



Reflections on the Development of Fascial Tissue: Starting from Embryology

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Abstract: A great many articles discuss the histological aspects of fascial tissue in detail, but at the same time, there are many contradictions within the literature. In addition, there is a paucity of scientific data that allow straightforward classification of what tissue the fascia truly is. More precise classification of fascial tissue is essential in improving clinical care and effectively framing patient needs. Embryology is an indispensable starting point for understanding the many functions of the fascial tissue. This scientific discipline allows us to observe the relationships and adaptability of fascia both at local and systemic levels. This article reflects on modern scientific knowledge concerning the classification of fascia from an embryological standpoint with the aim of improving our understanding of connective tissue.

Keywords: fascia, myofascial, embryology, anatomy, surgery, fibroblast

Introduction

The aim of this article is to clarify how fascia is considered in its embryological context. Embryology allows us to highlight the origin of tissues and understand not only tissue functions, but also the behavior of individual cells.^{1,2}

Although many surgical or clinical approaches precisely describe a wide variety of treatment techniques that involve fascial tissue, a number of inaccuracies remain. For example, in a recent article concerning the assessment of nerves in the knee by ultrasound, the fascia was stated to derive from undifferentiated mesenchymal tissue that develops between the 22nd and 35th weeks of gestation.³ From an embryological point of view, the fascia has a double origin and derives from both the mesodermal and ectodermal leaflets. These leaflets are, in fact, apparent within the first few weeks of development.⁴

In another study concerning cosmetic surgery, a technique to lift the tissues of the face and neck (i.e. cranial suspension with minimal access; MACS) cited surgically relevant tissue layers that were not conceptually exact: "... superficial musculoaponeurotic system and platysma".⁵ The term "superficial musculoaponeurotic" includes terms denoting both connective and muscular contractile tissue while also describing the name of a muscle (platysma). From an embryological point of view this term is correct, because at the level of the skull the musculature and connective tissues derive from the ectoderm.^{6,7} From the anatomical and functional point of view, such a description is inaccurate. The terms superficial and deep are used to delimit the layers of fascial tissue within the limbs. These terms are used to describe anatomy in order to improve surgical techniques while identifying age and morphological differences.⁸ The fascia can be divided into solid

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and liquid tissues.⁹ Blood and lymph are classified as specialized connective tissues in several anatomical texts and we can thus consider these body fluids to be liquid fascia.¹⁰ The solid fascia not only encompasses connective tissue (i.e. ligaments, tendons, aponeuroses, endomysium, perimysium, epimysium) but all tissues that possess certain mechanometabolic characteristics and the same embryological origin. From an embryological point of view, the fascia indeed has a double origin that includes the mesodermal and ectodermal (skull) leaflets.^{4,6,11,12} Blood and lymph, also fascial tissue, are in each layer.⁹ Distinguishing among the fascial layers is an antiquated perspective that does not take into account much current scientific knowledge.¹³ In all likelihood, use of the term “fascia” to separate the human body into tissue layers deserves reconsideration.

Reflections on Fascial Tissue

Classically, the fascial system has been considered to be connective tissue that covers and separates the musculature. In 2014, the Fascia Nomenclature Committee stated:

The fascial system includes adipose tissue, adventitia, neurovascular sheaths, aponeuroses, deep and superficial fasciae, dermis, epineurium, joint capsules, ligaments, membranes, meninges, myofascial expansions, periosteum, retinacula, septa, tendons (including endotendon/peritendon/epitendon/paratendon), visceral fasciae, and all the intramuscular and intermuscular connective tissues [...].¹⁴

