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A Novel Minimally Invasive Ultrasound-Guided Technique to Biopsy Supraspinatus Tendon

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A lack of access to the tendon tissue has proved a significant obstacle in developing our understanding of the pathogenesis of rotator cuff tendinopathy. In this article, we describe a new minimally invasive technique that may be used to biopsy the supraspinatus tendon in the outpatient clinic or in the operating theater.
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The histologic and molecular changes in painful human tendinopathy have become more fully characterized in recent years.[1-3] Historically, a scientific understanding of tendinopathy has relied on the work carried out on cadavers or biopsy specimens removed at the time of tendon surgery. Early pioneering work by Neer[4] and Codman and Akerson[5] on rotator cuff tendinopathy (RCT) utilized open surgical biopsy techniques to more fully understand this disorder. Nevertheless, despite advances, the study of cadaveric and surgical biopsy specimens has limitations. Cadaveric tissue lacks a clinical history to accurately phenotype the individual from whom the tissue was obtained. Furthermore, with this method, there is the potential for tissue changes to occur postmortem before laboratory analysis has occurred. A serious limitation with the use of surgical tissue is that specimens represent a relatively end stage of the disease process, in which mechanical failure of the tendon has already occurred. Owing to the limitations of these techniques, novel, minimally invasive biopsy techniques have been developed to sample a tendon at multiple stages throughout the evolution of a tendinopathy.

These minimally invasive biopsy techniques are a significant reason for recent progress in our understanding of tendinopathy and have been developed, and well described, in both Achilles and patellar tendinopathy.[6-12] In contrast, for the shoulder, sampling of intact, tendinopathic supraspinatus tendon has been limited to very few studies. In an early study by Tillander et al[13] large 4 × 4 mm biopsies were taken from the middle portion of the supraspinatus tendon during subacromial decompression surgery. Unfortunately, the location of these biopsies does not represent the common site of failure in the supraspinatus and such large biopsies are not ethically feasible to take in studies today. Tuoheti et al[14] obtained tissue from the insertion region of the supraspinatus tendon. However, the study was limited to 5 tissue samples and was carried out during open subacromial decompression surgery, an operation rarely performed now because of the widespread use of arthroscopic techniques.

Furthermore, control tissue used in RCT studies has also been limited to the subscapularis or cadaveric tendon. Subscapularis tendon is different in its anatomy, function, and pathology relative to the supraspinatus and thus does not represent a faithful control.[13,15–20] Finally, similar to the work by Tillander et al[13] with open biopsies, efforts to sample tissue from the supraspinatus tendon for controls has only been undertaken using large biopsies that are no longer ethically justifiable. As a direct result of the difficulty in accessing well-phenotyped tissue samples from the spectrum of RCT, there is a distinct lack of tissue studies investigating earlier stages of the condition. Regrettably, this is precisely the stage of disease when patients present with symptomatic shoulders with intact or only partially torn tendons. In addition to this, there are no published investigations on the biological effects of treatments for RCT by means of tissue analysis before and after a treatment intervention. Therefore, although there is good evidence describing the changes in both patient-reported outcome

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measures and radiological outcomes following certain common treatments such as steroid injection and rotator cuff repair, next to nothing is known about the tissue changes that result.

Owing to the aforementioned limitations, we have developed a novel, minimally invasive, ultrasound-guided rotator cuff tendon sampling technique to allow for direct analysis of the full spectrum of diseased tissue. Not only does this enable better characterization of the tissue changes that occur with the onset, progression, and treatment of RCT, but it also allows access to the ideal control tissue with which to compare diseased samples. The purpose of this article is to describe a novel minimally invasive ultrasound-guided technique developed specifically to obtain biopsies of the supraspinatus footprint where the tendon attaches to the bone of the greater tuberosity of the humerus.

