Invited lecture/Review

The Fascial System

Valenti Fabio[1,2*]

1. University of Ljubljana, Ljubljana, Slovenia
2. Biotechnical Faculty, Ljubljana, Slovenja

* Correspondence: Fabio Valenti; biofa76@gmail.com

Abstract:
The word Fascia has long been used by gross anatomists to embrace a spectrum of undifferentiated mesenchymal tissues that wrap organs and tissues of the body, or form a packing material between them. The inherent implication of this traditional view is that fasciae are inconsequential residues that are less important than the tissues with which they are associated. The errors of this assumption are being exposed and undoubtedly fascia is becoming more and more of considerable importance to many professionals working in health-related disciplines. Encouragingly, there has been a strong resurgence of interest into both basic and applied research in fasciae in recent years, also thanks to new fascia related findings. Knowledge of the fascial system's characteristics and functions is spreading from primary medical researchers to professionals in many health fields throughout the world. Nowadays is well known that the Fascia is a mechanically active tissue with a proprioceptive and nociceptive properties. The Fascial continuum complexity is the result of perfect synergy evolution among different tissues made up of solid and fluid portions, which interpenetrate and interact with each other, forming a polymorphic three-dimensional network. Normal movement of the body is allowed because of the presence of the fascial tissues and their inseparable interconnection, one of the fundamental characteristics of the fascia is the ability to adapt to mechanical stress, remodeling the cellular/tissue structure and mirroring the functional necessity of the environment where the tissue lays. So, Fascia can transmit tension and in view of its proprioceptive and nociceptive functions could be responsible for disorders and pain radiating to remote anatomical structures. Dysfunction of the fascial system that is perpetuated in everyday movements can also cause an emotional alteration of the person. So, the fascial unity could influence not only movement but also emotions. Because the importance of fascia in human movement (both motion and emotion), shock absorption, metabolic and physiological processes, proprioception, healing and repair, the fascia in a broadest sense may be the literal representation of our inner being. Theoretically, Fascia probably hold many of the keys for understanding muscle action and musculoskeletal pain, and maybe it is of pivotal importance in understanding the basis of the body functioning. Further intensive research is essential to understand the function of the Fascia. The proposed article is a reflection to better understand the anatomy and main characteristics of the human fascial system.

Keywords: Fascia; Facial system; Myofascial chains

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1. Fascia

The word Fascia has long been used by gross anatomiststs to embrace a spectrum of undifferentiated mesenchymal tissues that wrap around what are sometimes regarded as being the more 'specialized' organs and tissues of the body, or form a packing material between them. The inherent implication of this traditional view is that fasciae are inconsequential residues that are less important than the tissues with which they are associated (Benjamin, 2009). Increasingly, the errors of this assumption are being exposed and undoubtedly fascia is becoming more and more of considerable importance to many professionals working in health-related disciplines. Encouragingly, there has been a strong resurgence of interest into both basic and applied research in fasciae in recent times, but researchers do not agree on one comprehensive "fascia" definition (Benjamin, 2009). Despite the scientific uncertainty, there is an agreement with medical text that the fascia covers every structure of the body, creating a structural continuity that gives form and function to every tissue and organ.

The fascial tissue has a ubiquitous distribution in the body system; it is able to wrap, interpenetrate, support, and form the bloodstream, bone tissue, meningeal tissue, organs, and skeletal muscles. The fascia creates different interdependent layers with several depths, from the skin to the periosteum, forming a three-dimensional mechano-metabolic structure (Bordoni et al., 2017). The fascia includes everything that presumes the presence of collagen/connective tissue or from which it is derived. All the tissue considered as "specialized connective tissue" of mesodermal derivation is inserted into the fascial system. These include blood, bone, cartilage, adipose tissue, hematopoietic tissue, and lymphatic tissue. The fascial system has no discontinuity in its path, with layers of different characteristics and properties overlapping (Bordoni et al., 2022). Bordoni et al., (2019 and , 2021) more accurately explained that fascia is any tissue that contains features capable of responding to mechanical stimuli.