A variety of other organizations have provided definitions of fascial tissue between 1988 and 2011 (e.g. Anatomical Terminology Organization; Federative Committee on Anatomical Terminology or FCAT; Federative International Programme on Anatomical Terminologies or FIPAT) and have generally concurred that fascia is defined as “... a sheath, a sheet, or any other dissectible aggregation of connective tissue that forms beneath the skin to attach, enclose, and separate muscles and other internal organs.”¹⁵ This aforementioned concept first took root in literature of the last century and has continued into the present, conditioning the way in which the fascia is conceived and how the same fascia is viewed as an architectural structure.¹⁶ Despite an apparently clear, existing, definition of what fascial tissue is, in many texts the embryological origin of the fascia is not taken into consideration. In previous works we recalled, through the Foundation of Osteopathic Research and Clinical Endorsement (FORCE), that the fascial tissue of

the skull and part of the neck has a double embryological origin.¹⁷ For example, the meninges of the skull (which are considered to be fascial tissue) have an embryological derivation involving both the mesoderm and ectoderm; the dura mater that covers areas of the forebrain and caudal mesencephalon derive from the neural crests (or ectoderm).¹⁸ The dura mater that covers the remaining hindbrain and midbrain derives from the mesodermal leaflet.¹⁸ The hypoglossal canal and the area of the sigmoid, transverse and cavernous sinuses derive from the mesoderm; the falx cerebri and the falx cerebelli derive from the ectoderm, as does the dura mater covering the spinal cord.¹⁹ If the same tissue of the developed human body arises from different embryological origins, how are its boundaries accurately delineated? Of particular concern is the origin of the musculature and connective tissue of the cranio-cervical area. The 60 muscles of the skull derive from mesodermal cells (i.e. prechordal and pharyngeal mesoderm); these muscles influence the movement of the anterior and posterior portions of the cervical tract.⁶ These muscles come into contact with a particular connective tissue that has an ectodermal embryological origin (neural crests), such as, for example, the infrahyoid area muscles, the buccal floor and the tongue.⁶ The same ectodermal connective tissue merges, in part, with connective tissue of mesodermal origin and forms the musculature of the trapezius (anterior portion) and of the sternocleidomastoid (cleidomastoid portion) muscles.^{20,21} The final functional unit that is skeletal muscle thus possesses different embryological origins. Body fluids such as blood and lymph have a mesodermal origin, while cerebrospinal fluid (CSF) has an ectodermal origin. As fluids flow throughout the body and involve every tissue, borders between fascial divisions are unclear.^{9,22} Taking this into consideration, not all present fascial classifications are incomplete or contradictory. As the fascia has both ectodermal and mesodermal origins, several other tissues should be considered fascial tissue:

The 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, nourishing and connecting all regions of the body, from the epidermis to the bone, involving all its functions and organic structures. This continuum constantly transmits and receives mechanometabolic information that can influence the shape and physiology of the entire body. Such afferent/efferent impulses arise from the fascia and the tissues not considered as part of the fascia in a biunivocal mode. In accordance with this

definition, such tissues include the epidermis, dermis, fat, blood, lymph, lymphatic vessels, tissue covering nervous filaments (i.e. endoneurium, perineurium, epineurium), voluntary striated muscle fibers as well as tissue covering and permeating it (i.e. epimysium, perimysium, endomysium), ligaments, tendons, aponeuroses, cartilage, bones, meninges, and tongue.¹⁷

We believe that an anatomical nomenclature based on both physiology and embryology is required to accurately classify fascia. Altering the nomenclature, however, does not suffice; understanding the true anatomical functions and limits of fascia is also mandated. Embryological origins should be taken into consideration for the classification of different tissues, and further studies allowing for evidence-based classification of fascia are needed.

Conclusion

The nomenclature of fascial tissue does not always reflect its embryological function or origin, just as the anatomical nomenclature does not necessarily correspond to the true embryological origin of a given tissue. The definition of fascial tissue thus warrants reconsideration, taking into account its embryological development and clinically relevant functionality.

Disclosure

The authors report no conflicts of interest in this commentary.