Development

To develop an accurate, reproducible, safe, and well-tolerated biopsy method for sampling the rotator cuff tendons a number of factors should be considered including the sampling device used, technical aspects of the biopsy process, and participant-related factors. A number of steps were taken to address each of these areas to ensure that each variable in the sampling process was optimized. This development process included the use of sequential models before the technique was finally successfully tested in human trial participants (REC reference number: 09/H0605/111). It is beyond the scope of this article to describe the development process in further detail as we wish to focus on the technical details of the final validated technique.

Informed Consent

Patients undergoing tendon biopsy should be aware of exactly what the procedure entails and its associated risks. It is important to check that the patient is not allergic to local anesthetic and warn of the small risk of adverse reactions to this drug. There must also be adequate medical backup on site in case of a severe drug reaction. Obviously, the injection of the local anesthetic is slightly uncomfortable and there is a wait of 20 minutes until the biopsy is performed. It is worth warning the patient that the biopsy instrument does make a noise similar to a loud stapler and it may be worth demonstrating this noise to the patient in some cases. The patient needs to be aware that a very small skin incision of around 2 mm is made and there is a small theoretical risk of infection associated with this. It is explained that the tendon biopsy is about the size of a grain of rice and that removing this amount of tendon does not significantly alter the strength of the tendon. Although we have not seen a single case of infection or tendon rupture after more than 200 biopsies, it is important that the patient is aware that these small theoretical complications may occasionally happen. The routine recovery is explained, including the need to take things easy while the local anesthetic is in effect and the need to keep the plaster on for 24 hours. Normal activities can be resumed on the day following the biopsy.

Setting

The biopsy technique may be performed using local anesthesia in the outpatient clinic or under general anesthesia in the operating theater. For the purposes of this article, the procedure has been described for the outpatient setting, making translation to the operating room relatively straight forward. It is important that the room has adequate space to seat the patient, provide for instrumentation, and carry out the biopsy. The surgeon performing the biopsy must be competent in performing ultrasound assessment of the rotator cuff. This can be achieved by the attendance of formal training followed by a period of independent learning according to a specifically designed protocol.[21] Some useful landmarks for conducting the biopsy have been illustrated later. It is inadvisable to embark upon the use of this technique without adequate ultrasound experience.

Anatomy

The most frequent site for rotator cuff tear development is the bony insertion of the supraspinatus tendon. Tears typically begin at the junction between supraspinatus and the greater tuberosity, usually sparing the anterior edge (the so called "rotator cable") which borders the rotator interval and bicipital groove anteriorly.[22,23] Therefore, it is this region (approximately 5-10 mm posterior to the anterior edge of the tendon) that is biopsied. The anterior landmark, the biceps brachii tendon, is extremely useful in identifying the leading edge of the supraspinatus, as it would always lie just posterior to the groove.[24] Ultrasonographically, the footprint of the supraspinatus is clearly identifiable just lateral to the articular margin on the greater tuberosity (Fig. 1). These landmarks offer clear reference points in 2 orthogonal planes that can then be used to orientate a linear ultrasound probe in the longitudinal plane of the supraspinatus tendon fibers at a point in the mid substance of the tendon approximately 5-10 mm posterior to the rotator interval. The long-axis view of the supraspinatus is demonstrated in Figure 1 with and without the biopsy needle present. Figures 2 and 3 demonstrate a normal and abnormal footprint, respectively; the smooth bony surface in the normal footprint and the obvious defect in the bony surface present in the abnormal footprint can be noted.

Equipment

Ultrasound machine and appropriate probe suitable for musculoskeletal ultrasound.

Local anesthetic—8 ml of 2% lignocaine.

Blue 23-gauge needle and 10-ml syringe (for local injection).

Permanent marker pen (to circle entry point location).

Sterile probe cover kit with ultrasound gel and rubber bands (Fig. 5).

Scalpel (No11-type blade) (Fig. 5).

Alcohol wipe.

Bard Magnum Core Biopsy device with needle (14-gauge green needle of 10-cm length) (Figs. 4 and 5).

Sterile drape with circular hole and adhesive under surface (Fig. 5).