The fascial continuum is the result of the evolution of the perfect synergy among different tissues, liquids, and solids, capable of supporting, dividing, penetrating, feeding, and connecting all the districts of the body: epidermis, dermis, fat, blood, lymph, blood and lymphatic vessels, tissue covering the nervous filaments (endoneurium, perineurium, epineurium), voluntary striated muscle fibers and the tissue covering and permeating it (epimysium, perimysium, endomysium), ligaments, tendons, aponeurosis, cartilage, bones, meninges, involuntary striated musculature and involuntary smooth muscle (all viscera derived from the mesoderm), visceral ligaments, epiploon (small and large), peritoneum, and tongue. The continuum constantly transmits and receives mechano-metabolic information that can influence the shape and function of the entire body.

These scientific definitions allow healthcare practitioners to see the functioning of the body in a holistic way and make some deductions about fascia. Normal movement of the body is allowed because of the presence of the fascial tissues and their inseparable interconnection, which allow the proper distribution of tension information produced by different tissues covered or supported by the fascia so that the entire body system can interact in real-time, including the epidermis. One of the fundamental characteristics of the fascia is the ability to adapt to mechanical stress, remodeling the cellular/tissue structure and mirroring the functional necessity of the environment where the tissue lays (Bourne et al., 2022). This further indicates the importance of fascia as a sensory system. Fascia probably hold many of the keys for understanding muscle action and musculoskeletal pain, and maybe of pivotal importance in understanding the basis of the body functioning (Langevin et al. 2001; 2002; 2006; Langevin & Yandow, 2002; Iatridis et al. 2003). Dysfunction of the fascial system that is perpetuated in everyday movements can also cause an emotional alteration of the person. So the fascial unity could influences not only movement but also emotions (Bordoni et al., 2017).

2. Embryology

During embryonic development, the connective tissue influences the form (morphogenesis) of the structures that it will contain and connect. The embryonic mesenchyme or connective embryonic or undifferentiated mesenchyme is formed by star-branched cells with a high mitotic rate (high reproductive capacity). They are considered to be pluripotent cells, as they can differentiate into different tissues. The mesenchyme is found and is derived from all three embryonic layers (ectoderm, mesoderm, endoderm), especially mesoderm and ectoderm (Bordoni et al., 2020). The fascial system is classically understood to originate from the mesoderm layer divided during week 2 of development during the embryo's gastrulation phase. There is also some evidence that certain fascial layers, particularly in the cervical and cranial neck, derive from the ectoderm (Van der Wal, 2009).

3. Structure and function

To understand the function and architecture of the fascial system, it is important to understand its composition. Fascia must be understood first and foremost as connective tissue (textus connectivus) (FCAT, 1998). Fascia is made up of sheets of connective tissue that is found below the skin. Each fascial layer is distinct in important ways from each other. Each layer has its own orientation and composition. It can be classified as superficial, deep, visceral, or parietal and further classified according to anatomical location. Superficial fascia is loose and irregular, whereas deep fascia is a well-organized fibrous layer (Stecco et al., 2011).

3.1. Superficial fascia

The superficial fascia (tela subcutanea) is a membranous layer of connective tissue (thicker in the trunk and thinner in the limbs), formed by loosely packed interwoven collagen fibers mixed with elastic fibers. It is absent in the face, palm of hand and sole of the feet (Varghese and Priya, 2017). Its arrangement and thickness vary according to body structure, gender and region. It is connected to the skin by the retinaculum cutis superficialis, which presents vertical and thick collagen septa and with the deep fascia through the retinaculum cutis profundi, which presents loose oblique, very elastic collagen septa. The region between the skin and superficial fascia that includes the superficial retinacula cutis is called superficial adipose tissue, while the one between superficial fascia and deep fascia is called deep adipose tissue. Both impart the subcutis with specific mechanical proprieties (Lesondak et al., 2020). At some bony prominence the superficial layer adheres to the deep fascia (Varghese and Priya. 2017). Functionally, the superficial fascia may play a role in the integrity of the skin and support for subcutaneous structures, particularly veins, by ensuring their patency and also for the integrity of the lymphatic vessels. Within the superficial fascia the subcutaneous plexus that function for thermoregulation is also found. Some muscular fibers found in superficial fascia are platysma muscle in the neck and musculo aponeurotic system in the face (Varghese and Priya. 2017).

