RADIOLOGY—TECHNICAL ARTICLE

# Percutaneous tenotomy: Development of a novel, percutaneous, ultrasound-guided needle-cutting technique for division of tendons and other connective tissue structures

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## Summary

A variety of surgical procedures derive therapeutic benefit from the division of retinacular, ligamentous or tendinous structures. Examples include carpal tunnel release for median nerve impingement, annular pulley release for trigger finger and tendon division for spastic muscular contractures. Here, using an animal cadaveric model, we describe the first steps in determining the feasibility of a novel, percutaneous, ultrasound-guided needle-cutting technique to achieve the same ends. The technique we describe involves the creation of an effective needle tenotomy device via a simple modification to an 18G coaxial, beveled needle. The technique holds promise for the development of a minimally invasive alternative approach that utilises readily available technology and equipment with minimisation of morbidity and cost associated with open procedures.

**Key words:** musculoskeletal; musculoskeletal intervention; tenotomy; ultrasound.

## Background

An array of surgical procedures currently provide therapeutic benefit via division of retinacular, ligamentous or tendinous structures. Common examples include carpal tunnel release for median nerve impingement, annular pulley release for trigger finger, plantar fascia release, lateral release of the elbow and tendon division for conditions resulting in spastic muscular contractures.[1,2] We aimed to determine whether a novel, ultrasound-guided, percutaneous needle-cutting technique, utilising readily available and inexpensive equipment, could provide an alternate minimally invasive means of achieving the same ends.

To our knowledge the technique we present has not been described in the scientific literature. Ultrasound guidance for annular pulley release has been detailed.[3–5] The most similar previously described technique involved the use of a modified 19G hypodermic needle for sonographically assisted percutaneous annular pulley release,[3] angulating the needle in two points to serve as a cutting device. A combination of ultrasound-guided fenestration and hydrodissection has been applied to the carpal retinaculum.[6] Ultrasound-guided needle fenestration (dry needling) or tenotomy has been trialled in common extensor tendinosis and a variety of other chronic tendinoses.[7,8] Similarly, sonographically assisted lavage, steroid injection and needle barbotage of deposits in calcific tendinitis,[9,10] and brisement of adhesions, neovessels and neural tissue in achilles tendinosis have been performed.[11]

Here we present a new ultrasound-guided, percutaneous needle technique appearing highly effective in achieving selective partial tenotomy or complete tendon division.

## Methods

For the initial investigation of this technique we used the common calcaneal tendon of the porcine hind leg as a target for tenotomy. Porcine hind legs were sourced from a production animal wholesaler.

A linear array 12-MHz probe was used to provide ultrasound vision. Using a disposable scalpel, a small skin incision was made medial to the tendon 4 cm from its distal insertion. We made a simple modification to a commercially available 18G coaxial, beveled needle (18G Chiba biopsy needle, Cook Medical, Bloomington, IN, USA) to serve as a percutaneous cutting device. Using a scalpel, a small notch was cut into the hub of the needle

 

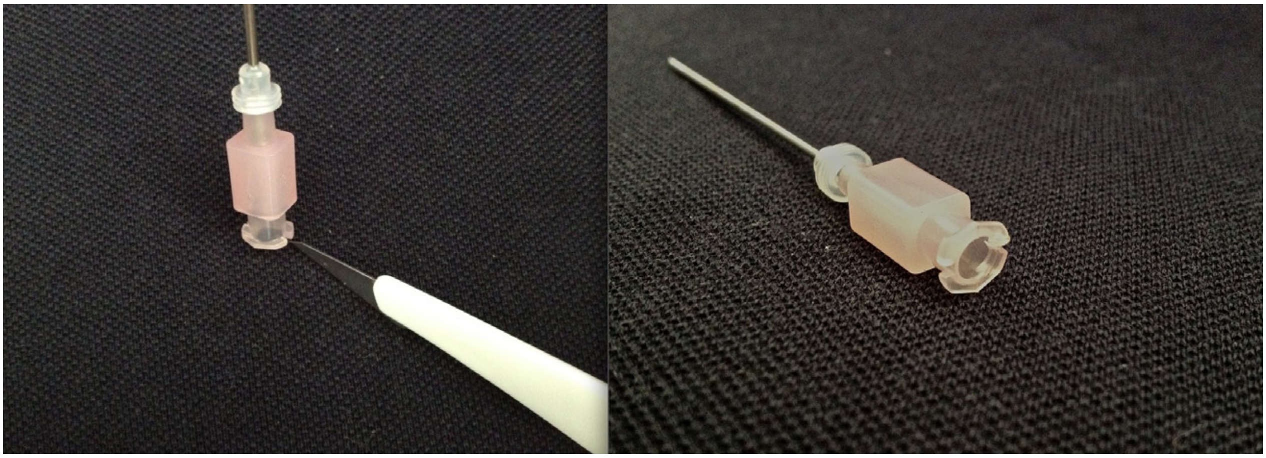

**Fig. 1.** Modified 5-cm 18G needle hub demonstrating newly created notch.

such that the stylet could be inserted and fixed at 180° to its normal orientation (Fig. 1). This created a 'v'-shaped cutting tip (Fig. 2). While kept in its conventional non-modified configuration, the needle was manoeuvred to the site of tenotomy. The needle was kept in this configuration (stylet bevel flush with the coaxial bevel) to minimise trauma to other tissues during positioning. This also allowed the bevel to be used to manipulate needle direction during manoeuvring, (turning the needle hub and bevel permitted changes in needle trajectory for subtle positioning adjustments).

