The fascial network: an exploration of its load bearing capacity and its potential role as a pain generator

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Objectives

While fasciae have been treated as the virtual 'cinderella tissue of orthopedic research' during recent decades, new methodological findings and hypotheses suggest that the bodywide fascial network may play a more important role in musculoskeletal medicine than is commonly assumed. However, in the literature there is great diversity as to which tissues are to be included under the term 'fascia' – be it the superficial fascia, the endomysium, perineurium, visceral membranes, aponeuroses, retinaculae or joint/organ capsules. Following the proposed comprehensive terminology of the 1st Fascia Research Congress, this brief review considers all collagenous connective tissues as 'fascial tissues' whose morphology is dominantly shaped by tensional loading and which can be seen to be part of an interconnected tensional network throughout the whole body (Findley & Schleip 2007). While morphological differences between aponeuroses and lattice-like or irregular fasciae can still be properly described with this terminology, it allows seeing specific tissue – e.g. septae, capsules and ligaments – as local adaptations of this ubiquitous network based on specific loading histories.

What are the biomechanical functions of this fascial network, and what role do they play in musculoskeletal dysfunctions? This brief literature review will highlight the load-bearing function of different fascial tissues and also their tendency to microtearing during physiological or excessive loading. It will review histological studies indicating the proprioceptive as well as nociceptive innervation of fascia. Finally the potential role of injury, inflammation and/or neural sensitization of the posterior layer of the human lumbar fascia in nonspecific low back pain will be explored.

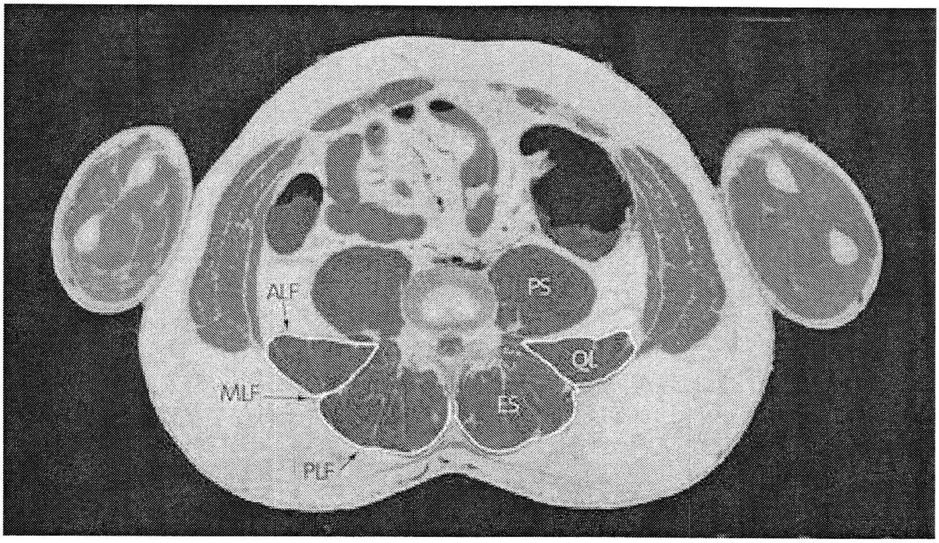

Fig. 1: Layers of lumbar fascia in a horizontal cross section of the human trunk at the layer of L4.

Note the large distance between the posterior layer of the lumbar fascia (PLF) and the axis of spinal flexion, making this layer susceptible to large strain deformations during forward bending. Note also the close association of the transversus abdominis (innermost abdominal muscle) with the middle layer of the lumbar fascia (MLF). ES: erector spinae. PS: psoas. QL: quadratus lumborum. ALF: anterior layer of lumbar fascia. Illustration adapted from the NPAC/OLDA Visible Human Viewer [17] with permission.