3.2. Deep fascia

The deep fascia is a well-organized connective membrane. It surrounds all the muscles, ligaments, bones, nerves, blood vessels, envelopes, various glands and organs and binds all these structures together. The deep fascia duplicates itself to form deep lamina in some regions of the trunk and limbs. For example, specialized structures of the deep fascia are termed as periosteum over the bone, paratendon over the tendon, capsule and tendons over the joint and neuromuscular sheath over the nerves and blood vessels. The deep fascia can be divided into the aponeurotic and epimysial fascia according to orientation, composition, and architecture. Aponeurotic fasciae are formed by two to three layers of parallel bundles of collagen fibers. Each layer is separated from the adjacent one by a thin layer of loose connective tissue (Lesondak et al., 2020). Aponeurotic fasciae envelope and connect whole groups of muscles. It covers the extremity muscles and includes both the thoracolumbar fascia (TLF) and the rectus abdominal sheath (RAS) in the torso. Under the aponeurotic deep fascia, the muscles are free to slide because of their epimysium. Loose connective tissue rich in hyaluronic acid lies between the epimysium and the deep fasciae responsible for free gliding of the deep fascia with epimysium (Mc Combe et al., 2001). Epimysial fasciae covers and adheres to the whole muscle and can be used to refer to all the intramuscular connective tissue, which includes the epimysium, perimysium, and endomysium. It is not possible to separate the epymysial fascia from the muscle because it is so intertwined with the muscle tissue, and the function of one is strongly dependent on the other (Lesondak et al., 2020).

4. Innervation

The main sensory receptors integrated into the fascial system are the proprioceptors, usually referred to as mechanoreceptors. Collagen fibers surround and are attached to the capsules of corpuscles and free nerve endings. The tissue function and the type of mechanical force transmission that is necessary in different parts of our body determines the number of mechanoreceptors that will be available. The most innervated tissue are the superficial layers of the deep fascia (Schleip and Muller, 2013; Stecco et al., 2007; Tesarz et al., 2011). Ruffini corpuscles, or free nerve endings, and Merkel discs are the slowly adapting touch receptors. They are responsive to prolonged stimuli. Merkel discs are abundant in the fingertips, hands, lips, and external genitals. Ruffini endings lie deep in the dermis, ligaments, tendons, and fasciae are most sensitive to stretch resulting from muscle movement, particularly movement in the limbs or digits. Ruffini and Meissner corpuscles are rapidly adapting touch receptors mostly located in hairless skin that react at the onset of a stimuli. Pacinian corpuscles are rapidly adapting receptors located in the dermis and subcutaneous tissue, tendons, and joints. They react to pressure against a broad area as opposed to a localized touch area. The Ruffini and Pacinian corpuscles are also present in deep fascia and retinacula (Vesalius, 1543). Together with the retinacula, the superficial and intermediate layers of the deep fascia are the most highly innervated structures of the fascia system (Schilder et al., 2018). The superficial tissues are rich in free nerve endings. The amount of free nerve endings, which can also sense temperature, mechanical stimuli, and nociception, may be up to seven times more numerous than other mechanoreceptors. These nerve endings are aligned perpendicularly to the collagen fibers, so stretching the muscle and fascia stimulates these receptors easily. Free nerve endings act as sensory receptors and a percentage of them also transmit pain. The pain caused by the fascia also called Myofascial pain syndrome can be even more aggravating than pain from the muscles. The pain may appear anywhere along the fascia even in an area more distal from the cause of the pain. Fascial pain is usually described as a stabbing, irritating, stinging, or beating sensation, whereas muscle pain is described as a more dull and aching type of pain (Schilder et al., 2014).

