knee flexion with his affected limb. Hamstring flexibility (as measured using the straight leg raise test) was measured as 80 degrees bilaterally.

DIFFERENTIAL DIAGNOSIS

Several possible diagnoses were considered for this patient: contusion of the quadriceps femoris, avulsion fracture of the anterior inferior iliac spine, complete quadriceps femoris rupture, and other specific quadriceps femoris strain. Reaggravation of the initial injury was strongly considered. Further evaluation was completed using visual and manual assessment of anterior and anterior-lateral thigh musculature including the rectus femoris, vastus lateralis, tensor fasciae latae and iliotibial band. Because of the mechanism onset with this episode, the lack of discoloration,

and the availability of full range of motion in the involved extremity following the second injury, a quadriceps femoris contusion was deemed an unlikely diagnosis. Furthermore, the patient's pain was located more lateral to the defect along the vastus lateralis and iliotibial band rather than directly over the proximal rectus femoris. The pain corresponded with trigger points along iliotibial band and biceps femoris as opposed to the area directly over the defect where a contusion would have been more likely to have taken place. That a contusion alone would result in the defect that was present in this case was also theorized to be unlikely. It was much more likely to be a tear/re-tear situation given increased size of the defect as reported by the patient.

To rule out avulsion fracture of the anterior inferior iliac spine, the proximal attachment of the rectus femoris was palpated, however, no tenderness to palpation over the proximal attachment of the rectus femoris was noted. Further, while the apparent injury was in the proximal third of the quadriceps femoris, the specific location was distal to this attachment



Figure 2. Static application of instrumented soft-tissue mobilization for scanning of tissue adhesions.



Figure 3. Instrumented soft tissue mobilization during active knee extension.

point. Therefore, an avulsion fracture involving the anterior inferior iliac spine was inconsistent with the clinical findings.

In the presence of full motion and the patient's capability to demonstrate considerable muscle contraction, a quadriceps femoris rupture was also improbable. This hypothesis was further supported by palpation of muscle belly and area surrounding the defect. In the case of a complete rupture, the defect would have likely been



Figure 4. Instrumented soft tissue mobilization along quadriceps femoris musculature during dynamic movement.

larger in surface area and would have presented with considerable fluid accumulation on the ultrasound image. Lastly, strains of either the vastus medialis or lateralis, though uncommon, were ruled out based upon location and palpation of the defect in the proximal third of the rectus femoris as opposed to the medial or lateral components of the quadriceps femoris musculature. Thus, the most plausible explanation, particularly with the direct visualization of the tissue defect with MSK US (Figure 1), was reinjury of the rectus femoris.

TREATMENT

The patient participated in physical therapy for a total of five sessions over the course of six weeks. Treatment consisted of initial soft tissue mobilization with augmented pressure applications to the right quadriceps femoris and anterolateral thigh (Figure 2). This was supplemented by ice massage following instrumented soft tissue mobilization during initial visits to control local hyperemia which resulted from instrumented friction along the proximal quadriceps femoris. As the patient's tolerance increased, these soft tissue techniques were performed during active movements such as knee extensions (Figure 3) and lunges (Figure 4). This progressed into an eccentrically focused home



Figure 5. Instrumented soft tissue mobilization during eccentrically focused machine leg press exercise.