Findings

Fascial force transmission is an important player in human biomechanics

While the tensional load bearing function of tendons and ligaments has never been disputed, recent publications from Huijing et al. revealed that muscles, via their epimysia, also transmit a significant portion of their force to laterally positioned tissues such as to adjacent synergistic muscles and also – more surprisingly - to antagonistic muscles (Huijing 2009). The reported contribution of M. transversus abdominis to dynamic lumbar spinal stability has been associated with the load-bearing function of the middle layer of the lumbar fasciae in humans (Barker et al. 2007). Similarly, EMG based measurements of the 'flexion-relaxation phenomenon' suggest a strong tensional load-bearing function of dorsal fascial tissues during healthy forward bending of the human trunk. This load shifting is reportedly absent in low back pain patients (Shirado et al. 1995.

Recent ultrasound based measurements indicate that fascial tissues are commonly used for a dynamic energy storage [catapult action] during oscillatory movements such as walking, hopping or running. During such movements the supporting skeletal muscles contract more isometrically while the loaded fascial elements lengthen and shorten like elastic springs (Fukunaga et al. 2002).

Fascial tissues are prone to deformation

Fibrous collagenous connective tissues are prone to viscoelastic deformations such as creep, hysteresis and relaxation. Such temporary deformations alter fascial stiffness and complete recovery may take up to several hours. Load-bearing tests also reveal the existence of a gradual transition zone between reversible viscoelastic deformation and complete tissue tearing. Various degrees of microtearing of collagenous fibers and their interconnections have been documented to occur within this transition zone (Butler et al. 1978).

The fascial network serves as a sensory organ

Fascia is densely innervated by myelinated sensory nerve endings which are assumed to serve a proprioceptive function. These include Pacini (and paciniform) corpuscles, Golgi tendon organs and Ruffini endings (Stecco et al. 2010). In addition they are innervated by free endings. When including periosteal, endomysial and perimysial tissues as part of a bodywide interconnected network, this fascial net can be seen as our largest sensory organ. It is definitely the richest sensory organ for the the socalled sixth sense, the sense of proprioception (Schleip 2003).

Fascia can be a source of nociception

More recent histological examinations have shown that some of the free nerve endings in fascia are substance P containing receptors which are commonly assumed to be nociceptive (Tesarz 2009).

Delayed onset muscle soreness (DOMS) can be induced by repetitive eccentric contraction. Interestingly, a recent experimental study revealed that the epimysial fascia of the affected musculature plays a major role in the generation of DOMS related pain symptoms (Gibson et al. 2009).

The human lumbar fascia as potential generator of low back pain

Panjabi's new explanatory model of low back pain injuries suggests that a single trauma or cumulative microtrauma causes subfailure injuries of paraspinal connective tissues and their embedded mechanoreceptors, thereby leading to corrupted mechanoreceptor feedback and resulting in further connective tissue alterations and neural adaptations (Panjabi 2006). Our group subsequently proposed an extension of that model which includes the posterior layer of the lumbar fascia as a potential focus of such microtrauma and resulting muscle control dysfunction. Factors raised in support of that explanation include the long distance of this layer from the axis of spinal flexion (Fig. 1) as well as its lesser stiffness compared with spinal ligaments (Schleip et al. 2007).

Langevin reports that the posterior layer of the lumbar fascia tends to be thicker in chronic low back pain patients. In addition it expresses less shear motion during passive trunk flexion (Langevin et al. 2009). Surgical examinations of the posterior layer of the lumbar fascia revealed frequent signs of injury (Bednar et al. 1995) and of inflammation (Dittrich 1963, Dittrich 1964) in low back pain patients. In addition new histological examinations at our laboratory have shown a high density of myofibroblasts, the existence of which is usually associated with excessive loading or injury repair – in the same fascial layer (Schleip et al. 2007). And finally, injection of the inflammatory agent Freund Adjuvans solution into the rat lumbar muscles resulted in a dramatic increase in the proportion of dorsal horn neurons with input from the posterior lumbar fascia (Taguchi et al. 2009).

Conclusions

Fascial tissues serve important load-bearing functions. Severe tensional loading can induce temporary viscoelastic deformation and even microtearing. The innervation of fascia indicates a potential nociceptive function. Microtearing and/or inflammation of fascia can be a direct source of musculoskeletal pain. In addition, fascia may be an indirect source of physical problems such as back pain due to a sensitization of fascial nerve endings associated with inflammatory processes in other tissues within the same segment.

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