With real-time ultrasound guidance the needle was positioned at the deep aspect of the tendon. The stylet was then rotated 180° and locked into the cutting position using the newly created notch in the needle hub. The needle was oriented such that the inverted stylet bevel was positioned adjacent to the deep aspect of the tendon. Under ultrasound guidance, the 'v'-shaped cutting tip was repeatedly advanced and retracted in a sawing action through the various layers of tendon fibres to achieve tendon division. Progress was assessed in real time sonographically and subsequently evaluated with open dissection. The procedure was performed by a fellowship-trained musculoskeletal radiologist adept at ultrasound-guided intervention.

## Results

We found the inverted 'v'-shaped cutting tip to be extremely effective in dividing the common calcaneal tendon. This was a thick structure, approximately $1.2 \times 2$ cm in transverse dimension (Fig. 3); however,

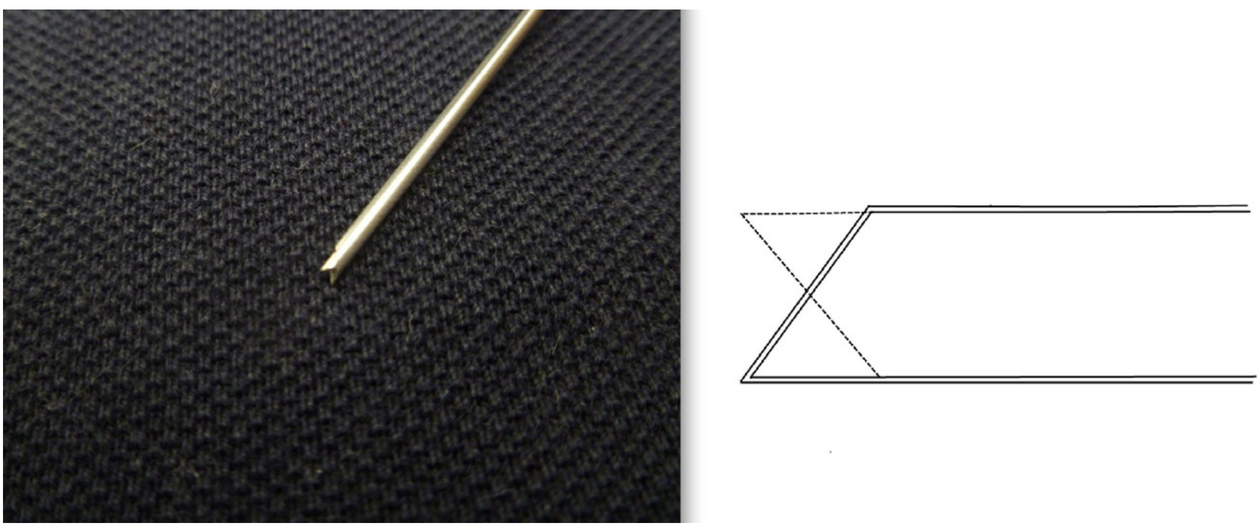

**Fig. 2.** Modified 18G needle 'v'-shaped cutting tip: photograph and line diagrammatic representation. 'V' tip created by turning stylet 180°; stylet then locked in modified configuration using the newly created notch in needle hub.

 

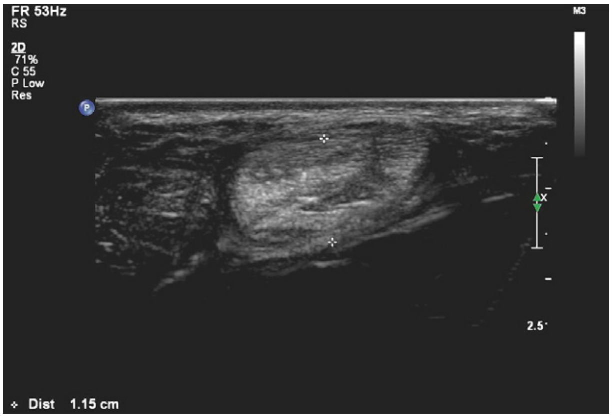


**Fig. 3.** Sonographic view of porcine common calcaneal tendon viewed in transverse plane.

agitation through the tendon resulted in destruction of fibres in little time. Initial resistance rapidly dissipated with division of fibres. Direct ultrasound vision permitted selectivity; we began with the deep/anterior portion of the calcaneal tendon and progressed through fibres to reach the superficial/posterior portion. Cutting needle tip visualisation was able to be maintained throughout. Within approximately 3 minutes, a large cleft was sonographically demonstrable (Fig. 4). Lengthening of the tendon was then possible. The entire procedure was completed in around 10 minutes. Open dissection subsequently confirmed the tendon to be near completely divided with demonstration of some remnant superficial paratenon (Fig. 5). During open dissection, we encountered no detectable injury to the surrounding soft tissues.