5. Myofascial chains

Understanding the fascial tissue mechanisms have become increasingly popular also thanks to new recent histological findings. The discovery of contractile cells, free nerve endings and mechanoreceptors in the fascia suggests that fascia in contrast to prior assumptions plays a proprioceptive and mechanically active role in the body (Bhattacharya et al., 2010; Yahia et al., 1992). We can conclude that the muscles do not function as independent units. Instead, they are regarded as part of a tensegrity-like, bodywide network with fascial structures acting as linking components. As fascia can transmit tension (Barker et al., 2004; Norton et al., 2013) and in view of its proprioceptive and nociceptive functions, existence of myofascial meridians could be responsive for disorders and pain radiating to remote anatomical structures. Myers (2014) defined from cadaveric dissections eleven myofascial meridians connecting distant parts of the body by means of muscles and fascial tissues. The central rule for the selection of a meridian's components is a direct linear connection between two muscles. Evidence for the existence of myofascial chains is growing, and the capability of force transmission via myofascial chains has been hypothesized. However, there is still a lack of evidence concerning the functional significance and capability for force transfer. Wilke et al. (2016) showed that there is good evidence for the existence of three myofascial chains proposed by Myers (2014): the superficial backline (SBL: plantar fascia, gastrocnemius, hamstrings, erector spinae); the back functional line (BFL: latissimus dorsi, contralateral glutueus maximus, vastus lateralis); and the front functional line (FFL: adductor longus, contralateral rectus abdominis, pectoralis major). In contrast to the solid evidence for these five meridians, doubts have to be raised about the existence of the superficial front line SFL. There is no structural connection between the rectus femoris muscle and M. rectus abdominis. Also, M. sternalis, which is suggested to be the cranial continuation of rectus abdominis, exists only in a small percentage of the population. Even if present, it does not fuse consistently with the rectus abdominis (Barlow, 1935; Saeed et al., 2002). Though the available evidence points towards existence of tensile transmission via myofascial pathways, most experimental research was carried out in vitro using cadavers. Randomized, controlled in-vivo studies are warranted in order to draw more precise assumptions on the significance of myofasical chains for the movement system (Wilke et al., 2016).

6. Conclusion

The fascia's nomenclature is the subject of debate in the academic world, as it is classified starting from different scientific perspectives. This disagreement is not a brake but is, in reality, the real wealth of research, the multidisciplinarity of thought and knowledge that leads to a deeper understanding of the topic. Since clinicians and anatomists show increasing interest in fascia, it is well possible that in the future, more focused research will verify the remaining myofascial missing links to understand the role and functioning of the fascia (Bordoni and Myers, 2020). Another topic of discussion is how the fascial model fits into the reality. Biotensegrity is a mechanical model, which takes into consideration the solid aspect of the fascia (structure) and fascintegrity considers the solid and the liquid aspect of the fascia (structure and gliding). Myofascial chains converge attention on the movement and transmission of force in the muscle continuum (Bordoni and Myers, 2020). Another aspect that is fundamental to understand the functioning of the fascia is the relationship between fascia and emotions. Chronic altered information from conditions such as pain, depression, lack of movement will negatively affect the cognitive aspect (memory, problem-solving, elaboration of ideas) and viceversa. From these concepts, the need arises to frame the fascial system in a model that can represent the living being and understand, prevent and possibly cure the dysfunctions that can result from the fascia (Malfliet et al., 2017). It was indicated that the importance of fascia in human movement (both motion and emotion), shock absorption, metabolic and physiological processes, proprioception, healing and repair the fascia in a broadest sense may be the literal representation of our inner being (Lesondak, 2017).