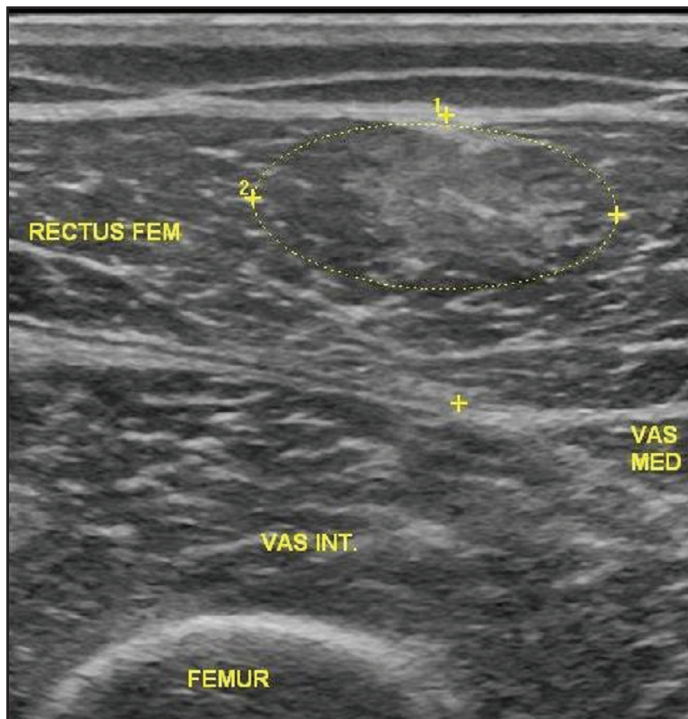


Figure 6. Post-treatment diagnostic musculoskeletal ultrasound demonstrating reduction of echogenicity within focal lesion, improved tissue continuity, and reduction of surrounding hypoechoic area.

Subjective Measure	Initial	Follow-up
Pain Rating (with activity)	7/10	2/10
Global Function Rating	80%	90%
LEFS Score	67/80	75/80
Global Rating of Change (2 nd & 5 th sessions)	+3	+6

Figure 7. Outcome measures for initial and final treatment sessions indicate improved subjective ratings.

exercise program performed three days per week with 30 repetitions per session divided over 3 sets, which incorporated leg extension and leg press exercises (Figure 5). Active quadriceps femoris stretching consisting of prone knee flexion and half-kneeling hip extension with knee on ground was recommended in addition to eccentric exercise to help facilitate the recovery of tissue extensibility. Stretches were performed 3 times and held 30 seconds with gluteal muscle activation incorporated to provide greater stretch and relaxation of tight quadriceps musculature through reciprocal inhibition. Normal range of motion values were sustained throughout treatment course.

TREATMENT OUTCOMES

The patient returned to his physician for a follow-up visit at eight weeks following the exacerbation event. Ultrasound imaging was used to document the status of the involved structures before and after physical therapy intervention (Figure 6). The size of the defect, which includes adjacent scar tissue, remained essentially unchanged with dimensions of 1.71 cm and 1.63 cm, respectively. A reduction of hypoechoic zone of surrounding tissue, indicative of edema and tissue damage, is evident in comparing the first and second images. Subjective pain ratings, ultrasound measurements and Lower Extremity Functional Scale (LEFS) scores (20 items scored 0-4 depending upon level of extreme to no difficulty performing task with a ceiling score of 80). These values are presented for both initial and final treatment sessions as referenced in the chart (Figure 7). The patient reported overall improved function, strength and pain levels following

six weeks of treatment sessions which incorporated augmented soft-tissue mobilization, eccentric-focused strengthening exercise and stretching. He was able to return to soccer with no return of symptoms and no residual soreness in the affected area.

DISCUSSION

A common mechanism of injury for quadriceps femoris muscle strain or tear is a maximal eccentric load to the muscle-tendon unit. The rectus femoris has been described as the most commonly injured muscle of the quadriceps muscle group due to its bi-articulate nature as both the hip and knee are traversed.⁵ Eccentric load is distributed throughout the muscle with a combination of hip flexion/knee extension or hip extension/knee flexion. The stress on the rectus femoris is further exaggerated in kicking sports where eccentric load is compounded by muscles counteracting the high velocity forces produced when striking the ball.⁶ This mechanism was recognized in the case of this cycling athlete as his injury occurred during soccer.

In a limited number of cases involving chronic symptomatic tears of the rectus femoris, the site of tearing is commonly reported to occur at the reflected head.⁵ One of the two heads of the rectus femoris, the reflected head, originates from the acetabulum and attaches distally within the quadriceps femoris tendon. It has been reported to be the most vulnerable to tearing and more commonly involved in rectus femoris injury in magnetic resonance imaging (MRI) studies.⁷⁻⁹ The other head of the rectus femoris, the straight head, arises from the anterior inferior iliac spine. The partial tear sustained by the athlete in this case report may have involved the reflected head as suggested by the specific location of the injury.