## Discussion

The cadaveric porcine common calcaneal tendon was chosen for this trial in part for accessibility but also to

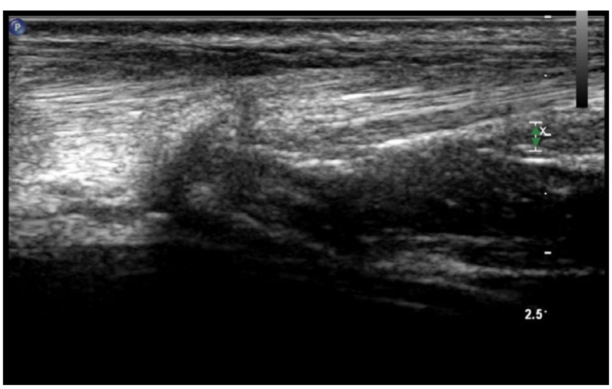


**Fig. 4.** Sonographic view of porcine common calcaneal tendon in longitudinal plane post tenotomy. Note the deep central cleft.

**Fig. 5.** Open dissection demonstrating division of porcine common calcaneal tendon with scant remnant superficial paratenon fibres.

provide a large diameter, tough structure upon which to evaluate the technique. We anticipated that needle tenotomy would prove difficult owing to its significant bulk and, indeed, a number of earlier attempts were unsuccessful. We had previously tested the effectiveness of a modified 22G needle with an angulated tip, passed through an 18G coaxial needle. In a somewhat similar vein to the technique described by Rajeswaran *et al.*,[3] we had considered that advancement of the angulated tip through the coaxial needle and then back and forth across the tendon surface might achieve fibre division. Instead we found that the fine needle tip quickly bent with the resistance encountered and was ineffective in fibre division. An 18G core biopsy technique was also trialled, whereby the biopsy needle was fired through the substance of the tendon in a series of positions in an attempt to achieve division. This approach proved awkward and relatively ineffectual. The proximal part of the open core biopsy tray does however resemble the 'v'-shaped cutting tip and proved a progenitor of the final product. Following the above-mentioned unsuccessful trials, the eventual modification to the 18G coaxial needle was conceived, anticipating it may be analogous to the cutting efficacy of a pair of scissors held in a fixed, open position and advanced through paper.

We found the 'v'-shaped tip to be extremely effective. The modified tip cut through tendon fibres readily, and the 18G coaxial needle provided the requisite stiffness to push through such a tough structure. We believe the primary cutting mechanism involved tendon fibres being drawn into, and cut by the 'v' on the forward stroke. In addition, downward angulation of the needle hub on the backward stroke with resultant upward angulation of the sharp, inverted stylet bevel tip against the undersurface of the tendon probably contributed in part to fibre division. We suspect that the tip did not accumulate cut tendon debris by virtue of clearing of this material on the backward stroke.

Under direct ultrasound vision, it was possible to accurately target specific portions of the tendon. This is obviously desirable and confers the ability to perform selective, partial tenotomy or complete tendon division depending upon the intended outcome. Continuous direct vision of the tip was also reassuring in terms of restriction of injury to surrounding tissues. Given the ability to divide a structure of the calibre of the porcine common calcaneal tendon, we anticipate there would be no difficulty in applying this technique to any of the larger tendons in the human body. We also feel confident that the above-mentioned accuracy and selectivity would permit use on smaller or more delicate ligaments and retinacula with minimal damage to adjacent structures.

There are limiting factors to our animal cadaveric model, with considerations such as patient analgesia, movement and the potential for bleeding to interfere with acoustic windows not being encountered. Any potential *in vivo* trial would require careful pre-procedural planning in order to minimise risk to local neurovascular structures. Conversely, in our cadaveric model, there was a lack of muscle tone causing active tension on the tendon, which might assist with tendon separation *in vivo*.

Clearly, these results provide little more than proof of concept, but we feel there is considerable potential for development, refinement and investigation of clinical applications. We hope to further explore potential applications by trialling the technique on other clinically relevant connective tissue structures in cadaveric models and potentially *in vivo* with the support of a surgical unit and ethics committee approval.

This procedure was possible using readily available, inexpensive equipment and a very simple modification to a coaxial needle. Furthermore, this was completed in a matter of only a few minutes. The procedure could potentially be performed in the outpatient setting with local or regional anaesthesia. If successfully applied in the clinical setting, the potential benefits in terms of minimisation of morbidity and cost are self-evident.

## Conclusion

Here, we have demonstrated efficacy of a novel, percutaneous, ultrasound-guided needle-cutting technique in selective partial tenotomy or complete tendon division. A simple modification to an 18G coaxial, beveled needle created a highly effective needle tenotomy device. The procedure was performed in very little time and was possible using readily available and inexpensive equipment.

We consider that this technique holds significant potential for further development, refinement and investigation of clinical applications. It is conceivable that such a technique may eventually provide a safe, minimally invasive, highly cost-effective alternative approach to a variety of common surgical procedures.

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