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References

1. Barker PJ, Briggs CA, Bogeski G. Tensile transmission across the lumbar fasciae in unembalmed cadavers: effects of tension to various muscular attachments. Spine. 2004; 29: 129-138. DOI: 10.1097/01.BRS.0000107005.62513.32
2. Barlow RN. The sternalis muscle in American whites and negroes. Anat Rec. 1935; 61: 413-426
3. Benjamin M. The fascia of the limbs and back–a review. Journal of anatomy. 2009; 214: 1-18. DOI: 10.1111/j.1469-7580.2008.01011.x
4. Bhattacharya V, Barooah P, Nag T, Chaudhuri G, Bhattacharya S. Detailed microscopic analysis of deep fascia of lower limb and its surgical implication. Indian J Plast Surg. 2010; 43: 135. DOI: 10.4103/0970-0358.73424
5. Bordoni B, Marelli F, Morabito B, Sacconi B. The indeterminable resilience of the fascial system. J Integr Med. 2017; 15: 337-343. DOI: 10.1016/S2095-4964(17)60351-0
6. Bordoni B, Simonelli M, Morabito B. The Other Side of the Fascia: Visceral Fascia, Part 2. Cureus. 2019; 11: e4632. DOI: 10.7759/cureus.4632
7. Bordoni B, Morabito B. Reflections on the Development of Fascial Tissue: Starting from Embryology. Adv Med Educ Pract. 2020; 11: 37-39. DOI: 10.2147/AMEP.S232947
8. Bordoni B, Myers T. A Review of the Theoretical Fascial Models: Biotensegrity, Fascintegrity, and Myofascial Chains. Cureus. 2020; 12: e7092. DOI: 10.7759/cureus.7092