References

- Louryan S, Vanmylder N. Contributions of embryology and comparative anatomy for teaching of cranial nerves. *Morphologie*. 2018;102(337):111–121. doi:10.1016/j.morpho.2018.04.002
- Verheyden JM, Sun X. Embryology meets molecular biology: deciphering the apical ectodermal ridge. *Dev Biol*. 2017;429(2):387–390. doi:10.1016/j.ydbio.2017.01.017
- Míguez-Fernández M, Miguel-Pérez M, Ortiz-Sagrìstà J, et al. Ultrasound and anatomical study of accessing the nerves in the knee by fascial planes. *Pain Pract*. 2019. doi:10.1111/papr.12836
- Chal J, Pourquie O. Making muscle: skeletal myogenesis in vivo and in vitro. *Development*. 2017;144:2104–2122. doi:10.1242/dev.151035
- Chopan M, Buchanan PJ, Mast BA. The minimal access cranial suspension lift. *Clin Plast Surg*. 2019;46(4):547–557. doi:10.1016/j.cps.2019.06.005
- Masyuk M, Brand-Saberi B. Recruitment of skeletal muscle progenitors to secondary sites: a role for CXCR4/SDF-1 signalling in skeletal muscle development. *Results Probl Cell Differ*. 2015;56:1–23.
- Heude E, Tesarova M, Sefton EM, et al. Unique morphogenetic signatures define mammalian neck muscles and associated connective tissues. *Elife*. 2018;19(7):e40179. doi:10.7554/eLife.40179
- Casabona G, Frank K, Koban KC, et al. Influences of age, gender, and body mass index on the depth of the superficial fascia of the arm and thigh. *Dermatol Surg*. 2019. Epub ahead of print.
- Bordoni B, Marelli F, Morabito B, Castagna R. A new concept of biotensegrity incorporating liquid tissues: blood and lymph. *J Evid Based Integr Med*. 2018;23:2515690X18792838. doi:10.1177/2515690X18792838
- Adstrum S, Hedley G, Schleip R, Stecco C, Yucesoy CA. Defining the fascial system. *J Bodyw Mov Ther*. 2017;21:173–177. doi:10.1016/j.jbmt.2016.11.003
- Sambasivan R, Kuratani S, Tajbakhsh S. An eye on the head: the development and evolution of craniofacial muscles. *Development*. 2011;138:2401–2415. doi:10.1242/dev.040972
- Nandkishore N, Vyas B, Javali A, Ghosh S, Sambasivan R. Divergent early mesoderm specification underlies distinct head and trunk muscle programmes in vertebrates. *Development*. 2018;145:18. doi:10.1242/dev.158527
- Bordoni B, Marelli F, Morabito B, Sacconi B. The indeterminable resilience of the fascial system. *J Integr Med*. 2017;15(5):337–343. doi:10.1016/S2095-4964(17)60351-0
- Zügel M, Maganaris CN, Wilke J, et al. Fascial tissue research in sports medicine: from molecules to tissue adaptation, injury and diagnostics: consensus statement. *Br J Sports Med*. 2018;52(23):1497. doi:10.1136/bjsports-2018-099308
- Bordoni B, Marelli F, Morabito B, Castagna R, Sacconi B, Mazzucco P. New proposal to define the fascial system. *Complement Med Res*. 2018;25:257–262. doi:10.1159/000486238
- Bordoni B, Varacallo MA, Morabito B, Simonelli M. Biotensegrity or fascintegrity? *Cureus*. 2019;11(6):e4819.
- Bordoni B, Walkowski S, Morabito B, Varacallo MA. Fascial nomenclature: an update. *Cureus*. 2019;11(9):e5718.
- Dasgupta K, Jeong J. Developmental biology of the meninges. *Genesis*. 2019;57:23288. doi:10.1002/dvg.v57.5
- Tanaka M. Embryological consideration of dural AVFs in relation to the neural crest and the mesoderm. *Neurointervention*. 2019;14:9–16. doi:10.5469/neuroint.2018.01095
- Sambasivan R, Kuratani S, Tajbakhsh S. An eye on the head: the development and evolution of craniofacial muscles. *Development*. 2011;138:2401–2415. doi:10.1242/dev.040972
- Heude E, Tesarova M, Sefton EM, et al. Unique morphogenetic signatures define mammalian neck muscles and associated connective tissues. *Elife*. 2018;7:e40179. doi:10.7554/eLife.40179
- Bueno D, Parvas M, Nabiuni M, Miyani J. Embryonic cerebrospinal fluid formation and regulation. *Semin Cell Dev Biol*. 2019;S1084-9521(18)30241–6.

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