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FASCIA SCIENCE AND CLINICAL APPLICATIONS: FASCIAL PATHOPHYSIOLOGY IMAGING

Case study: Could ultrasound and elastography visualized densified areas inside the deep fascia?

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Summary Many manual techniques describe palpable changes in the subcutaneous tissue. Many manual therapists have perceived palpable tissue stiffness and how it changes after treatment. No clear demonstration exists of the presence of specific alterations in the subcutaneous tissue and even less a visualization of their changes following manual therapy.

This case study visualizes by ultrasound and elastography an alteration of the deep fascia in a 40-year-old male with subacute pain in the calf area. Ultrasound and elastography permits visualization of gliding, echogenicity and elasticity of deep fascia and their changes, after manual therapy (Fascial Manipulation©).

This study suggests the possible use of the ultrasound and elastography to furnish a more objective picture of the "sensations" that are commonly reported by manual therapists, and which supports clinicians in the diagnosis of the myofascial pain.

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Introduction

Ever since Hippocrates, palpation has been used to detect differences in tissue stiffness. Many manual techniques describe the presence of various alterations in the subcutaneous tissue that are appreciable with alpation, and most manual therapists have perceived stiffness variation after treatment (Huguenin, 2004). Really, no clear demonstration of the presence of specific alterations in the subcutaneous tissue exists and even less a visualization of their changes with manual therapy. Palpation may be able to reveal the presence of a mass or hardening of tissue, however it cannot demonstrate the localization of the problem (is it in the muscle or into the fascia?).

For many years researchers looked for muscular alterations, but recently some authors suggest the possible role of the deep fascia (Stecco et al., 2008; Van der Wal, 2009; Benjamin, 2009). Conventionally, connective tissue has been seen as a container and a force transmitter. The current knowledge concerning fascia is mainly based on dissections and on the macroscopic, histological and cadaveric studies. Less is known about factors affecting the fascial system of living individuals. Studies (Stecco and Stecco, 2009; Van der Wal, 2009; Corey et al., 2011; Tesarz et al., 2011) have pointed out the role of proprioception, motor control and activation of the fascial system. Many questions still remain unanswered.

Recently, the development of ultrasound and elastography instruments furnishes the clinicians with a new method to detect and display the relative stiffness of tissue within the body, as well as stiffer nodules in the specific regions of tissue (Konofagou et al., 2003), opening a host of new opportunities and perspectives (Sikdar et al., 2009; Supriyanto et al., 2011). Ultrasound can assist in teaching the role of palpation of functional anatomy. This teaching method is known as sonopalpation (Heiskanen and Comerford, 2012).

Ultrasound devices enable detection of superficial and deep fascia and their independent or dysfunctional movements and structures; regularity, shadows, homogeneity, reflectivity and density. Also functional aspects such as gliding can be visualized (Gao et al., 1996, Bianchi and Martinoli, 2007). The ultrasound imaging method provides an accurate, reliable, non-invasive means of evaluating muscles size, shape and architecture, and the effects of different pathologies and interventions have been documented (Whittaker, 2007). It uses colors to mark different tissue permeability in different colors. The muscle layers appear darker with fewer shades of grey while the encapsulating fascia appears quite white.

Elastography also known as elasticity imaging, is an *in vivo* non-invasive assessment of mechanical strain changes in tissues. A compressive force is applied to the tissue surface to produce transverse tissue displacement. The amount is estimated by comparing the echo signal sets obtained before and after compression. Real-time freehand ultrasound elastography (RTE) is the simplest technique allowing direct viewing of the elastogram superimposed on the B-mode image. The main limitation in this method is subjectivity since the operator manually controls the transducer. Thus, the pressure, orientation and direction of the ultrasound transducer can change the resulting images (Drakonaki et al., 2009).

Both ultrasound and elastography provides an extra dimension that complements existing imaging technology of gray scale and color Doppler imaging by showing differences in tissues elasticity (Ophir et al., 1991; Konofagou et al., 2003). The major problem of ultrasound and elastography is that they furnish operator-dependent images, that are often not easy to interpret. To better understand ultrasound images, it is necessary to keep in mind the organization of the fascial apparatus. The anatomy of the human fascial system can be divided into different layers (Fig. 1).

Superficial fascia lies beneath the epidermis and corium (Stecco and Stecco, 2009) and adheres via ligamentous folds into the deep fascia. It is clearly visible by ultrasound as a white fibrous layer in the middle of the adipose subcutaneous tissue. Functionally, the superficial fascia may play a role in the integrity of the skin, in thermal regulation, metabolism and the protection of vessels and nerves and in participating in the perceptive system (Stecco et al., 2008). The superficial fascia is formed by interwoven collagen fibers, which are loosely packed together and mixed with abundant elastic fibers. Due to the undulated collagen and elastic fibers, the fascia stretches and then returns to its original resting state.

The deep fascia envelops the muscles and their aponeurosis up to where it is inserted into the bone (Schleip et al., 2012). The deep fascia and muscles work together like a transmission belt between two adjacent joints and also between synergic muscle groups. Different levels of innervation can be recognizable inside the fascia, according to their different roles in movement, coordination and perception (Benjamin, 2009; Schleip et al., 2012). The deep fascia of the trunk is very different from that of the limbs. In the limbs fascia is easily separable from the underlying muscles because under the deep fascia, the muscles are free to slide because of the epimysial fascia. In the trunk, the deep fascia cannot be separated from the muscle. So, only the deep fascia of the limbs (and the thoracolumbar fascia and rectus sheath) are clearly visible with ultrasound. In the limbs, the deep fascia has a composite structure forming 2—3 layers of parallel bundles of collagen fibers. Each layer is separated from the adjacent one by a thin layer of loose connective tissue; this system allows the layers to slide one on the other. Overuse, trauma, disuse and misuse can compromise capacity of the sliding system. Different orientation of collagen fibers creates a strong resistance to traction even when the muscle is exercised in different directions. This sublayer organization could be studied by ultrasound, but it is necessary to use a high definition probe (Stecco et al., 2008).

The aim of this case study is to visualize a densification inside the deep fascia and compare its status before and after a manual treatment.

Materials and method

This case study was conducted in Finland with the ultrasound machine GE Healthcare's LOGIQ P6 that is equipped with elastography. LOGIQ P6 provides the modalities of SR,