9. Bordoni B, Escher AR, Tobbi F, Ducoux B, Paoletti S. Fascial Nomenclature: Update 2021, Part 2. Cureus. 2021; 13: e13279. DOI: 10.7759/cureus.13279
10. Bordoni B, Mahabadi N, Varacallo M. Anatomy, fascia. 2022. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan–. PMID: 29630284.
11. Bourne M, Talkad A, Varacallo M .Anatomy, Bony Pelvis and Lower Limb, Foot Fascia. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 . PMID: 30252299.
12. Federative Committee on Anatomical Terminology (FCAT). 1998. Stuttgart: Georg Thieme Verlag. ISBN-10: 3-13-114361-4. ISBN-13: 978-3-13-114361-7. 300 pp.
13. Iatridis JC, Wu J, Yandow JA, Langevin HM. Subcutaneous tissue mechanical behavior is linear and viscoelastic under uniaxial tension. Connect Tissue Res. 2003; 44: 208–217.
14. Langevin HM, Churchill DL, Cipolla MJ. Mechanical signaling through connective tissue: a mechanism for the therapeutic effect of acupuncture. Faseb J. 2001; 15: 2275–2282. DOI: 10.1096/fj.01-0015hyp
15. Langevin HM, Churchill DL, Wu J, et al. Evidence of connective tissue involvement in acupuncture. Faseb J. 2002; 16: 872– 874. DOI: 10.1096/fj.01-0925fje
16. Langevin HM, Bouffard NA, Badger GJ, Churchill DL, Howe AK. Subcutaneous tissue fibroblast cytoskeletal remodeling induced by acupuncture: evidence for a mechanotransductionbased mechanism. J Cell Physiol. 2006; 207: 767–774. DOI: 10.1002/jcp.20623
17. Langevin HM and Yandow JA. Relationship of Acupuncture Points and Meridians to Connective Tissue Planes. The Anatomical Record. 2002; 269: 257-265. DOI: https://doi.org/10.1002/ar.10185
18. Lesondak, D. 2017. Fascia: What It Is and Why It Matters. Edinburgh: Handspring Publishing.
19. Lesondak D, Akey AM. (Eds.). Fascia, function, and medical applications (1st ed.). CRC Press. 2020; 19: 19-29. DOI: https://doi.org/10.1201/9780429203350
20. Malfliet A, Coppieters I, Van Wilgen P, Kregel J, et al. Brain changes associated with cognitive and emotional factors in chronic pain: a systematic review . Eur J Pain. 2017, 21: 769-786. DOI: 10.1002/ejp.1003
21. McCombe D, Brown T, Slavin J, Morrison WA. The histochemical structure of the deepfascia and its structural response to surgery.J Hand Surg (Br). 2001; 26: 89–97. DOI: 10.1054/jhsb.2000.0546
22. Myers TW. Anatomy trains: Myofascial meridians for manual and movement 249 therapists. 3rd ed. New York: Churchill Livingstone; 2014.
23. Norton-Old KJ, Schache AG, Barker PJ, Clark RA, Harrison SM, Briggs CA. Anatomical and mechanical relationship between the proximal attachment of adductor longus and the distal rectus sheath. Clin Anat. 2013; 26: 522-530. DOI: 10.1002/ca.22116
24. Saeed M, Murshid KR, Rufai AA, Elsayed SE, Sadiq MS. Sternalis. An anatomic variant of chest wall musculature. Neurosciences (Riyadh). 2002; 7: 248-255.
25. Schilder A, Hoheisel U, Magerl W, Benrath J, Klein T, Treede RD. Deep tissue and back pain: Stimulation of the thoracolumbar fascia with hypertonic saline. Schmerz. 2014; 28: 90 –92. DOI: 10.1007/s00482-013-1373-3
26. Schilder A, Magerl W, Klein T, Treede RD. Assessment of pain quality reveals distinct differences between nociceptive innervation of low back fascia and muscle in humans. Pain Rep. 2018; 3: e662. DOI: 10.1097/PR9.0000000000000662
27. Schleip R, Muller D. Training principles for fascial connective tissue: Scientific foundation and suggested practical application. J Bodyw Mov Ther. 2013; 17: 103–115. DOI: 10.1016/j.jbmt.2012.06.007
28. Stecco C, Gagey O, Belloni A, Pozzuoli A, et al. Anatomy of the deep fascia of the upper limb. Second part: Study of innervation. Morphologie. 2007; 91: 38–43. DOI: 10.1016/j.morpho.2007.05.002
29. Stecco C, Macchi V, Porzionato A, Duparc F, De Caro R. The fascia: the forgotten structure. Ital J Anat Embryol. 2011; 116: 127-138.
30. Tesarz J, Hoheisel U, Wiedenhöfer B, Mense S. Sensory innervation of the thoracolumbar fascia in rats and humans. Neuroscience. 2011; 194: 302–308. DOI: 10.1016/j.neuroscience.2011.07.066
31. Van der Wal J. The architecture of the connective tissue in the musculoskeletal system-an often overlooked functional parameter as to proprioception in the locomotor apparatus. Int J Ther Massage Bodywork. 2009 2: 9-23. DOI: 10.3822/ijtmb.v2i4.62
32. Varghese JG, Priya GA. (2017). Role of fascia in human function. Research J Pharm. and Tech. 2017; 10: 2759-2764. DOI : 10.5958/0974-360X.2017.00489.9
33. Vesalius A. 1543. De humani corporis fabrica libri septem. Basel: Johannes Oporinus.
34. Wilke J, Krause F, Vogt L, et al. What is evidence-based about myofascial chains? A systematic review Arch Phys Med Rehabil. 2016; 97: 454–61. DOI: 10.1016/j.apmr.2015.07.023
35. Yahia L, Rhalmi S, Newman N, Isler M. Sensory innervation of human thoracolumbar fascia. An immunohistochemical study. Acta Orthop Scand. 1992; 63: 195-197. DOI: 10.3109/17453679209154822