Non-operative management of partial rectus femoris tears has been supported in the literature. In two isolated cases of proximal avulsion of the rectus femoris in professional football, non-operative treatment resulted in return to play within three to six weeks.¹⁰ Non-operative treatment in these cases incorporated protected weight bearing with crutches, ice, NSAIDS, range of motion exercise, gradual return to resistance training and cardiovascular conditioning which progressed towards running. To the authors knowledge, there are currently no published case studies which have specifically examined the addition of augmented

use of Graston® techniques as a part of overall non-operative treatment intervention for rectus femoris tears. Improved range of motion measured by a standard goniometer and quadriceps femoris function based upon subjective ratings using the lower extremity functional scale (LEFS) and progression through quad strengthening program was shown in a patient recovering from a patellar tendon repair following five physical therapy treatment sessions over the period of 1 month.¹¹ Improved function based upon subjective rating scales and increased tissue healing response has been proposed as the effect created by instrumented soft tissue mobilization resulting in local hyperemia and reduction of scar tissue, possibly enhancing fibroblastic response.¹²⁻¹³ Importantly, these techniques are only a part of the treatment plan, which included active motion through strengthening and stretching exercise to aid tissue healing and remodeling and then progression to advanced strengthening with an eccentric emphasis. This case report incorporated all these elements into a rehabilitation program which resulted in marked improvement as demonstrated by improved function and subjective outcomes.

The gold standard for cross-sectional area measurements of muscle size is considered to be MRI. Because of the expense and lack of availability for clinicians, serial imaging to follow muscle and tendon injuries with MRI imaging is cost prohibitive. The widespread interest in the use of MSK US imaging in care and management of patients with musculoskeletal disorders over the last decade has led to improvements in technology and the development of smaller, less expensive machines with improved resolution.¹⁴ MSK US has also been reported to be a cost-effective and highly feasible method, among the imaging modalities, to measure muscle dorso-plantar thickness, medio-lateral width and cross-sectional area of muscles.¹⁵⁻¹⁶

Walton et al.¹⁷ showed that MSK US is a reliable alternative to MRI of the quadriceps femoris musculature when determining tissue injury. Their study was performed by taking 10 healthy volunteers and measuring their quadriceps femoris with diagnostic ultrasound and then measuring their quadriceps femoris with MRI. There were no significant differences in the cross sectional area estimates or volume estimates when ultrasound and MRI were compared.

Most musculoskeletal ultrasound is done using “gray scale”, which means images are produced in varying shades of gray, ranging from the extremes of black and white. Each white dot in the image represents a reflected sound wave. Sound waves travel in a similar way that light waves do and therefore the denser a material is, the more reflective it is and the whiter it appears on the screen. Therefore, bones will reflect a significant amount of the sound waves back to the transducer and will produce a white image. Fluids are the least reflective body material and therefore they appear as a black image because the sound waves travel straight through it. Defects in tendons or hematomas usually appear dark or described as hypoechoic. The bones, calcific tendons, or myositis ossificans will appear white or hyperechoic. With training and practice, the practitioner can be able to distinguish normal muscle, tendons, bones, and ligaments from injured ones.

In rare cases, musculoskeletal ultrasound can be used when a standard evaluation is not possible. Such was the case when evaluating a quadriceps femoris tendon tear in an uncooperative patient who presented to an emergency room where ultrasound was used as an alternative to hands-on evaluation.¹⁸ While this may be the exceptional case, further research could make a compelling argument for regular utilization of musculoskeletal ultrasound as part of a thorough evaluation in a clinical setting.

This case report demonstrates utilization of MSK US both before and after rehabilitation to document both differential diagnosis and outcome of treatment interventions. While .08 cm may not be considered a significant difference in terms of the defect size, an improvement in tissue quality was suggested by the ultrasound imaging. This utilization of diagnostic ultrasound in a clinical setting should be recognized as a potential means of identifying tissue lesions or inflammatory processes within healing muscle. In this case report, the post-treatment ultrasound demonstrated that there was not an increased lesion area as a result of augmented soft-tissue technique. Due to this finding, the decreased lesion size may be presumed to be a product of healing. In the presence of a skilled and experienced diagnostic ultrasound user, imaging techniques may be considered a reliable measure of what is shown on screen. More research

incorporating diagnostic ultrasound to measure treatment outcomes, however, is needed to support this assumption.

SUMMARY

Musculoskeletal ultrasound is a valuable clinical tool for both diagnosis of soft tissue injury and measurement/documentation of changes within injured tissue. The use of musculoskeletal ultrasound allows the clinician to better determine if interventions are effective based upon objective imaging of lesions. Augmented soft tissue techniques (Graston®) were used in conjunction with a typical stretching and exercise/strengthening program, which may have provided an effective environment in which healing appeared to result. In the case of this cycling athlete, MSK US imaging provided visual, objectively measureable evidence that corresponded with the patient's subjectively reported outcomes and improved function.

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